1.1.1: The Institution ensures effective curriculum planning and delivery through a well-planned and documented process including Academic calendar and conduct of continuous internal Assessment

INDEX

Principal
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Cherukupally (V), Bhogapuram Mandal
Vizianagaram Dt., - 531162

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AIPS/PO/APAC-2020/01 **Date: 30-05-2020**

CIRCULAR

This is to inform all the staff members that Academic Planning and Advisory Committee will be meeting to discuss important issues at 10.00 Am in the Principals chamber on 01st June 2020. All members are requested to attend the meeting without fail.

Agenda:

1. Preparation of institute academic calendar of 2020-21
2. Value added courses
3. Hospital training sessions and visits
4. Pharmacological and Analytical Project works
5. Research works and collaboration
6. Workshops/FDPs
7. Industrial visits
8. Training and Placements
9. Extracurricular/Co-curricular activities
10. Sports/NSS activities
11. Any other issues

Copy to

Dr.M.B. V.Raju	Principal
Mr.V.Umasankar	Professor, M.Pharma, PGDCR, PGDAS, Ph.D, Vice principal
Prof.S.Satyanarayana	M.Pharma,Ph.D,Scientist Emirates, Former Principal,Andhra University college of PharmaceuticalSciences, Andhra University
Dr.S.VijaySrinivas	Ph.D,Industrial Person
Shri.C.S.Mujebuddhin	M.Pharma,CEO,CLINISOL research pvt ltd
Dr.Ch.Hemasudha	MD Gynaecology & Obstetrics Sri Sai Aditya Hospital, Visakhapatnam
Dr.N Nelima	HOD–Department of Pharmacy
Dr.G.Prashanti	Professor, M.Pharm Pharmaceutical Technology
Mr.R.Ramana	Librarian
Mr.D.KoteswaraRao	Physical Director

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MINUTESOFTHEACADEMICPLANNINGANDADVISORYCOMMITTEE

The Academic Planning and Advisory Committee meeting was held on 10:30 AM at Principal Sir's chamber.

The Principal gave a brief description on the above objective of the Academic Planning and Advisory Committee meeting. The principal started discussing about the academic issues and emphasized the need to follow the new University regulations.

AgendaItem1:

Preparation of Institute academic calendar of 2020-21.

Resolution:

- Mr.V.UmaShankar, IQAC Coordinator, prepared the college Academic Calendar based on the Academic Calendar issues by the University and is handed over to the Head of the Department of Pharmacy.
- Department wise Academic Calendar was prepared by the Head of the Department basing on the Calendar issued by the Coordinator and was sent to the IQAC coordinator for his approval.
- Timetableswerepreparedandworkloadswereallottedtothefacultybasedon Academic Calendar of the institute as per the curriculum of the current semester.

Agenda Item 2:

Value added Courses

Resolution:

The members of the committee have been proposed that value added courses should be included in each department though it's not included in the curriculum as it find important for the development and employability of the students.

Agenda Item 3:

Hospital training sessions and visits:

Resolution:

The member suggested that every student should complete at least one internship per year.

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Agenda Item 4:

Pharmacological and Analytical Project works

Resolution:

The members of the committee assigned the faculty to guide the students in project works.

Agenda Item 5:

Research works

Resolution:

- Prof.S.Satyanaran advised the faculty members to publish at least one research paper per semester in High Indexed Journal. The entire remaining faculties were suggested to publish one paper in Scopus journal.
- Shri C.S.Mujebuddhin advised all the faculty members to attend the FDP every year.
- Dr.S.Vijay Srinivas advised all the faculty members to undergo Internship Academic Interaction programmes.

AgendaItem6:

Training and placements

Resolution:

- The Principal, AIPS staff members discussed and took is solution and informed and the faculty members to implement the following from the academic year.
- Students who cleared all the subjects and secured CGPA above 7 should enroll for GPAT Programme.
- Students who cleared all the subjects and obtained CGPA between6-7shouldenroll for PGECET programme.
- All the remaining students should attend CRT classes conducted by the college.
- The coordinator. S. Chandrasekhar informed the faculty members to organize various activities in the form of Competitions, Guest lectures, Career guidance, Entrepreneurship programmes etc for the students to improve their knowledge, skills and keep them abreast with the changing demands of the industries.

AgendaItem7:

Workshops/FDPs

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Resolution:

- Dr.Ch.Hema Sudha suggested the faculty to attend the FDP every year.
- She suggested the importance of proving training programmes to non-teaching staff in

Ms Office, Ms Word and Excel which are very useful in drafting and for preparing documents.

•She also advised the English faculty to train the junior faculty and non teaching staff to Compose emails, notices, official letters ,circulars which are necessary for the need so of their job and also for the professional development of the institution.

Agenda Item 8:

Hospital Training and Rosters:

Resolution:

- Dr.Ch.Hemasudha suggested the faculty of followed side teaching to the students in their hospital visits which is a main programme of the curriculum.

Agenda Item 9:

Industrial Visits

Resolution:

- Dr.S.Vijay Srinivas proposed an idea of organizing regular industrial visits for the students in reputed industries like Pfizer, Aurabindo.

•To acquire knowledge on the working of men and machinery in different pharmacy industries.

- Prof.S.Satyanarayana, suggested for arranging atleast two guest lecturers to students in a semester.

Agenda Item 10:

Sports/NSS Activities

Resolution:

- Dr.M.B.V.RAJU proposed organizing Sports activities for the students and encourages the students to participate in competitions at the university, state or national level tournaments.
- He also informed the faculty members to conduct various technical events and NSS activities like Blood donation campus, Plantation drive, Swacch Bharat Campaign ,Health check-up programs etc.

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Agenda Item 11:

Anyother Issues

Resolution:

- The IQAC coordinator instructed all the staff members to maintain updated stock registers, Maintenance registers, Complaint registers etc of all the laboratories duly verified by the committee.
- It was also resolved after the discussion and should follow IQAC Audit Action Taken Report.

Attendance Sheet:

S.No	Name	Designation	Signature
1.	Dr.M.B.V.Raju	Professor, M.Pharma, Ph.D, Principal	
2.	Mr.V.Uma sankar	Professor, M.Pharma, PGDCR, PGDAS,Ph.D, Viceprincipal	
3.	Prof.S.Satyanarayana	M.Pharma,Ph.D,Scientist emirates,Former Principal, Andhra University collegeof Pharmaceutical Sciences,Andhra University	
4.	Dr.S.VijaySrinivas	Ph.D,Industrial Person	
5.	Shri.C.S.Mujebuddhin	M.Pharma,CEO,CLINISOL Research pvt ltd.	
6.	Dr.Ch.HemaSudha	MDGynaecology&Obstetrics Sri Sai Aditya Hospital ,Visakhapatnam	
7.	Dr.N.Neelima	HOD-Department of Pharmacy	
8.	Dr.G.Prasanthi	Professor,M.Pharm Pharmaceutical Technology	
9.	Mr.R.Ramana	Librarian	
10.	Mr.D.KoteswaraRao	Physical Director	

Principal

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DEPARTMENT OF PHARMACY

Date:15-06-2020

CIRCULAR

This is to inform that the Department Academic Committee (DAC) will be held on 22thJune 2020 10:30AM at Principal Sir's chamber.

Agenda:

1. Preparation of Department progress academic year 2020-21
2. Value added courses related to medical coding ,Clinical SAS
3. Certificate courses/Internship programs on Instrumentation handling
4. Project works on Pharmacological activities and Analytical designs
5. Research works on Plant extracts and their Pharmacological action
6. Training and Placements with respect to Multinational Pharmaceutical Industry needs
7. Industrial visits of formulation Pharmaceutical Industries
8. Extra curricular/ Co-curricular activities
9. Sports/NSS activities
10. Any other issues

AgendaItem1:

Preparation of Department progress academic year 2020-2021

Resolution:

- HOD Pharmacy analysed the results of B.Pharmacy 2019-2020 academic year and expressed satisfaction for getting more than 85% of pass percentage.
- Committee congratulated the faculty who met the target of 90% or more.

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Agenda Item2:

Value added Courses related to medical coding ,Clinical SAS

Resolution:

The members of the committee have been proposed that value added courses related to medical coding, medical scribing and clinical SAS related to be included in each department thoughit is not included in the curriculum as it finds important for the development and employability of the B.Pharmacy & M.Pharmacy students.

Agenda Item3:

Certificate courses/Internship programs on Instrumentation handling

Resolution:

The members suggested that every B.Pharmacy & M..Pharmacy students should complete certification courses /Internship courses related to latest instrumentation handling, thesis writing courses.

Agenda Item4:

Project works on Pharmacological activities and Analytical designs

Resolution:

The members of the committee assigned the faculty to guide the B.Pharmacy & M.Pharmacy students in project works related to plant extracts and pharmacological activities, pharmaceutics related projects and analytical projects.

Agenda Item5:

Research works on Plant extracts and their Pharmacological action

Resolution:

- Dr.M.B.V.RAJU Principal adviced the faculty members to publish at least one research Paper per semester in High Indexed Journal.The entire remaining faculty were suggested To publish one paper in Scopus journal.
- Mr.A.Nanaji advised all the faculty members to attend the FDP programs every year.
- Ms.D. Purnima Yadav advised all the faculty members to register in APTI.

Agenda Item6:

Training and placements with respect to Multinational Pharmaceutical Industry needs

Resolution:

- The Principal, AIPS staff members discussed and took are solution and informed the

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faculty members to implement the following from the academic year:

•Students who cleared all the subjects and secured CGPA above7 should enroll for GPAT Programme

• Students who cleared all the subjects and obtained CGPA between 6-7 should enroll For PGECET programme.

•All the remaining students should attend CRT classes conducted by the college.

•The coordinatorY.Pavani informed the faculty members to organize various activities in the form of Competitions ,Guest lectures ,Career guidance, Entrepreneurship programmes etc for the students to improve their knowledge, skills and keep them abreast with the changing demand so for the industries.

Agenda Item7:

Industrial Visits to formulation Pharmaceutical Industries

Resolution:

•Mr.A.Naga Srinivas proposed an idea of organizing regular industrial visits for the students in reputed industries like Pfizer, Aurabindo, Dr.Reddys Laboratories ,DIVIS Laboratories.

• To acquire knowledge on the working of men and machinery in different pharma industries.

Mr.S.Rama Krishna, suggested for arranging atleast two guest lecturers to students in a Semester.

Agenda Item 8:

Sports/NSS Activities

Resolution

•Mr.D.KoteswaraRao proposed organizing Sports activities for the students and encourages the students to participate in competitions at the university,state or national level tournaments.

•He also informed the faculty members to conduct various technical events and NSS activities like Blood donation camps, Plantation drive,Swacch Bharat Campaign, Health check-up programs etc.

Agenda Item 9:

Any other Issues

Resolution:

•The IQAC coordinator instructed all the staff members to maintain updated stock registers, Maintenance registers, Complaint registers etc of all the laboratories duly verified by the committee.

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•It was also resolved after the discussion and should follow IQAC Audit Action Taken Report.

List of DAC members attended:

S. No	Name	Designation	Signature
1.	Dr.M.B.V.Raju	Principal	
2.	Mr.V.UmaSankar	HOD-Department of Pharmacy Practice	
3	Mr.A.Nanaji	Associate Professor	
4	Ms.D.Purnima Yadav	Associate Professor	
5	Mr.Bhargav Krishna Raju	Associate Professor	
6	Mr.V.H.S.Reddy	Associate Professor	
7.	Mr.M.Vasu	Associate Professor	
8.	Mr.Vamsi KrishnaYadav	Associate Professor	
9.	Ms.B.Mehree.Jyothi	Assistant Professor	
10.	Mrs.Y.Anveshi Dhanunjaya	Assistant Professor	

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DEPARTMENT OF PHARMACY PRACTICE

Date: 05-05-2020

CIRCULAR

This is to inform that the Department Academic Committee (DAC) will be held on 09th June 202 10:30 AM at Principal Sir's chamber.

Agenda:

1. Preparation of department academic calendar of 2020-21
2. Hospital training and Hospital visits
3. Clinical Project works
4. Community centers correlated training
5. Placement in Pharma-IT Sector Companies.
6. Value added courses
7. Research works
8. Sports/NSS activities
9. Any other issues

AgendaItem1:

Preparation of Department progress academic year 2020-21

Resolution:

- HOD Pharmacy Practice analysed the results of Pharm.D 2019-2020 academic year and expressed satisfaction for getting more than 85% of pass percentage.
- Committee congratulated the faculty who met the target of 90% or more.

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Agenda Item 2:

Hospital training and Hospital visits

Resolution:

- Mr.V. Umasankar suggested faculty to train the students to participate in bed side learning.
- Dr.V.C.Randeep Raj proposed an idea of organizing regular hospital visits for the students in reputed hospitals like K.G.H& MIMS.

Agenda Item 3:

Clinical Project works:

Resolution:

The members suggested that every student should complete atleast one clinical project which includes both cases and controls

Agenda Item 4

Community centers correlated training

Resolution:

The members of the committee assigned the Pharmacy practice faculty to guide the students to participate in community center correlated training such as B.P monitoring, Glucose monitoring.

AgendaItem5:

Placement in Pharma – IT Sector Companies:

Resolution:

- The Principal, AIPS staff members discussed and took is solution and informed and the faculty members to implement the following from the academic year:
- Students should attend CRT classes conducted by the college.
- The coordinator Dr.V.C.Randeep Raj informed the faculty members to organize various activities in the form of Competitions, Guestlectures, Careerguidance, Entrepreneurship programmes etc for the students to improve their knowledge, skills and keep them abreast with the changing demands of the industries.

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Agenda Item 6:

Value added courses

Resolution:

The members of the committee have been proposed that value added courses related to clini-SAP, clinicalresearch,Pharmacovigilance should be included in each department though its not included in the curriculum as it finds important for the development and employability of the student.

Agenda Item 7:

Research works

Resolution :

- Dr.T.Rishi advised the faculty members to publish at least one research paper per semester in High Indexed Journal. The entire remaining faculty was suggested to publish one paper in Scopus Journal.

Agenda Item 8:

Sports/NSS activities

Resolution:

- Mr.D.Koteswara Rao proposed organizing Sports activities for the students and encourages the students to participate in competitions at the university, state or national level tournaments.
- Dr.T.Rishialsoinformedthefacultymemberstoconductvarioustechnicaleventsand NSS activities like Blood donation camps, Plantation drive, Swacch Bharat Campaign, Health check-up programs etc.

Agenda Item 9:

Any other Issues

Resolution:

- The IQAC coordinator instructed all the staff members to maintain updated stock registers, Maintenance registers, and Complaint registers of all the laboratories duly verified by the committee.
- It was also resolved after the discussion and should follow IQAC Audit Action Taken Report

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List of DAC mem bers attended:

S.No	Name	Designation	Signature
1.	Dr M.B.V.Raju	Principal	
2.	Mr V.Uma Sankar	HOD-Department of Pharmacy Practice	V. Uma Sankar
3.	Dr V.C.Randeep Raj	Associate Professor	
4.	Dr B.Manoj Kumar	Associate Professor	B. Manoj
5.	Dr T.Rushi	Assistant Professor	
6.	Dr D SubhaSri	Assistant Professor	SubhaSri
7.	Dr B.Harinipriya	Assistant Professor	B Harini Priya
8.	Dr B.Tejasree	Assistant Professor	B. Tejasree
9.	Dr G.Sravani	Assistant Professor	G. Sravani
10.	Dr S.Dhana Lakshmi	Assistant Professor	

Principal

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DEPARTMENT OF PHARMACY

Ref:AIPS/B.PHARM/PAC/Cir/2020-21/01 **Date: 17-08-2021**

CIRCULAR

Members of the **Program Assessment Committee (PAC)** are requested to attend a meeting at **2:00 PM** on **23rd August 2021** in the HOD's chamber.

Agenda:

1. Review on CO-PO attainment level in the academic year 2020-2021.
2. Spreading of Vision, Mission of the department.
3. Explanation of CO, PO and PSOs to the newly appointed faculty members and discussion on lab COs attainment level.
4. Attainment of CO-PO PSO & measures taken for continuous improvement.
5. Program effectiveness.
6. Faculty and student's motivation and participation.
7. Activities leading to Quality improvement.
8. Curriculum gap identification.
9. The verification of lab maintenance record and equipment's.
10. Remedial classes schedule for 2020-2021 first semester.
11. Add-on Courses Schedule

Copy To:

1. Principal Office
2. HOD
3. PAC Members

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DEPARTMENT OF PHARMACY

Ref:AIPS/B.PHARM/PAC/Cir/2020-21/01 **Date: 17-08-2020**

MINUTES OF PAC MEETING

A meeting of Program assessment committee (PAC) was held in HOD's chamber at **2:00 P.M** on **23rd August** 2020. The following members were present.

S.No	Name	Designation	Category
1.	Dr.S.Satya Prasad	Head of the Department	Chair Person
2.	Ms.D.PurnimaYadav	Department PAC Coordinator	Member
3.	Mr.A.Nanaji	Exam Cell Coordinator	Member
4.	Mrs.Y.AnveshiDhanunjaya	Student Mentoring Coordinator	Member
5.	Mrs.B.MeherJyothi	Attendance Coordinator	Member
6.	Dr.S.Satya Prasad	M.Pharm Coordinator	Member

Review on Action taken in Previous Meeting:

- Chairperson presented the earlier meeting action report

S.No	Agenda Points	Action Taken
1.	Analysis of CO,PO and PSO attainment level	CO,PO and PSO attainments for all the courses is verified and discussed to improve attainment levels

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Minutes of Meeting:

Item-1:

- Review on CO-PO attainment level in the academic year 2020-2021.

Resolution:

- HOD PHARMACY discussed and observed the CO-PO attainment target levels of the previous year and directed the faculty members concerned to take appropriate steps to attain satisfactory levels.
- HOD PHARMACY apprised the faculty members to involve students in knowledge upgradation programs like Workshops, seminars, guest lectures etc, for the it was also suggested to organize various training programs in soft skills to improve the confidence levels, leadership qualities, team working, creative skills etc, of the students.

Item-2:

- Spreading of Vision, Mission of the department.

Resolution:

- HOD PHARMACY briefed the process followed in evolving vision and mission and also presented the relation between vision and mission with institute and department and explained the process of spreading and publicizing of vision and mission through website and through stack holders etc.

Item-3:

- Explanation of CO,PO and PSOs to the newly appointed faculty members and discussion on lab COs attainment level

Resolution:

- HOD PHARMACY directed the senior faculty members to explain and train the newly appointed faculty members about COs, POs and PSOs.
- HOD PHARMACY instructed the faculty members to provide the knowledge and information to the students regarding laboratory course objectives, outcomes and ways of achieving it.

Item-4:

- Attainment of CO-PO-PSO & measures taken for continuous improvement

Resolution:

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- The attainment of CO, PO & PSOs for all the courses was verified and discussions to improve attainments levels were carried out.
- In addition Academic performance, suggestions to improve PO &PSOs attainments are discussed and it was proposed to conduct guest lectures and seminars to create OBE awareness.
- Learning activities conducted by the faculty in the previous semester was analyzed and appreciated by the HOD.

Item-5:

- Program Effectiveness

Resolution:

- Mr.Bhargav Krishna Raju, advised to improve Quality Teaching Learning process Methodologies to support week students and encourage bright students.
- He also discussed to identify curriculum gaps, content beyond the syllabus in process implementation for attaining the program outcomes and program specific outcomes.

Item-6:

- Faculty and student's motivation and participation

Resolution:

- Members of PAC suggested that department must have a plan for every semester to improve the academic result and placements.
- The students should be motivated to do multidisciplinary projects during their course of study which will enhance their understanding of multidisciplinary subjects.
- The students must be encouraged to participate in project exhibitions, which will create a project based learning environment inside the campus.

Item-7:

- Activities leading Quality improvement.

Resolution:

- Association activities should be organized and conducted by the students. It will help in not only belongingness to the college but also their leadership qualities.
- Effective Student mentoring through a separate hour. .
- Industrial visit can be arranged in the MOU signed industries / organizations.

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Item-8:

- Curriculum gap identification

Resolution:

- Discussed to instruct the students to register in Swayam, NPTEL online courses to reduce the gap between academic and industry.
- HOD-PHARMACY proposed to organize regular industrial visits for the students in reputed multinational Organizations like Pfizer, AUROBINDO.

Item-9:

- The verification of lab maintenance records and equipment's.

Resolution:

- Mr.M.Vasu has been appointed as Department Overall Lab in-charge to find the required maintenance and to purchase the required equipment.
- The Lab technicians were asked to verify the minimum Lab requirements such as manuals, equipment login books to ensure the smooth functioning of Lab experiments for the coming semester.
- A discussion on the new labs introduced as per the current regulation for the next semester was carried out.
- Suggested maintaining lab manuals according to university.
- The conduction of experiments beyond the syllabus in the respective labs to enhance the practical knowledge of students.

Item-10:

- Remedial classes schedule for 2020-2021 first semester

Resolution:

- Mrs.M.Venkata Naga Deepika has been appointed as Remedial class in-charge to identify the underperforming students with their semester results.
- After completion of mid I exams, remedial classes are going to conduct for slow learners based on their performance in mid exams.
- A proposal was mooted to conduct extra classes and remedial classes to slow learners with an aim to improve the pass percentage.

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Item-11:

- Add-on courses

Resolution:

- PAC discussed the schedule of Add-on courses , proposed to be conducted in semester –II and IV B.Pharmacy students.
- Based on the Add-on courses options given by the students, the courses will be according scheduled.
- Some faculty members suggested starting of courses like Medical coding, Pharmacovigilance, Clinical SAS.
- Swayam, NPTEL,APSCHE training program were recommended.

Venue: HOD'S Cabin

S.NO	Name	Signature
1.	Dr.S.Satya Prasad HOD Pharmacy	S. Satya Prasad
2.	Ms.D.PurnimaYadav Department PAC Coordinator	D. Purnima
3.	Mr.Ch.Madhu Exam Cell Coordinator	
4.	Mrs.Y.Anveshi Dhanunjaya Student Mentoring Coordinator	Y. Dhanunjaya
5.	Mrs.B.Meher Jyothi Attendance Coordinator	M Jyothi
6.	Dr.G.Prashanti M.Pharm Coordinator	G. Prasanthi

S. Satya Prasad
HOD Pharmacy

Principal

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DEPARTMENT OF PHARMACY

Ref:AIPS/B.PHARM/PAC/Cir/2020-21/01 **Date:09-02-2021**

CIRCULAR

This is to inform that a meeting will be held for the Members of the Program Assessment Committee (PAC) in the HOD's chamber on 11th February 2021 at 2:00 P.M. All the members are requested to attend the meeting without fail.

Agenda:

1. Teaching Learning methods practiced.
2. Result Analysis.
3. Assessment methods, attainment of COs, Pos, with program effectiveness.
4. Training and placement progress with feedback from recruiters.
5. Report on program activities and status.
6. Industrial training and Internships.
7. Students's participation in co curricular and extracurricular activities.
8. Faculty Research and publications and participation in FDP's, seminars. Workshops etc.
9. Add-on Courses Schedule.

Copy To:

1. Principal Office
2. HOD
3. PACMembers

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Vizianagaram Dt., - 531162

ESTD : 2005

AVANTHI INSTITUTE OF PHARMACEUTICAL SCIENCES

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Cherukupally (Village), Chittivalasa (SO), Bhogapuram (Mandal), Vizianagaram (Dist) -531162.
www.avanthipharma.ac.in, principal@avanthipharma.ac.in

DEPARTMENT OF PHARMACY

Ref:AIPS/B.PHARM/PAC/Cir/2020-21/01 **Date:14-02-2020**

MINUTES OF PAC MEETING

A meeting of Program assessment committee (PAC) was held in HOD's chamber at 2:00 P.M on 16 thFebruary 2021. The following members were present.

S.No	Name	Designation	Category
1.	Dr.S.Satya Prasad	Professor & Head of the Department	Chair Person
2.	Mrs.B.Chaitanya	Training and Placement Coordinator	Member
3.	Ms.D.PurnimaYadav	Department PAC Coordinator	Member
4.	Mrs.Y.AnveshiDhanunjaya	Student MentoringCoordinator	Member
5.	Mrs.B.MeherJyothi	Attendance Coordinator	Member
6.	Mr.Ch.Madhu	Exam Cell Coordinator	Member
7.	Mr.A.Nanaji	Project Coordinator	Member
8.	Dr.G.Prashanti	M.Pharm Coordinator	Member

Review on Action taken in Previous Meeting:

- Welcome to our beloved Chairperson Dr.M.B.Venkatapathi Raju Garu to review the action taken in previous meeting.
- Committee discussed about recently announced B.Pharmacy II semester and IV semester results
- Chairperson expressed satisfaction for getting > 80% of results.
- Committee discussed about minor changes in course outcome of B.Pharmacy final semester Elective subjects.

S.No	Agenda Points	Action Taken
1.	Analysis of CO,PO and PSO attainment level	CO,PO and PSO attainments for all the courses is verified and discussed to improve attainment levels

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Minutes of Meeting:

Item-1:

- Teaching and Learning methods practiced.

Resolution:

- PAC members suggested that every faculty practice innovative ideas of teaching that can be updated periodically.
- The Outcome of the FDP Participation can be shared with other faculty members in the department.
- The knowledge gained from online courses completed by faculty should be disseminated to the students.
- The identified curriculums gap and fulfillment of the same can be documented in the course file.

Item-2:

- Result Analysis.

Resolution:

- Class wise results were presented and department wise comparisons were also done.
- The results for the results in some subjects are need to be analyzed.
- The class mentors are requested to closely interact with students during the mentor meetings and identify the difficulties faced by them in learning subjects.
- The faculty members are advised to identify the follow effective teaching learning methods for improvement of academic performance.
- Members suggested to get the feedback from the students for poor results and based on that remedial action can be planned.
- Faculty members are requested to analyze internal and external factors influencing the performance of their subject and based on that plan should prepared to improve performance of students.

Item-3:

- Assessment methods, attainment of COs, POs, with program effectiveness.

Resolution:

- The reasons for decrease in attainment level of few subjects can be analyzed and the result can be discussed with faculty members who is currently taking the course.

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- The faculty members can provide the reasons behind the decrease in the attainment level for few subjects and the remedial actions can be suggested.
- The CO calculations for odd semester can be filed in the corresponding course files.

Item-4:

- Training and placement progress with feedback from recruiters.

Resolution:

- It has been suggested to collect feedback given by the employers specific to the B.PHARMACY department, analyze the same and provide the reports.
- Members asked to provide the actions taken based on feedback and suggested to implement those actions for the current final year students.
- Members suggested to display the placed students in various places of the department.
- Insisted to motivate the II and III year students to participate in virtual internship training.
- Suggested to include department faculty in the group discussion and mock interviews along with English faculty.
- The appointment orders of the current passed students should be collected and filled properly.

Item-5:

- Report on program activities and status

Resolution:

- Members suggested executing all the planned activities without fail and the benefits received by the students should be recorded.
- The members advised to publish the activities and events organized by the department in the respective newsletters and college website.

Item-6:

- Industrial training and Internships.

Resolution:

- The students must undergo one internship during the course of study and hence members advised to check the status of the final year students and encourage them to undergo the training in online.

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- Members suggested to incorporate industrial training outcomes as a quantitative measure in outcome attainment.

Item-7:

- Student's participation in co curricular and extracurricular activities.

Resolution:

- Members suggested to consolidate the number of events participated by students and the number of prizes won by the students.
- The student's publications need to be properly tracked by the faculty members and should be documented.
- The certificates of recent online courses completed by the students should be collected.

Item-8:

- Faculty Research and publications and participations in FDP's, seminars, workshops etc.

Resolution:

- HOD - PHARMACY advised the faculty members to attend at least one FDP organized by AICTE/ Universities and informed each and every faculty to enroll in NPTEL courses and to complete certification.
- He further stated about the provision of research incentives to the faculty involved in Research and Development activities as per the Research Promotion Policy of the college in order to promote research culture and to encourage faculty to involve in research activities.
- Discussions were carried out on the learning activities conducted by the faculty members in the last semester.

Item-9:

- Add –on Courses Schedule.

Resolution:

- PAC discussed the schedule of Add- on courses, proposed to be conducted in semester - III B.Pharmacy students.
- Based upon the Add – on courses options given by the students, the courses will be according scheduled.

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- Some faculty members suggested starting of courses like Clinical SAS programming, Pharmacovigilance and Medical coding.

Venue: HOD's Cabin

S.No	Name	Signature
1.	Dr.S.Satya Prasad Professor&Head of the Department	S. Satya Prasad
2.	Mrs.B.Chaitanya Training and Placement Coordinator	B. Chaitanya
3.	Ms.D.PurnimaYadav Department PAC Coordinator	D. Purnima
4.	Mrs.Y.Anveshi Dhanunjaya Student Mentoring Coordinator	Y. Dhanunjaya
5.	Mrs.B.Meher Jyothi Attendance Coordinator	M.Jyothi
6.	Mr.Ch.Madhu Exam Cell Coordinator	
7.	Mr.A.Nanaji Project Coordinator	
8.	Dr.G.Prashanti M.Pharm Coordinator	G. Prashanthi

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DEPARTMENT OF PHARMACY PRACTICE

Ref:AIPS/PHARM.D/PAC/Cir/2020-21/01 **Date: 18-08-2020**

MINUTES OF PAC MEETING

A meeting of Program assessment committee (PAC) was held in HOD's chamber at 10:00 A.M on 20th August 2020. The following members were present.

S.No	Name	Designation	Category
1.	Mr.V.Uma Sankar	Head of the Department	Chair Person
2.	Dr.V.C.Randeep Raj	Training and Placement Coordinator	Member
3.	Dr.S.Murali Mohan	Department PAC Coordinator	Member
4.	Dr.T.Rushi	Student MentoringCoordinator	Member
5.	Dr.B.Manoj Kumar	Attendance Coordinator	Member
6.	Mr.Ch.Madhu	Exam Cell Coordinator	Member

Review on Action taken in Previous Meeting:

Welcome to our beloved Chairperson Mr.V.Uma Sankar Garu to review the action taken in previous meeting. Chairperson presented the earlier meeting action report

S.No	Agenda Points	Action Taken
1.	Analysis of CO,PO and PSO attainment level	CO,PO and PSO attainments for all the courses is verified and discussed to improve attainment levels

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Minutes of Meeting:

Item-1:

- Teaching and Learning methods practiced.

Resolution:

- PAC members suggested that every faculty practice innovative ideas of teaching that can be updated periodically.
- The Outcome of the FDP Participation can be shared with other faculty members in the department.
- The rubrics can be formed for the evaluation of the assignments and tutorials.
- The knowledge gained from online courses completed by faculty should be disseminated to the students.
- The identified curriculums gap and fulfillment of the same can be documented in the course file.

Item-2:

- Result Analysis.

Resolution:

- Class wise results were presented and department wise comparisons were also done.
- The results for the results in some subjects are need to be analyzed.
- The class mentors are requested to closely interact with students during the mentor meetings and identify the difficulties faced by them in learning subjects.
- The faculty members are advised to identify the follow effective teaching learning methods for improvement of academic performance.
- Members suggested to get the feedback from the students for poor results and based on that remedial action can be planned.
- Faculty members are requested to analyze internal and external factors influencing the performance of their subject and based on that plan should prepared to improve performance of students.

Item-3:

- Assessment methods, attainment of COs, POs, with program effectiveness.

Resolution:

- The reasons for decrease in attainment level of few subjects can be analyzed and the result can be discussed with faculty members who is currently taking the course.

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- The faculty members can provide the reasons behind the decrease in the attainment level for few subjects and the remedial actions can be suggested.
- The CO calculations for odd semester can be filed in the corresponding course files.

Item-4:

- Training and placement progress with feedback from recruiters.

Resolution:

- It has been suggested to collect feedback given by the employers specific to the PHARM.D department, analyze the same and provide the reports.
- Members asked to provide theactions taken based on feedback and suggested to implement those actions for the current final year students.
- Members suggested to display the placed students in various places of the department.
- Insisted to motivate the II and III year students to participate in virtual internship training.
- Suggested to include department faculty in the group discussion and mock interviews along with English faculty.

Item-5:

- Report on program activities and status

Resolution:

- Members suggested executing all the planned activities without fail and the benefits received by the students should be recorded.
- The members advised to publish the activities and events organized by the department in the respective newsletters and college website.

Item-6:

- Internships.

Resolution:

- The students must undergo one internship during the course of study and hence members advised to check the status of the final year students and encourage them to undergo the training in Hospital.

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Item-7:

- Student's participation in co curricular and extracurricular activities.

Resolution:

- Members suggested to consolidate the number of events participated by students and the number of prizes won by the students.
- The student's publications, research articles and review articles need to be properly tracked by the faculty members and should be documented.
- The certificates of recent online courses related to medical scribing and CDM completed by the students should be collected.

Item-8:

- Faculty Research and publications and participations in FDP's, seminars, workshops etc.

Resolution:

- HOD – PHARM.D advised the faculty members to attend at least one FDP organized by AICTE/ Universities and Hospitals informed each and every faculty to enroll in NPTEL and vigilance related courses and to complete certification.
- He further stated about the provision of research incentives to the faculty involved in Research and Development activities as per the Research Promotion Policy of the college in order to promote research culture and to encourage faculty to involve in research activities.
- Discussions were carried out on the learning activities conducted by the faculty members in the last year.

Item-9:

- Add –on Courses Schedule.

Resolution:

- PAC discussed the schedule of Add- on courses, proposed to be conducted for III & IV PHARM.D students
- Based upon the Add – on courses options given by the students, the courses will be accordingly scheduled.
- Some faculty members suggested starting of courses like Clinical SAS programming, Pharmacovigilance and Medical coding.

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Venue: HOD's Cabin

S.NO	Name	Signature
1.	Mr.V.Uma Sankar Head of the Department	V. UmaSankar
2.	Dr.V.C.Randeep Raj Training and Placement Coordinator	
3.	Dr.S.Murali Mohan Department PAC Coordinator	S. Murali Mohan
4.	Dr.T.Rushi Student MentoringCoordinator	
5.	Dr.B.Manoj Kumar Attendance Coordinator	B. Manu
6.	Mr.Ch.Madhu Exam Cell Coordinator	

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DEPARTMENT OF PHARMACY PRACTICE

Ref:AIPS/PHARM.D/PAC/Cir/2020-21/01 **Date: 10-11-2020**

MINUTES OF PAC MEETING

A meeting of Program assessment committee (PAC) was held in HOD's chamber at 10:00 A.M on 12th November 2020. The following members were present.

S.No	Name	Designation	Category
1.	Mr.V.Uma Sankar	Head of the Department	Chair Person
2.	Dr.V.C.Randeep Raj	Training and Placement Coordinator	Member
3.	Dr.S.Murali Mohan	Department PAC Coordinator	Member
4.	Dr.T.Rushi	Student MentoringCoordinator	Member
5.	Dr.B.Manoj Kumar	Attendance Coordinator	Member
6.	Mr.Ch.Madhu	Exam Cell Coordinator	Member
7.	Dr.B.Harini priya	Project Coordinator	Member
8.	Dr.D.Subhasree	Pharm.D Coordinator	Member

Review on Action taken in Previous Meeting:

Chairperson presented the meeting action report.

S.No	Agenda Points	Action Taken
1.	Analysis of CO,PO and PSO attainment level	CO,PO and PSO attainments for all the courses is verified and discussed to improve attainment levels

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Minutes of Meeting:

Item-1:

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Resolution:

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Item-7:

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Vizianagaram Dt., - 531162

Venue: HOD's Cabin

S.NO	Name	Signature
1.	Mr.V.Uma Sankar Head of the Department	V. Uma Sankar
2.	Mr.V.C.Randeep Raj Training and Placement Coordinator	
3.	Dr.S.Murali Mohan Department PAC Coordinator	S. Murali Mohan
4.	Mr.T.Rushi Student MentoringCoordinator	
5.	Mr.B.Manoj Kumar Attendance Coordinator	B. Manoj
6.	Mr.Ch.Madhu Exam Cell Coordinator	Ch.
7.	Dr.B.Harini priya Project Coordinator	B. harini priya
8.	Dr.D.Subhasree Pharm.D Coordinator	Subha Sree

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Directorate of Academic Planning

JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY KAKINADA
KAKINADA-533003, Andhra Pradesh, INDIA
(Established by AP Government Act No. 30 of 2008)

Lr. No. JNTUK/DAP/RAC/B. Pharmacy/I Year/2020-21 *Date: 24-05-2021*

Dr. R. Srinivasa Rao,
Director, Academic Planning
JNTUK, Kakinada

To
All the Principals of Affiliated Colleges,
JNTUK, Kakinada.

Academic Calendar for B. Pharmacy I Year
Academic year 2020-21

I SEMESTER			
Description	From	To	Weeks
Commencement of Class Work	**22.02.2021**		
I Unit of Instruction	**15.02.2021**	10.04.2021	7W
I Mid Examinations	05.04.2021	10.04.2021	1W
II Unit of Instructions	12.04.2021	29.05.2021	7W
II Mid Examinations			
Preparation & Practicals			
End Examinations			
Commencement of II Semester Class Work			
II SEMESTER			
I Unit of Instructions	**24.05.2021**	10.07.2021	7W
I Mid Examinations	05.07.2021	10.07.2021	1W
II Unit of Instructions	12.07.2021	28.08.2021	7W
II Mid Examinations	23.08.2021	28.08.2021	1W
Preparation & Practicals	30.08.2021	04.09.2021	1W
End Examinations	06.09.2021	18.09.2021	2W
Commencement of next Year Class Work	**18.10.2021**		
Note: I Semester Examinations may be conducted at the convenience during the II Semester.			

R. Srinivasa Rao

Director Academic Planning

Director
Academic Planning
JNTUK Kakinada

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Copy to Rector, Registrar JNTUK
Copy to Director Academic Audit, JNTUK
Copy to Director of Evaluation, JNTUK

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Directorate of Academic Planning

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KAKINADA-533003, Andhra Pradesh, INDIA
(Established by AP Government Act No. 30 of 2008)

Lr. No. 01-08/ JNTUK/DAP/AC/B. Tech-B. Pharmacy/II-III-IV Year/2020-21 *Date: 29-12-2020*

Dr. R. Srinivasa Rao,
Director, Academic Planning
JNTUK, Kakinada

To
All the Principals of Affiliated Colleges,
JNTUK, Kakinada.

Academic Calendar for II, III and IV - B. Tech & B. Pharmacy
Academic year 2020-21

I SEMESTER			
Description	**From**	**To**	**Weeks**
Commencement of Class Work	**02.11.2020**		
I Unit of Instruction	02.11.2020	19.12.2020	7W
II Unit of Instructions	21.12.2020	23.01.2021	5W
I Mid Examinations	25.01.2021	30.01.2021	1W
II Unit of Instructions(Continued)	01.02.2021	20.02.2021	3W
II Mid Examinations	22.02.2021	27.02.2021	1W
Preparation & Practicals	01.03.2021	06.03.2021	1W
End Examinations	08.03.2021	20.03.2021	2W
Commencement of II Semester Class Work	**22.03.2021**		
II SEMESTER			
I Unit of Instructions	**22.03.2021**	08.05.2021	7W
I Mid Examinations	10.05.2021	12.05.2021	1/2W
II Unit of Instructions	13.05.2021	30.06.2021	7W
II Mid Examinations	01.07.2021	03.07.2021	1/2W
Preparation & Practicals	05.07.2021	10.07.2021	1W
End Examinations	12.07.2021	24.07.2021	2W
Commencement of next Year Class Work			
Note: Calendar is prepared with 8 hrs/day hence 7 weeks per instruction period			

R. Srinivasa Rao
Director Academic Planning

Director
Academic Planning
JNTUK Kakinada

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Copy to Director Academic Audit, JNTUK
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Directorate of Academic Planning

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KAKINADA-533003, Andhra Pradesh, INDIA
(Established by AP Government Act No. 30 of 2008)

Lr. No. JNTUK/DAP R4C/M. Tech/M. Pharmacy/Pharma D/I Year/2020-21 *Date: 31-05-2021*

Dr. R. Srinivasa Rao,
Director, Academic Planning
JNTUK, Kakinada

To
All the Principals of Affiliated Colleges,
JNTUK, Kakinada.

Revised Academic Calendar for I Year M. Tech/M. Pharmacy
Academic year 2020-21

I SEMESTER			
Description	**From**	**To**	**Weeks**
Commencement of Class Work	**22.02.2021**		
I Unit of Instruction	**22.02.2021**	10.04.2021	7W
I Mid Examinations	05.04.2021	10.04.2021	1W
II Unit of Instructions	12.04.2021	29.05.2021	7W
II Mid Examinations	24.05.2021	29.05.2021	1W
Preparation & Practicals			
End Examinations			
Commencement of II Semester Class Work			
II SEMESTER			
I Unit of Instructions	**31.05.2021**	17.07.2021	7W
I Mid Examinations	12.07.2021	17.07.2021	1W
II Unit of Instructions	19.07.2021	04.09.2021	7W
II Mid Examinations	30.08.2021	04.09.2021	1W
Preparation &Practicals	06.09.2021	11.09.2021	1W
End Examinations	13.09.2021	25.09.201	2W
Commencement of next Year Class Work	**18.10.2021**		

Note: : I Semester Examinations may be conducted at the convenience during the II Semester.

Director Academic Planning

Director
Academic Planning
JNTUK Kakinada

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Avanthi Institute of Pharmaceutical Sciences
Cherukupally (V), Bhogapuram Mandal
Vizianagaram Dt., - 531162

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Phone: 0884-2300991
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Directorate of Academic Planning

JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY KAKINADA
KAKINADA-533003, Andhra Pradesh, INDIA
(Established by AP Government Act No. 30 of 2008)

Lr. No. 06-08/ JNTUK/DAP/AC/II Year/ M. Tech /2020-21 *Date: 29-12-2020*

Dr. R. Srinivasa Rao,
Director, Academic Planning
JNTUK, Kakinada

To
All the Principals of Affiliated Colleges,
JNTUK, Kakinada.

Academic Calendar for II Year M. Tech/M. Pharmacy Academic Year 2020-21

I SEMESTER			
Description	**From**	**To**	**Weeks**
Commencement of Class Work & Commencement of Project Work Phase-I	**02.11.2020**		
I Unit of Instruction	02.11.2020	19.12.2020	7W
I Mid Examinations	21.12.2020	23.01.2021	5W
II Unit of Instructions	25.01.2021	30.01.2021	1W
II Mid Examinations	01.02.2021	20.02.2021	3W
Preparation & Practicals	22.02.2021	27.02.2021	1W
End Examinations	01.03.2021	06.03.2021	1W
	08.03.2021	20.03.2021	2W
Commencement of II Semester Class Work	**22.03.2021**		
II SEMESTER			
Commencement of Project Work Phase - II	**22.03.2021**	26.06.2021	14W
Thesis submission duration	28.06.2021	24.07.2021	4W
Note: Calendar is prepared with 8 hrs/day hence 7 weeks per instruction period			

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Academic Planning
JNTUK Kakinada

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KAKINADA-533003, Andhra Pradesh, INDIA
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Lr. No. JNTUK/DAP/AC/I Year/Pharm D/2020-21 *Date: 19-02-2020*

Dr. R. Srinivasa Rao,
Director, Academic Planning
JNTUK, Kakinada

To
All the Principals of Affiliated Colleges,
JNTUK, Kakinada.

Academic Calendar of I Year Pharm D
Academic year 2020-21

Description	From	To	Weeks
Commencement of Class Work	**22.02.2020**		
I Unit of Instruction	22.02.2020	08.05.2021	11W
I Mid Examinations	03.05.2021	08.05.2021	1W
II Unit of Instructions	10.05.2021	24.07.2021	11W
II Mid Examinations	19.07.2021	24.07.2021	1W
III Unit of Instructions	26.07.2021	09.10.2021	11W
III Mid Examinations	04.10.2021	09.10.2021	1W
Preparation & Practical Exams	11.10.2021	16.10.2021	1W
End Examinations	18.10.2021	30.10.2021	2W
Commencement of next Year Class Work	**01.11.2021**		
Note: Calendar is prepared with 8 hrs/day hence 7 weeks per instruction period			

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Lr. No. 10-8/JNTUK/DAP/AC/II Year/Pharm D/2020-21 *Date: 29-12-2020*

Dr. R. Srinivasa Rao,
Director, Academic Planning
JNTUK, Kakinada

To
All the Principals of Affiliated Colleges,
JNTUK, Kakinada.

Academic Calendar of II, III, IV and V Year Pharm D
Academic year 2020-21

Description	From	To	Weeks
Commencement of Class Work	**02.11.2020**		
I Unit of Instruction	02.11.2020	16.01.2021	11W
II Unit of Instructions	18.01.2021	23.01.2021	1W
I Mid Examinations	25.01.2021	30.01.2021	1W
II Unit of Instructions (Continued)	01.02.2021	10.04.2021	10W
II Mid Examinations	05.04.2021	10.04.2021	
III Unit of Instructions	12.04.2021	26.06.2021	11W
III Mid Examinations	21.06.2021	26.06.2021	
Preparation & Practical Exams	28.07.2021	03.07.2021	1W
End Examinations	05.07.2021	17.07.2021	2W
Commencement of next Year Class Work	**26.07.2021**		
Note: Calendar is prepared with 8 hrs/day hence 7 weeks per instruction period			

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Lr. No. 11-8/JNTUK/DAP/ AC/ VI Year/Pharm D/2020-21 *Date: 29-12-2020*

Dr. R. Srinivasa Rao,
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Academic Calendar of VI Year Pharm D
for Academic year 2020-21

Description	Date
Commencement of Class Work for Internship	02.11.2020
Closing of Internship (12 Months)	30.10.2021

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INSTITUTE ACADEMIC CALENDER 2020-2021

B.PHARMACY

DESCRIPTION	I YEAR		II YEAR		III YEAR		IV YEAR	
	Semester I	Semester II	Semester I	Semester II	Semester I	Semester II	Semester I	Semester II
Commencement of classwork	22-02-2021	21-06-2021	02-11-2020	22-03-2021	02-11-2020	22-03-2021	02-11-2020	22-03-2021
I unit of instructions	22-02-2021	21-06-2021	02-11-2020	22-03-2021	02-11-2020	22-03-2021	02-11-2020	22-03-2021
I mid examinations	05-04-2021	02-08-2021	25-01-2021	10-05-2021	25-01-2021	10-05-2021	25-01-2021	10-05-2021
II unit of instructions	12-05-2021	09-08-2021	01-02-2021	13-05-2021	01-02-2021	13-05-2021	01-02-2021	13-05-2021
II mid examinations	24-05-2021	20-09-021	22-02-2021	01-07-2021	22-02-2021	01-07-2021	22-02-2021	01-07-2021
Preparation and practicals	31-05-2021	27-09-2021	01-03-2021	05-07-2021	01-03-2021	05-07-2021	01-03-2021	05-07-2021
End examinations	07-06-2021	04-10-2021	08-03-2021	12-07-2021	08-03-2021	12-07-2021	08-03-2021	12-07-2021

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INSTITUTE ACADEMIC CALANDER 2020-2021

PHARM D

DESCRIPTION	I YEAR	II YEAR	III YEAR	IV YEAR	V YEAR
Commencement of classwork	22-02-2020	02-11-2020	02-11-2020	02-11-2020	02-11-2020
I unit of instruction	22-02-2020	02-11-2020	02-11-2020	02-11-2020	02-11-2020
I mid examinations	03-05-2021	25-01-2021	25-01-2021	25-01-2021	25-01-2021
II unit of instructions	10-05-2021	01-02-2021	01-02-2021	01-02-2021	01-02-2021
II mid examinations	19-07-2021	05-04-2021	05-04-2021	05-04-2021	05-04-2021
III unit instructions	26-07-2021	12-04-2021	12-04-2021	12-04-2021	12-04-2021
III mid examinations	04-10-2021	21-06-2021	21-06-2021	21-06-2021	21-06-2021
Preparation and practicals examinations	11-10-2021	28-07-2021	28-07-2021	28-07-2021	28-07-2021
End examinations	18-10-2021	05-07-2021	05-07-2021	05-07-2021	05-07-2021

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COLLEGE ACADEMIC CALENDAR2020-2021

DATE	DESCRIPTION
17-08-2020	Commencement of classwork for II, III, IV, V pharm D
16-09-2020	RESEARCH METHODOLOGY: Importance of performing extensive literature review for best research outcomes
07-10-2020	INTELLECTUAL PROPERTY RIGHTS: Managing intellectual property in the book publishing
26-10-2020	Commencement of I mid examinations for II, III, IV, V Pharm D
02-11-2020	Commencement of classwork for II, III, IV B. pharmacy I SEM
19-11-2020	RESEARCH METHODOLOGY: Clinisol- Interactive session on article and publications
01-12-2020	INTELLECTUAL PROPERTY RIGHTS: Intellectual Property Rights And Strategies To Protect IPR's
05-12-2020	RESEARCH METHODOLOGY: A one day webinar on case cohort studies
07-12-2020 12-12-2020	VAC –Neuropharmacology and CNS medications
04-01-2021 09-01-2021	VAC-Advances in NMR Spectroscopy or Chemical Analysis and Molecular characterization
07-01-2021	ENTERPRENEURSHIP: Aone day seminar on entrepreneurship skills,attitude on behavioral development for becoming a successful entrepreneur
18-01-2021 23-01-2021	VAC- Enhancement of Pharmaceutical devices through medication management & patient counseling
18-01-2021	Commencement of II mid examinations for II, III, IV, V pharm D
25-01-2021	Commencement of I mid examinations for II, III, IV B. pharmacy I SEM
26-01-2021	Republic day celebrations in college
01-02-2021 06-02-2021	VAC- Novel Approaches to overcome Antibiotic Resistance
08-02-2021 13-02-2021	VAC- Forensic Toxicology: techniques for clinicians

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04-02-2021	World cancer day awareness following COVID rules
16-02-2021	RESEARCH METHODOLOGY: Quillbot software applications and their usage in thesis writing
22-02-2021	Commencement of classwork for I pharm D
22-02-2021	Commencement of II mid examinations for II, III, IV B. pharmacy I SEM Commencement of classwork for I B. pharmacy I SEM
01-03-2021	Commencement of practical examinations for II, III, IV B. pharmacy I SEM
01-03-2021 06-03-2021	VAC – Principle and practice of Pharmacovigilance
03-03-2021	RESEARCH METHODOLOGY: Ethical guidelines on research methodology
08-03-2021	Commencement of End examinations for II, III, IV B. pharmacy I SEM
15-03-2021 20-03-2021	VAC-Pricing transparency and Ethics in Pharmacy
22-03-2021	Commencement of class work for II, III, IV B. pharmacy II SEM
22-03-2021 27-03-2021	Exploration of carbohydrates from botanical sources to the therapeutic potentials
05-04-2021	Commencement of III mid examinations for II, III, IV, V Pharm D Commencement of I mid examinations for I B. pharmacy I SEM
05-04-2021 10-04-2021	VAC-Emerging technologies in Pharmaceutical manufacturing & quality assurance
12-04-2021	Commencement of practical examinations for II, III, IV, V Pharm D
19-04-2021 24-04-2021	VAC-Pharmaceutical Marketing and strategies
03-05-2021	Commencement of I mid examinations for Ipharm D
10-05-2021	Commencement of II Unit of instructions for Ipharm D
12-05-2021	Commencement of II Unit of instructions for I B. pharmacy I SEM

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24-05-2021	Commencement of II mid examinations for I B. pharmacy I SEM
31-05-2021	Commencement of practical examinations for I B. pharmacy I SEM
21-06-2021	Commencement of class work for I B. pharmacy II SEM
01-07-2021	Commencement of mid examinations for II, III, IV B. pharmacy II SEM
05-07-2021	Commencement of practical examinations for II, III, IV B. pharmacy II SEM
19-07-2021	Commencement of II mid examinations for I Pharm D
26-07-2021	Commencement of III Unit of instructions forIpharm D
02-08-2021	Commencement of I mid examinations for I B. pharmacy II SEM
09-08-2021	Commencement of II Unit of instructions for I B. pharmacy II SEM
20-09-021	Commencement of II mid examinations for I B. pharmacy II SEM
27-09-2021	Commencement of practical examinations for I B. pharmacy II SEM
04-10-2021	Commencement of III mid examinations for I Pharm D
11-10-2021	Commencement of practical examinations for I Pharm D

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FACULTY WORKLOAD (June- Nov)

Academic Year 2020 – 2021

S. No.	Name of the Faculty	Subjects					Department/ Institute Level duties	Work Load (hrs)	Signature
		Theory -1 (5)	Theory-2 (5)	Lab-1	Lab-2	Project/ Seminar			
1.	Dr. M. B. V. Raju	I/II/M Pharm CQA	----	Practical-IV	----	Project GPAT	Professor & Principal	11	
2.	Dr. Hema Naga Durga	I/II M Pharm CADDS	----	Practical-IV	----	Project GPAT	Pharmaceutical Technology Professor	11	
3.	Dr. G. Prasanthi	I/II M Pharm CADDS	----	Practical-IV	----	Project	Pharmaceutics Professor	10	
4.	Dr. K. Murali Krishna	I//II M Pharm PTSM-II	----	----	----	Seminar/ Assignments Project	Pharmacology Professor	10	
5.	Dr. S. Arun Satya Dev	III Pharm D MC	----	III Pharm D MC	----	Project	Student Mentor	7	
6.	Dr. N. Neelima	II/I POC-II SEC-A		II/I POC-II SEC-A				11	
7.	Saraswathi Sowmya	III/I –MC-II SEC-A&B				Project	1.Coordinator, library. 2.Class Incharge – III-B-Pharm (Sec -B)	10	
8.	B. Ramavathi	I/II M Pharm PDD	II- Pharm D COLOGY	III- Pharm D COLOGY	----	Project	Student Mentor	11	
9.	Ch. Madhu	I/II M Pharm	----	Practical-IV	----	Project	Exam cell Incharge	10	

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		CMB							
10.	A. Nanaji	III/I COGNOSY-II (SEC- A)	----	III/I COGNOSY-II (SEC- A)	----	Project GPAT	1. Member, IQAC 2. Member, AC& AC 3. Coordinator, Examination, Time Table and Admissions.	11	
11.	V. Uma Sankar	IV-Pharm D HP	I Pharm D RB	IV-Pharm D HP	I Pharm D RB	Project GPAT	1. Vice-Principal &HOD of Pharmacy Practice. 2. Member, Women Empowerment cell 3. Member, NSS 4. Coordinator, IQAC 5. Coordinator, Purchase & Store.	10	V. Uma Sankar
12.	B. Chaitanya	I/II M. Pharm - AIA	----	Practical – III	----	Project GPAT	Student mentor	11	B. Chaitanya
13.	A. H. V. Santhoshi	I/II M Pharm MBT	----	Practical – IV	----	Project GPAT	Student mentor	11	A.H.V. Santhoshi
14.	Y. Vishnu Vandana	I/II M Pharm MP	----	Practical - III	----	Project	Women Empowerment cell Coordinator 2. Student Mentor	10	Y. Vandana
15.	M. Krishna Rekha	I/II M Pharm MP	----	PRACTICAL - III	----	Project	1.Timetables in-charge 2.Student mentor	10	M. Krishna
16.	M. Madhavi Kumari	I/II M Pharm AP-II	----	PRACTICAL - III	----	Project	Student mentor	10	Madhavi
17.	S Vijaya Lakshmi	I/II M Pharm BPPK	----	----	----	1. Project 2.Seminars 3.GPAT	Student mentor	11	Lakshmi
18.	Dr. B. Manoj Kumar	II Pharm D		II Pharm D	----	Project	1.Class Incharge	11	

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		THERAPY-1	V- Pharm D EPIDIMEOLOGY	THERAPY-1			V Pharm D 2. Member , NSS 3. Member , IQAC 4. NAAC Incharge-7 5. Coordinator, relation & media.		
19.	M. Suresh Kumar	III/I B. Pharm PJ	I/II M Pharm JOURNAL CLUB	----	----	Project	Member, NSS	7	Suresh
20.	S. Chandra Sekhar	I/II POC –I (SEC- B)	----	I/II POC –I (SEC- B)	----	Project	Tutorial	13	Chandrasekhar
21.	B. Poornima	I/II PH. BIOCHEM (SEC- B)	----	I/II BIOCHEM (SEC- B)	----	Project	Student mentor	12	B. Poornima
22.	L. Divyasri	I/II BIOCHEM (SEC- A)	----	I/II BIOCHEM (SEC- A)	---	Project	Student mentor	11	L. Divyasri
23.	B. Bhagya Sri	I/II M PHARMBPPK	----	----	----	1. Project 2.Seminars	Student mentor	10	B. Bhagya Sri
24.	P. Sandeep	IV-PHARM D BPPK	----	IV-PHARM D BPPK	----	Project		10	
25.	D. Purnima Yadav	I ;I/II POC – (SEC- A)	----	I/II POC –I (SEC- A)	----	Project	Member, IQAC Tutorial	12	Purnima
26.	S. Rama Krishna	IV/I IP – II (SEC – B)	----	----	----	Project	Student mentor	5	B. Rama Krishna

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27.	A. Naga Srinivas	III/I COGNOSY- II (SEC – B)	----	III/I COGNOSY- II (SEC – B)	----	Project	Student mentor	11	A. Srinivas
28.	Y. Anveshi Dhananjaya	I /II – HAP -II (SEC– B)	----	I /II HAP (SEC – B)	----	Project	Student mentor	11	Dhanajaya
29.	B. Meher Jyothi	I/II PP (SEC – A&B)	----	----	----	Project	Student mentor	10	Jyothi
30.	M. Divya	IV /I PP (SEC- B)	----	----	----	Project	Student mentors	6	Divya
31.	V.C.Randeep Raj	III Pharm D THERAPY	IV Pharm D CP	III Pharm D THERAPY	IV Pharm D CP	Project	1. Class Incharge –VI Pharm D. 2.Member , women empowerment cell 3.Member , NSS 4. Coordinator sports	14	
32.	N.Reshma	I /II HAP	----	I /II HAP	----	Project	Tutorial	12	
33.	B. Aruna	IV / I IMA (SEC – A)	----	IV / I IMA (SEC – A)	----	Project GPAT	1.Class teacher 2. Tutorial 3. Member, IQAC	14	B. Aruna
34.	B. Rama Madhuri	I /II CA (SEC – B)	----	I /II CA (SEC – B)	----	----	Student mentor	10	
35.	Vamsi Krishna Yadav	III/I COLOGY – II (SEC- A)	----	III/I COLOGY – II (SEC- A)	----	----	Tutorial	12	
36.	K. Venkata Radhika	I /II CA	----	I /II CA	----	----	Student mentors	10	Radhika

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		(SEC – A)		(SEC – A)					
37.	I.Adi Lakshmi	III/I IP – I (SEC– A)	----	III/I IP – I (SEC– A)	----	Project	Class teacher tutorial	12	
38.	M.Venkat Naga Deepika	IV / I NDDS (SEC- B)	----	----	----	Project	Student Ment	5	
39.	Y.Pavani	IV / I IMA (SEC – B)	----	IV / I IMA (SEC – B)	----	Project	Class Incharge – IV B. Pharm (SEC –B)	11	
40.	B. Yerni Kumar	III PHARM D PA	IV PHARM D BIOSTAT	III PHARM D PA	----	Project	1.Class Incharge- III Pharm D	11	
41.	Bhargav Krishna Raju	III/I COLOGY – II (SECT– B)	----	III/I COLOGY – II (SEC – B)	----	Project	Student Mentors	12	
42.	M.Vasu	III/I IP – I (SEC – B)	----	III/I IP – I (SEC – B)	----	Project	Student Mentors	11	
43.	V.H.S.Reddy	IV /I PP (SEC- A)	----	----	----	Project	Student Mentors	5	
44.	M.Rajaswara Rao	IV / I NDDS (SEC- A)	----	----	----	Project	Class Incharge – II B.Pharm (Sec – B)	5	
45.	M.S.V Sudeep	IV/I IP – II (SEC – A)	----	----	----	Project	1.Class Incharge – II B. Pharm (Sec – A) 1. Student Mentor	5	
46.	D. Subha Sri	I PHARM D CEUTICS	V PHARM D CR	I PHARM .D CEUTICS	----	Project	Student Mentor	11	
47.	M.Geetanjali	I Pharm D	II Pharm D	I Pharm D	II Pharm D	Project	Class Incharge – I	14	

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		PIC	MB	PIC	MB		Pharm D.		
48.	S.Murali Mohan	II Pharm D COLOGY	III Pharm D PF IV Pharm D CT	III Pharm D PF	----	Project	Class Incharge – IV Pharm D	15	
49.	T.Rushi	IV Pharm D THERAPY	V Pharm D PKTDM	IV Pharm D THERAPY	----	Project	1.NSS Coordinator 2. Member, WEC 3. Senior AO	10	
50.	B. Harini Priya	I Pharm D POC	II Pharm D COGNOSY	I Pharm D POC	II Pharm D COGNOSY	Project	Class Incharge – II Year.	14	
51.	G. Sravani Girija	I/II B. Pharm EVS (SEC-A&B)	----	----	----	Project	Student Mentor	6	
52.	S. Dhana Lakshmi	I Pharm D HAP	II Pharm D – PP	I Pharm D HAP	----	Project	Student Mentor	11	
53.	Ch. Geetha	I Pharm D BIOCHEM	II Pharm D CP III PHARM D PJ	I Pharm D BIOCHEM	----	Project	1. Member, NSS. 2.Member, WEC	14	
54	A. Seshu	I Pharm D RM	-----	-----	----	----	-----	3	
55	K Subha Lakshmi	I/II B. Pharm CA	-----	-----	----	----	-----	16	

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FACULTY WORKLOAD (Dec- May)
Academic Year 2020 – 21

S. No.	Name of the Faculty	Subjects					Department/ Institute Level duties	Work Load	Signature
		Theory -1 (5)	Theory-2 (5)	Lab -1	Lab -2	Project/ Seminar			
1.	M.B.V. Raju	I/I M.PHARM MPAT	----	Practical-I	----	Project GPAT	1. Professor& Principal	11	
2.	Dr. K Hema Naga Durga	I/I M.PHARM MPAT	----	Practical-I	----	GPAT	1. Professor	11	
3.	Dr. G. Prasanthi	I/I M.PHARM MPAT	----	Practical-I	----	----	1. Professor	10	G. Prasanthi
4.	Dr. K. Murali Krishna	I/I M.PHARM MPAT	----	Practical-I	----	----	1. Professor	10	K. Murali Krishna
5.	Dr. S. Arun Satya Dev	III PHARM.D MC	----	III PHARM. D MC	----	----	1. Student Mentor	7	
6.	Dr. N. Neelima	II/II MC-I SEC-A		II/II MC-I SEC-A				11	N. Neelima
7.	Saraswathi Sowmya	III/II MC-III Sec-A	----	III/II MC-III Sec-A	----	Project	1. Class Teacher 1. 2. Tutorial	11	M.S. Sowmya
8.	B. Ramavathi	III PHARM.D COLOGY	I/I M.PHARM PTSM-1	III PHARM.D COLOGY	----	----	1. Student Mentor	10	Ramavathi
9.	Ch. Madhu	I/I M.PHARM SEM-1 CMB	II/I M.PHARM SEM-1 RM&BS	I/I M.PHARM Practical-I	----	Project	Exam Cell 1. Incharge	14	
10.	A. Nanaji	II/II	----	II/II		Project	1. Exam Cell	23	

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		COGNOSY (SEC – A&B)		COGNOSY (SEC – A&B)		GPAT	Member		
11.	V. Uma Shankar	IV PHARM.D HP	----	IV PHARM. D HP	----	Project GPAT	1. Vice-Principal & HOD of Pharmacy Practice. 2. Member , Women Empowerment Cell 3. Member , NSS 4. Co-ordinator, IQAC. 1. 5. Co-ordinator, Purchase & Store	8	V. Uma Sankar
12.	B. Chaitanya	I/I M. PHARM APA	----	Practical-II	----	Project GPAT	1. Student Mentor	10	B. Chaitanya
13.	A.H.V.Santhoshi	I/I M. PHARM PV	----	----	----	Seminars Project GPAT	Student Mentor	10	A.H.V. Santhoshi
14.	Y. Vishnu vandhana	I/I M. PHARM DDS	----	Practical-II	----	Project GPAT	1. Women Empowerment Cell Co-ordinator 1. 2. Student Mentor	10	Y. Vandana
15.	M. Krishna Rekha	I/I M. PHARM DDS		PRACTICAL- II		Project	1. Student Mentor	10	M.K. Rekha
16.	M. Madhavi Kumari	I/I M.PHARM SEM-1 AP-I	----	Practical-II		Project	1. Student Mentor	10	Madhavi
17.	S Vijaya Lakshmi	I/I M.PHARM RA	----	Practical-II	----	Seminars Project GPAT	1. Student Mentor	16	Lakshmi
18.	Dr.B.Manoj Kumar	II PHARM.D THERAPY-I	V PHARM.D EPIDIMEOL	II PHARM.D	----	Project	Class Incharge-V Pharm.D	11	

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			OGY	THERAPY -I			2. Member , NSS 3. Member , IQAC 4. NAAC Incharge-7 1. 5. Co-ordinator, Relation & Media.		
19.	M.Suresh Kumar	III/II HDT (SEC- A)	I/I M. PHARM MP	III/II HDT (SEC- A)	----	Project	1. Student Mentor	15	Suresh
20.	S. Chandra Sekhar	I/I CEUTICS –I (SEC- B)	I/I M.PHARM DDS	I/I CEUTICS –I (SEC- B)	----	Assignments	1. Student Mentor	16	Chandra Sekhar
21.	B. Poornima	II/I MB (SEC- B)	----	II/I MB (SEC- B)	----	Assignment/ Project	1. Student Mentor	12	B.Poornima
22.	L. Divya Sree	III/II HDT (SEC- B)	----	III/II HDT (SEC- B)	----	Project	1. Tutorial	12	L. Divyasri
23.	B. Bhagya Sri	I/I M. PHARM RA	----	----	----	Seminars	1. Student Mentor	10	B. Bhagya Sri
24.	P. Sandeep	IV PHARM. D BPPK	----	IV PHARM. D BPPK	----	Assignments	1. Student Mentor	7	
25.	D. Purnima Yadav	II/I PE (SEC- B)	----	II/I PE (SEC- B)	----	----	1. Student Mentor	11	Purnima
26.	S. Rama Krishna	II/I POC– II (SEC – A)	----	II/I POC– II (SEC – A)	----	Project	1. Student Mentor	11	S. Rama Krishna
27.	A. Naga Srinivas	II/I POC– II (SEC – B)	----	II/I POC– II (SEC – B)	----	Project	1. Student Mentor	11	A. Srinivas
28.	Y. Anveshi Dhananjaya	IV /II	----	----	----	Project	1. Class Teacher	10	

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		SPP SEC – A&B							
29.	B. Meher Jyothi	III/II COLOGY (SEC – A)	----	III/II COLOGY (SEC – A)	----	Project	1. Tutorial	11	
30.	M. Divya	IV /II CS (SEC A&B)	----	----	----	Assignments Project	1. Student Mentor	10	
31.	V.C.Randeep Raj	III PHARM D THERAPY	IV PHARM D CP	III PHARM D THERAPY	IV PHARM .D CP	Project	1. Class Incharge – VI Year 2. Member , Women Empowerment Cell 3. Member , NSS 4. Coordinator, 1. Sports & Games.	14	
32.	J. Vinay Ramji	III/II COLOGY (SEC – B)	----	III/II COLOGY (SEC – B)	----	Project	1. Tutorial	11	
33.	B. Aruna	III / II QA (SEC – A&B)	----	----	----	Project GPAT	1. Class Teacher	11	
34.	B. Rama Madhuri	I /I PA-I (SEC-B)	IV/II BRM (SEC-B)	I /I PA-I (SEC-B)	----	Project	1. Student Mentor Student Mentor	16	
35.	Vamsi Krishna Yadav	I/I HAP-I (SEC- A)	----	I/I HAP-I (SEC- A)	----	Project	1. Student Mentor	11	
36.	K. Venkata Radhika	I /I PIC (SEC – B)	----	I /I PIC (SEC – B)	----	Project	1. Student Mentor	11	
37.	I.Adi Lakshmi	I/I CEUTICS –I	----	I/I CEUTICS	----	Project	1. Class Teacher 1. Tutorial	11	

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		(SEC- A)		–I (SEC- A)					
38.	M.Venkat Naga Deepika	II/I PE (SEC- A)	----	II/I PE (SEC- A)	----	Project	1. Tutorial	12	Deepika
39.	Y.Pavani	I /I PA-I (SEC-A)	III/II BIOTECH (SEC-A)	I /I PA-I (SEC-A)	----	----	1. Student Mentor	15	Y. Pavani
40.	B. Yerni Kumar	I/I HAP-I (SEC- B)	IV/II BRM (SEC-B)	I/I HAP-I (SEC- B)	----	Project	1. Student Mentor	16	Yerni Kumar
41.	Bhargav Krishna Raju	III/II BPPK (SEC – A&B)	----	----	----	Project	1. Student Mentor	10	B.K. Raju
42.	M.Vasu	III/II MC III Sec- B	----	III/II MC III Sec- B	----	Project	1.Class Teacher 1. 2.Tutorial	11	M. Vasu
43.	V.H.S.Reddy	II / I PP-I (SEC –B)	III/II BIOTECH (SEC –B)	II / I PP-I (SEC –B)	----	----	1. Class Teacher 2. Tutorial 3. Student Teacher Interaction	17	S. Reddy
44.	M.Rajaswara Rao	II / I PP-I (SEC –A)	----	II / I PP-I (SEC –A)	----	Project	1. Class Teacher 2. Tutorial 1. 3.Student-Teacher Interaction	13	Rajaswara Rao
45.	M.S.V Sudeep	I PHARM D CEUTICS	V PHARM D CR	I PHARM D CEUTICS	----	Project	Student Mentor	11	Sudeep
46.	D. Subha Sri	I PHARM D PIC	II PHARM D MB	I PHARM D PIC	II PHARM D MB	Project	1. Class Incharge – I Pharm D	14	Subhasree

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47.	M. Geetanjali	I /I PIC (SEC – A)	----	I /I PIC (SEC – A))	----	----	1. Student Mentor	11	
48.	S Murali Mohan	II PHARM D COLOGY	III PHARM D PF	III PHARM D PF	IV PHARM D CT	Project	Class Incharge – IV Pharm.D	15	
49.	T. Rushi	IV PHARM D THERAPY	V PHARM D PKTDM	IV PHARM D THERAPY	----	Project	1.NSS Coordinator 2.Member , WEC 1. Senior Administrative Officer	11	
50.	B. Harini Priya	I PHARM D POC	II PHARM D COGNOSY	I PHARM D POC	II PHARM D COGNOSY	Project	Class Incharge – II Pharm.D.	14	
51.	N. Reshma	II/I MB (SEC - A)	----	II/I MB (SEC - A)	----	Project	Tutorial	12	
52.	G. Sravani Girija	I PHARM D HAP	II PHARM D PP	I PHARM D HAP	----	Project	1. Member, NSS. 2. Member , WEC	11	
53.	S. Dhana Lakshmi	I PHARM D BIOCHEM	II PHARM D CP III PHARM D PJ	I PHARM D BIOCHEM	----	Project	Student Mentor	15	
53.	Ch. Geetha	III PHARM D PA	IV PHARM D – BRM	III PHARM D PA	----	Project	1. 1. Class Incharge- III Pharm.D.	11	
54	A. Seshu	I PHARM.D	I/I	----	----	----		7	

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		RM	RM (SEC-A&B)						
55	Subba lakshmi	I/I CS (SEC-A&B)	----	----	----	----	3. ----	8	Subba Lakshmi

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DEPARTMENT OF PHARMACY
CLASS TIME TABLE AY: 2020-2021

CLASS:I B.Pharm I Sem (PCI Regulation) **w.e.f:15/02/2021**
SECTION– A (2020 Admitted Batch)

Class Teacher: Mrs.M. Geethanjali **Batch A:Roll01-25** **Batch B: Roll 26-55**

DAY/TIME	9.30 - 10.30	10.30 - 11.20	11.20 - 12.10	12.10 - 01.00	1.00 - 1.50	1.50 - 2.40	2.40 - 3.20	3.20 - 4.30
MON	HAP	CEUTICS	PA - I	LUNCH	CS	BATCH A -HAP LAB BATCH B – PA I LAB		
TUE	PA - I	HAP	CEUTICS		PIC	BATCH A - PA I LAB BATCH B -HAP LAB		
WED	RM / RB	PA - I	HAP		PIC	BATCH A - PIC LAB BATCH B- CEUTICS LAB		
THU	CEUTICS	HAP	PIC		RM/ RB	BATCH A - CEUTICS LAB BATCH B- PIC LAB		
FRI	CEUTICS	PIC	PA - I		HAP	BATCH A - RM /RB BATCH B- CS		
SAT	CS	PA - I	CEUTICS		PIC	BATCH A- CS BATCH B- RM /RB		

S. No	NAME OF THE FACULTY	DESIGNATION	NAME OF THE SUBJECT(Hrs)	DEPARTMENT
1.	Mr. Vamsi Krishna Yadav	Associate Professor	Human Anatomy and Physiology - 1(HAP-I) (5)	B. Pharm
2.	Mrs.Y. Pavani	Assistant Professor	Pharmaceutical Analysis -I(PA-I) (5)	B. Pharm
3.	Mrs. M. Geethanjali	Associate Professor	Inorganic Chemistry (PIC)(5)	B. Pharm
4.	Mrs.I. Adi Lakshmi	Associate Professor	Pharmaceutics (5)	B. Pharm
5.	Mr. A. Nanaji	Associate Professor	Remedial Biology –(RB) (2)	B. Pharm
6.	Mr. A Seshu	Assistant Professor	Remedial Maths-(RM) (2)	B. Pharm
7.	Mrs.K. Subha Lakshmi	Assistant Professor	Communication Skills-(CS) (2)	B. Pharm
8.	Mr. Vamsi Krishna Yadav	Associate Professor	Human Anatomy and Physiology (HAP-I) Lab (6)	B. Pharm
9.	Mrs.Y. Pavani	Assistant Professor	Pharmaceutical Analysis -1(PA-I) Lab (6)	B. Pharm
10.	Mrs.M. Geethanjali	Associate Professor	Inorganic Chemistry Lab –(PIC) (6)	B. Pharm
11.	Mrs.I. Adi Lakshmi	Associate Professor	Pharmaceutics Lab- (6)	B. Pharm
12.	Mr. A. Nanaji	Associate Professor	Remedial Biology Lab-(RB) (3)	B. Pharm
13.	Mrs.K. Subha Lakshmi	Assistant Professor	Communication Skills Lab-(CS) (2)	B. Pharm

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DEPARTMENT OF PHARMACY
CLASS TIME TABLE AY: 2020-2021

CLASS:I B.Pharm I Sem (PCI Regulation) **w.e.f:15/02/2021**
SECTION– B (2020 Admitted Batch)

Class Teacher: Mr.B.Yerni KumarBatch C: Roll 56-80 Batch D: Roll 81-B0

DAY/ TIME	9.30 - 10.30	10.30 - 11.20	11.20 - 12.10	2.10- 01.00	1.00 – 1.50	1.50- 2.40	2.40- 3.20	3.20 - 4.30
MON	CEUTICS	HAP	PIC	LUNCH	PA-1	Batch C: RB Lab Batch D:CS Lab		
TUE	PA-1	RM/RB	CEUTICS		HAP	Batch C: Tutorial Batch D: CS Lab		
WED	PIC	PA-1	CS		HAP	Batch C: HAP Lab Batch D: PA1 Lab		
THU	CS	CEUTICS	PA-1		PIC	Batch C: PA1 Lab Batch D: HAP Lab		
FRI	CEUTICS	PIC	HAP		CEUTICS	Batch C: PIC Lab Batch D: CEUTICS Lab		
SAT	HAP	RM/RB	PA-1		PIC	Batch C: CEUTICS Lab Batch D: PIC Lab		

S.No	NAME OF THE FACULTY	DESIGNATION	NAME OF THE SUBJECT	DEPARTMENT
1.	Mr. B. Yerni Kumar	Assistant Professor	Human Anatomy and Physiology -1(HAP-I) - (5)	B. Pharm
2.	Mrs. B. Rama Madhuri	Associate Professor	Pharmaceutical Analysis -1(PA-I) -(5)	B. Pharm
3.	Mrs. K. Venkata Radhika	Associate Professor	Inorganic Chemistry (PIC)- (5)	B. Pharm
4.	Mr. S. Chandrasekhar	Associate Professor	Pharmaceutics (5)	B. Pharm
5.	Mr. A. Nanaji	Associate Professor	Remedial Biology (RB) - (3)	B. Pharm
6.	Mr. A Seshu	Assistant Professor	Remedial Maths (RM) -(2)	B. Pharm
7.	Mrs. K. Subha Lakshmi	Assistant Professor	Communication Skills (CS) - (2)	B. Pharm
8.	Mr. B. Yerni Kumar	Assistant Professor	Human Anatomy and Physiology -1 Lab(HAP)- (6)	B. Pharm
9.	Ms. B. Rama Madhuri	Associate Professor	Pharmaceutical Analysis -1 Lab (PA)-(6)	B. Pharm
10.	Mrs. K. Venkata Radhika	Associate Professor	Inorganic Chemistry Lab (PIC) - (6)	B. Pharm
11.	Mr. S. Chandrasekhar	Associate Professor	Pharmaceutics Lab -(6)	B. Pharm
12.	Mr. A. Nanaji	Associate Professor	Remedial Biology Lab (RB)-(3)	B. Pharm
13.	Mrs. K. Subha Lakshmi	Assistant Professor	Communication Skills Lab (CS)-(2)	B. Pharm

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DEPARTMENT OF PHARMACY
CLASS TIME TABLE AY: 2020-2021

CLASS:II B.Pharm I Sem (PCI Regulation) **w.e.f:02/11/2020**

CLASS TEACHER - Mr.M.Rajeswara Rao				Batch A:Roll 01-25		Batch B: Roll 26-55		
DAY/ TIME	**9:30-10:30**	**10:30–11:20**	**11:20–12:10**	**12:10 1:00**	**1:00 – 01:50**	**1:50 – 2:40**	**2:40 – 3:30**	**3:30 – 4:20**
MON	PE	POC-II	PP-I	**LUNCH**	MB	BATCH A - POC-II LAB BATCH B - PP-I LAB		
TUE	PP-I	PE	MB		POC-II	BATCH A - PP-I LAB BATCH B - POC-II LAB		
WED	MB	PP-I	PE		TUTORIAL (PP-I)	BATCH A –MB LAB BATCH B –PE LAB		
THU	POC-II	MB	PP-I		PE	BATCH A – MB LAB BATCH B – PE LAB		
FRI	MB	PE	POC-II		TUTORIAL (PE)	PP-I	TUTORIAL (POC-II)	LIBRARY/ SPORTS
SAT	PP-I	POC-II	MB		PE	STI	TUTORIAL (MB)	LIBRARY/ SPORTS

SECTION– A (2019 Admitted Batch)

S. No	NAME OF THE FACULTY	DESIGNATION	NAME OF THE SUBJECT(Hrs)	DEPARTMENT
1.	Dr. N. Neelima	Associate Professor	Pharmaceutical Organic Chemistry- II (POC-II) (5)	B. Pharm
2.	Mr.M. Rajeswararao	Assistant Professor	Physical Pharmaceutics – I (PP-I) (5)	B. Pharm
3.	Mr. S. Rama Krishna	Assistant Professor	Pharmaceutical Microbiology (MB)(5)	B. Pharm
4.	Mrs.M. Venkata Naga Deepika	Associate Professor	Pharmaceutical Engineering (PE)(5)	B. Pharm
5.	Dr. N. Neelima	Associate Professor	Pharmaceutical Organic Chemistry- II (POC-II) lab (6)	B. Pharm
6.	Mr M. Rajeswararao	Assistant Professor	Physical Pharmaceutics – I (PP-I) Lab (6)	B. Pharm
7.	Mr. S. Rama Krishna	Assistant Professor	Pharmaceutical Microbiology (MB) Lab (6)	B. Pharm
8.	Mrs. M. V.Naga Deepika	Associate Professor	Pharmaceutical Engineering (PE) Lab (6)	B. Pharm
9.	Dr. N. Neelima	Associate Professor	Pharmaceutical Organic Chemistry- II (POC-II) Tutorial (1)	B. Pharm
10.	Mr.M. Rajeswararao	Assistant Professor	Physical Pharmaceutics – I (PP-I) Tutorial (1)	B. Pharm
11.	Mr. S. Rama Krishna	Assistant Professor	Pharmaceutical Microbiology (MB) Tutorial (1)	B. Pharm
12.	Mrs. M. Venkata Naga Deepika	Associate Professor	Pharmaceutical Engineering (PE) Tutorial (1)	B. Pharm
13	Mr. M. Rajeswara Rao	Associate Professor	Student Teacher Interaction (STI) (1)	B. Pharm
14	Mr. R. Ramana	Librarian	Library (1)	B. Pharm
15	Mr. D. Koteswara Rao	Physical Director	Sports (1)	B. Pharm

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DEPARTMENT OF PHARMACY
CLASS TIME TABLE AY: 2020-2021

CLASS: II B.Pharm I Sem (PCI Regulation)
SECTION– B (2019 Admitted Batch) **w.e.f: 02/11/2020**

CLASS TEACHER :Mr.V.H.S REDDY	Batch C:Roll 56-80				Batch D: Roll 81-A7			
DAY/ TIME	**9:30 - 10:30**	**10:30 – 11:20**	**11:20– 12:10**	**12:10 -1:00**	**1:00 – 01:50**	**1:5– 2:40**	**2:40– 3:30**	**3:30 – 4:20**
MON	PP-I	MB	PE	**LUNCH**	POC-II	BATCH C – MB LAB BATCH D – PE LAB		
TUE	MB	POC-II	PP-I		PE	BATCH C – PE LAB BATCH D – MB LAB		
WED	PE	POC-II	PP-I		TUTORIAL (MB)	BATCH C - POC-II LAB BATCH D - PP-II LAB		
THU	PP-I	PE	POC-II		MB	BATCH C - PP-II LAB BATCH D - POC-II LAB		
FRI	POC-II	PP-I	MB		TUTORIAL (POC-II)	STI	TUTORIAL (PE)	LIBRARY/ SPORTS
SAT	MB	PE	PP-I		POC-II	MB	TUTORIAL (PP-I)	LIBRARY/ SPORTS

S.No	NAME OF THE FACULTY	DESIGNATION	NAME OF THE SUBJECT (Hrs)	DEPARTMENT
1.	Mr. A. Srinivas	Associate Professor	Pharmaceutical Organic Chemistry-II (POC-II) (6)	B. Pharm
2.	Mr. V.H.S.Reddy	Associate Professor	Physical Pharmaceutics – I (PP-I) (5)	B. Pharm
3.	Mr. S. Chandrasekhar	Associate Professor	Pharmaceutical Microbiology (MB) (6)	B. Pharm
4.	Ms.D.Purnima	Associate Professor	Pharmaceutical Engineering (PE) (5)	B. Pharm
5.	Mr. A. Srinivas	Associate Professor	Pharmaceutical Organic Chemistry-II (POC-II) Lab (6)	B. Pharm
6.	Mr.V.H.S.Reddy	Associate Professor	Physical Pharmaceutics – I (PP-I) Lab (6)	B. Pharm
7.	Mr. S. Chandrasekhar	Associate Professor	Pharmaceutical Microbiology (MB) Lab (5)	B. Pharm
8.	Ms.D.Purnima	Associate Professor	Pharmaceutical Engineering (PE) Lab (5)	B. Pharm
9.	Mr. A. Srinivas	Associate Professor	Pharmaceutical Organic Chemistry-II (POC-II) Tutorial (1)	B. Pharm
10.	Mr.V.H.S.Reddy	Associate Professor	Physical Pharmaceutics – I (PP-I) Tutorial (1)	B. Pharm
11.	Mr. S. Chandrasekhar	Associate Professor	Pharmaceutical Microbiology Tutorial (MB) (1)	B. Pharm
12.	Ms. D.Purnima	Associate Professor	Pharmaceutical Engineering (PE) Tutorial (1)	B. Pharm
13	Mr. V.H.S.Reddy	Associate Professor	Student Teacher Interaction (STI) (1)	B. Pharm
14	Mr. R.Ramana	Librarian.	Library (1)	B. Pharm
15	Mr. D.Koteswara Rao	Physical Director	Sports (1)	B. Pharm

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Cherukupally (Village), Chittivalasa (SO), Bhogapuram (Mandal),Vizianagaram (Dist)-531162.
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DEPARTMENT OF PHARMACY

CLASS TIME TABLE AY: 2020-2021

CLASS: III B.Pharm I Sem (PCI Regulation)
(2018 Admitted Batch) **w.e.f: 02/11/2020**

CLASS TEACHER – Dr.M.Sowmya			Batch A: Roll 01-25		Batch B:Roll 25 - 50			
DAY/ TIME	**9:30 - 10:30**	**10:30 – 11:20**	**11:20 – 12:10**	**12:10 -1:00**	**1:00 – 01:50**	**1:50 2:40.**	**2:40 –3:30**	**3:30 – 4:20**
MON	MC-II	COLOGY-II	IP-I	**LUNCH**	COGNOSY - II	BATCH A - IP-I LAB BATCHB - COLOGY-II LAB BATCH C - COGNOSY - II LAB		
TUE	PJ	MC-II	COLOGY-II		TUTORIAL (IP-I)	BATCH A - COGNOSY - II LAB BATCH B - IP-I LAB BATCH C - COLOGY-II LAB		
WED	IP-I	COGNOSY - II	MC-II		COLOGY-II	BATCH A - COLOGY-II LAB BATCH B - COGNOSY - II LAB BATCH C - IP-I LAB		
THU	PJ	COLOGY-II	COGNOSY - II		IP-I	STI	TUTORIAL (COG)	IP-I
FRI	COLOGY-II	COGNOSY - II	PJ		MC-II	PJ	TUTORIAL (MC-II)	LIBRARY/ SPORTS
SAT	COGNOSY - II	MC-II	PJ		IP-I	STI	TUTORIAL (COL)	LIBRARY /SPORTS

S. No	NAME OF THE FACULTY	DESIGNATION	NAME OF THE SUBJECT(Hrs)	DEPARTMENT
1.	Dr. M.Sowmya	Associate Professor	Medicinal Chemistry – II (MC-II) (5)	B. Pharm
2.	Mrs. Y. Anveshi Dhananjaya	Assistant Professor	Pharmacology (COLOGY-II) (5)	B. Pharm
3.	Mr.K.B.K.Raju	Assistant Professor	Industrial Pharmacy – I (IP-I) (5)	B. Pharm
4.	Mr. A. Nanaji	Associate Professor	Pharmacognosy – II (5)	B. Pharm
5.	Mrs. M. Geethanjali	Associate Professor	Pharmaceutical Jurisprudence (5)	B. Pharm
6.	Mrs. Y. Anveshi Dhananjaya	Assistant Professor	Pharmacology Lab (6)	B. Pharm
7.	Mr.K.B.K.Raju	Assistant Professor	Industrial Pharmacy – I Lab (6)	B. Pharm
8.	Mr. A. Nanaji	Associate Professor	Pharmacognosy – II (COGNOSY-II) Lab (6)	B. Pharm
9.	Mr. A. Nanaji	Associate Professor	Pharmacognosy - II Tutorial-(1)	B. Pharm
10.	Mrs. Y. Anveshi Dhananjaya	Assistant Professor	Pharmacology (COLOGY-II) Tutorial (1)	B. Pharm
11.	Mr.K.B.K.Raju	Assistant Professor	Industrial Pharmacy – I (IP-I) Tutorial (1)	B. Pharm
12	Dr. M.Sowmya	Associate Professor	Student Teacher Interaction (STI) (1)	B. Pharm
13	Mr. R.Ramana	Librarian	Library (2)	B. Pharm
14	Mr. D.Koteswara Rao	Physical Director	Sports (2)	B. Pharm

Time Table Incharge

Principal
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ESTD : 2005

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DEPARTMENT OF PHARMACY
CLASS TIME TABLE AY:2020-2021

CLASS: IV B.PHARM I SEM (PCI REGULATION)
(2017 Admitted Batch)

w.e.f: 02/11/2020

Class Teacher: Mrs.B.Aruna Batch A: Roll 01-25 Batch B:Roll 26-50

DAY/ TIME	9:30-10:30	10:30–11:20	11:20–12:10	12:10 1:00	1:00 – 01:50	1:50 – 2:40	2:40 – 3:30	3:30–4:20
MON	IMA	IP-II	GPAT	LUNCH	NDDS	Batch-A- IMA LAB Batch-B– PROJECT Batch- C- LIB/SPORTS		
TUE	NDDS	IMA	IP-II		GPAT	Batch-A- LIB/SPORTS Batch-B–IMA LAB Batch-C- PROJECT		
WED	IP-II	PP	IMA		GPAT	Batch-A- PROJECT Batch-B– LIB/SPORTS Batch-C- IMA LAB		
THU	NDDS	IP-II	PP		TUTORIAL (IMA)	GPAT	PROJECT	
FRI	PP	IMA	NDDS		PP	GPAT	PROJECT	
SAT	IP-II	NDDS	PP		IMA	GPAT	PROJECT	

S. No	NAME OF THE FACULTY	DESIGNATION	NAME OF THE SUBJECT (Hrs)	DEPARTMENT
1.	Mrs. B.Aruna	Assistant Professor	Instrumental Methods of Analysis (IMA) (5)	B. Pharm
2.	Mr. M.Suresh Kumar	Assistant Professor	Industrial Pharmacy – II (IP-II) (5)	B. Pharm
3.	Mr. M.Vasu	Associate Professor	Pharmacy Practice (PP) (5)	B. Pharm
4.	Mrs. I. Adi Lakshmi	Associate Professor	Novel Drug Delivery Systems(NDDS) (5)	B. Pharm
5.		Associate Professor	GPAT (6)	B. Pharm
6.	Mrs. B.Aruna	Assistant Professor	Instrumental Methods of Analysis (IMA) Lab (6)	B. Pharm
7	Mrs. B.Aruna	Assistant Professor	Instrumental Methods of Analysis (IMA)Tutorial (1)	B. Pharm
8	Mrs. B.Aruna	Assistant Professor	Student Teacher Interaction(STI)(1)	B. Pharm
9	Mr. R.Ramana	Librarian	Library (1)	B. Pharm
10	Mr. D.Koteswara Rao	Physical Director	Sports (1)	B. Pharm

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DEPARTMENT OF PHARMACY
CLASS TIME TABLE AY: 2020-2021

CLASS:I B.Pharm IISem (PCI Regulation) **w.e.f: 24/05/2021**
SECTION– A (2020 Admitted Batch)

CLASS TEACHER: Mrs. L. Divya Sri		Batch A:Roll01-25		Batch B: Roll 26-55				
DAY/ TIME	**9:30 – 10:30**	**10:30 - 11:20**	**11:20 – 12:20**	**12:00 1:00**	**1:00 - 1:50**	**1:50 2:40**	**2:40 3:30**	**3:30 – 4:20**
MON	POC-I	PATHO	BIOCHEM	**L U N C H**	HAP-II	Batch A: POC-I Lab Batch B: BIOCHEM Lab		
TUE	BIOCHEM	HAP-II	POC-I		ES	Batch A: BIOCHEM Lab Batch B: POC-II Lab		
WED	HAP-II	CA	PATHO		POC-I	Batch A: HAP-II Lab Batch B :CA Lab		
THU	BIOCHEM	PATHO	CA		TUTORIAL (OC)	Batch A :CA Lab Batch B :HAP-II Lab		
FRI	PATHO	POC-I	CA		BIOCHEM	ES	HAP-II	TUTORIAL (HAP)
SAT	CA	BIOCHEM	HAP-II		PATHO	POC-I	ES	L/S

S. No	NAME OF THE FACULTY	DESIGNATION	NAME OF THE SUBJECT (Hrs)	DEPARTMENT
1.	Ms. D. Purnima Yadav	Associate Professor	Pharmaceutical Organic Chemistry-I (POC-I) (5)	B. Pharm
2.	Mrs. L. Divya Sri	Associate Professor	Pharmaceutical Biochemistry(BIOCHEM) (5)	B. Pharm
3.	N Reshma	Assistant Professor	Human Anatomy and Physiology- II (HAP-II) (5)	B. Pharm
4.	Mrs. B. MeherJyoti	Assistant Professor	Pathophysiology (PATHO) (5)	B. Pharm
5.	Ms. S Vijaya Lakshmi	Assistant Professor	Environmental Sciences (ES) (3)	B. Pharm
6.	Mrs. K. Venkata Radhika	Assistant Professor	Computer Applications (CA) (4)	B. Pharm
7.	Ms. D. Purnima Yadav	Associate Professor	Pharmaceutical Organic Chemistry-I (POC-I)Lab (6)	B. Pharm
8.	Mrs. L. Divya Sri	Associate Professor	Pharmaceutical Biochemistry Lab (BIOCHEM) (6)	B. Pharm
9.	Mr. Vinay Ramji	Assistant Professor	Human Anatomy and Physiology- II (HAP-II) Lab (6)	B. Pharm
10.	Mrs. K. Venkata Radhika	Assistant Professor	Computer Applications (CA) Lab (6)	B. Pharm
11.	Ms. D. Purnima Yadav	Associate Professor	Pharmaceutical Organic Chemistry-I (POC-I)Tutorial (1)	B. Pharm
12.	N Reshma	Assistant Professor	Human Anatomy and Physiology- II (HAP-II) Tutorial (1)	B. Pharm
13.	Mr. R. Ramana	Librarian	Library (1)	B. Pharm
14.	Mr. Koteshwar Rao	Physical Director	Sports (1)	B. Pharm

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CLASS TIME TABLE AY: 2020-2021

CLASS:I B.PharmIISem (PCI Regulation) **w.e.f: 24/05/2021**
SECTION– B (2020 Admitted Batch)

CLASS TEACHER: Mrs. B. MeherJyotiBatch C:Roll 56-80 Batch D : Roll- 81-B_0								
DAY/ TIME	**9:30- 10:30**	**10:30– 11:20**	**11:2– 12:10**	**12:10 1:00**	**1:00 – 01:50**	**1:50– 2:40**	**2:40– 3:30**	**3:30 – 4:20**
MON	POC-1	HAP-II	BIOCHEM	**LUNCH**	PATHO	BATCH C-HAP-II LAB BATCH D –CA LAB		
TUE	CA	PATHO	POC-1		HAP-II	BATCH C-CA LAB BATCH D-HAP-II LAB		
WED	PATHO	BIOCHEM	HAP-II		CA	BATCH C-POC1 LAB BATCH D-BIOCHEM LAB		
THU	POC1	BIOCHEM	ES		CA	BATCH C- BIOCHEM LAB BATCH D-POC1 LAB		
FRI	BIOCHEM	POC-1	PATHO		TUTORIAL (HAP)	POC1	ES	(L/S)
SAT	HAP-II	PATHO	BIOCHEM		ES	CA	HAP-II	TUTORIAL (OC)

S. No	NAME OF THE FACULTY	DESIGNATION	NAME OF THE SUBJECT (Hrs)	DEPARTMENT
1.	Mr. S. Chandra Sekhar	Associate Professor	Pharmaceutical Organic Chemistry-I (POC-I) (5)	B. Pharm
2.	Mrs.B. Poornima	Associate Professor	Pharmaceutical Biochemistry(BIOCHEM) (5)	B. Pharm
3.	Mrs. Anveshi Dhananjaya	Assistant Professor	Human Anatomy and Physiology- II (HAP-II)(5)	B. Pharm
4.	Mrs.B. MeherJyoti	Assistant Professor	Pathophysiology (PATHO) (5)	B. Pharm
5.	Ms. S Vijaya Lakshmi	Assistant Professor	Environmental Sciences (ES) (3)	B. Pharm
6.	Mrs.B. Rama Madhuri	Assistant Professor	Computer Applications (CA) (4)	B. Pharm
7.	Mr. S. Chandra Sekhar	Associate Professor	Pharmaceutical Organic Chemistry-I (POC-I) Lab (6)	B. Pharm
8.	Mrs.B. Poornima	Associate Professor	Pharmaceutical Biochemistry (BIOCHEM) Lab (6)	B. Pharm
9.	Mrs.Anveshi Dhananjaya	Assistant Professor	Human Anatomy and Physiology- II (HAP-II) Lab (6)	B. Pharm
10.	Mrs.B. Rama Madhuri	Assistant Professor	Computer Applications (CA) Lab (6)	B. Pharm
11.	Ms. D. Purnima Yadav	Associate Professor	Pharmaceutical Organic Chemistry-I (POC-I)(Tutorial (1)	B. Pharm
12.	Mr.Vinay Ramji	Assistant Professor	Human Anatomy and Physiology- II (HAP-II)Tutorial (1)	B. Pharm
13.	Mr. R. Ramana	Librarian	Library (1)	B. Pharm
14.	Mr. Koteshwar Rao	Physical Director	Sports(1)	B. Pharm

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DEPARTMENT OF PHARMACY
CLASS TIME TABLE AY: 2020-2021

CLASS: II B.PHARM II SEM (PCI REGULATION)
SECTION – A (2019 Admitted Batch) **w.e.f: 22/03/2021**

Class Teacher: Mr. M. RajeswararaoBatch A: Roll 01-25 Batch B:Roll 26-55

DAY/ TIME	9:30 - 10:30	10:30 – 11:20	11:20 – 12:10	12:10 -1:00	1:00 – 01:50	1:50 – 2:40	2:40 – 3:30	3:30– 4:20
MON	COLOGY-I	COGNOSY-I	MC-I	LUNCH	POC-III	BATCH A - COLOGY-I LAB BATCH B - COGNOSY-I LAB		
TUE	PP-II	COLOGY-I	COGNOSY-I		TUTORIAL (PP-II)	BATCH A - COGNOSY-I LAB BATCH B - COLOGY -I LAB		
WED	MC-I	PP-II	COLOGY-I		COGNOSY -I	BATCH A - MC-I LAB BATCH B - PP-II LAB		
THU	PP-II	MC-I	POC-III		COLOGY-I	BATCH A- - PP-II LAB BATCH B - MC-I LAB		
FRI	COGNOSY-I	POC-III	MC-I		TUTORIAL (COLOGY)	TUTORIAL (POC-III)	PP-II	POC-III
SAT	POC-III	MC-I	PP-II		TUTORIAL (MC-I)	COGNOSY-I	MC-I	LIBRARY/ SPORTS

S. No	NAME OF THE FACULTY	DESIGNATION	NAME OF THE SUBJECT (Hrs)	DEPARTMENT
1.	Mrs. I. Adi Lakshmi	Assistant Professor	Pharmaceutical Organic Chemistry-III(POC-III) (5)	B. Pharm
2.	Dr. N. Neelima	Associate Professor	Medicinal Chemistry-I (MC-I) (5)	B. Pharm
3.	Mr. M.Rajeswararao	Assistant Professor	Physical Pharmaceutics-II (PP-II)(5)	B. Pharm
4.	Mr. S. Rama Krishna	Assistant Professor	Pharmacology-I (COLOGY-I)(4)	B. Pharm
5.	Mr.A.Nanaji	Associate Professor	Pharmacognosy&Phytochemistry-I(COGNOSY-I) (5)	B. Pharm
6	Dr. N. Neelima	Associate Professor	Medicinal Chemistry-I Lab (MC-I) (6)	B. Pharm
7	Mr. M.Rajeswararao	Assistant Professor	Physical Pharmaceutics-II (PP-II) Lab (6)	B. Pharm
8	Mr. S. Rama Krishna	Assistant Professor	Pharmacology-I (COLOGY-I)Lab (6)	B. Pharm
9	Mr.A.Nanaji	Associate Professor	Pharmacognosy&Phytochemistry-I(COGNOSY-I) Lab (6)	B. Pharm
10	Mr. R.Ramana	Librarian	Library(1)	B. Pharm
11	Mr. D.Koteswara Rao	Physical Director	Sports (1)	B. Pharm

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DEPARTMENT OF PHARMACY
CLASS TIME TABLE AY: 2020-2021

CLASS: II B.PHARM II SEM (PCI REGULATION) **w.e.f: 22/03/2021**
SECTION – B (2019 Admitted Batch)

Class Teacher :Mr. V. H. S ReddyBatch C: Roll 56-80 Batch D : Roll 81-A7

DAY/ TIME	9:30-10:30	10:30–11:20	11:20–12:10	12:10 1:00	1:00 – 01:50	1:50 – 2:40	2:40 – 3:30	3:30-4:20
MON	MC-I	PP-II	COLOGY-I	LUNCH	COGNOSY-I	BATCH C - PP-II LAB BATCH D - MC-I LAB		
TUE	COGNOSY-I	MC-I	PP-II		POC-III	BATCH C - MC-I LAB BATCH D - PP-II LAB		
WED	COLOGY-I	COGNOSY-I	MC-I		TUTORIAL (POC-III)	BATCH C – COLOGY-ILAB BATCH D – COGNOSY-I LAB		
THU	POC-III	COLOGY-I	COGNOSY-I		TUTORIAL (PP-II)	BATCH C – COGNOSY-I LAB BATCH D – COLOGY-I LAB		
FRI	MC-I	PP-II	COLOGY-I		TUTORIAL (MC-I)	POC-III	MC-I	TUTORIAL (COLOGY-I)
SAT	PP-II	POC-III	COGNOSY-I		TUTORIAL (COGNOSY-I)	POC-III	PP-II	LIBRARY/SPORTS

S. No	NAME OF THE FACULTY	DESIGNATION	NAME OF THE SUBJECT (Hrs)	DEPARTMENT
1.	Mr. Vinay Ramji	Assistant Professor	Pharmaceutical Organic Chemistry-III (POC-III) (5)	B. Pharm
2.	Mrs. B. Poornima	Assistant Professor	Medicinal Chemistry-I (MC-I) (5)	B. Pharm
3.	Mr. V. H. S Reddy	Assistant Professor	Physical Pharmaceutics-II (PP-II) (5)	B. Pharm
4.	Mrs. M. Venkata Naga Deepika	Assistant Professor	Pharmacology-I (COLOGY-I) (4)	B. Pharm
5.	Mr. K.B.K. Raju	Assistant Professor	Pharmacognosy &Phytochemistry (COGNOSY-I) (5)	B. Pharm
6	Mrs. B. Poornima	Assistant Professor	Medicinal Chemistry-I (MC-I) Lab (6)	B. Pharm
7	Mr. V. H. S Reddy	Assistant Professor	Physical Pharmaceutics-II Lab (PP-II) (6)	B. Pharm
8	Mrs. M. Venkata Naga Deepika	Assistant Professor	Pharmacology-I (COLOGY-I) Lab (6)	B. Pharm
9	Mr. K.B.K. Raju	Assistant Professor	Pharmacognosy&Phytochemistry-I (COGNOSY-I) Lab (6)	B. Pharm
10	Mr. R. Ramana	Librarian	Library (1)	B. Pharm
11	Mr. D. Koteswara Rao	Physical Director	Sports (1)	B. Pharm

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DEPARTMENT OF PHARMACY
CLASS TIME TABLE AY: 2020-2021
CLASS: III B.PHARM II SEM (PCI REGULATION)

(2018 Admitted Batch) **w.e.f: 22/03/2021**

Class Teacher : Dr. M. Sowmya **Batch A: Roll 01-25** **Batch B: Roll 26- 50**

DAY/ TIME	9:30 - 10:30	10:30 11:20	11:20 – 12:10	12:10 -1:00	1:00 – 01:50	1:50 – 2:40	2:40 – 3:30	3:30 – 4:20
MON	QA	COLOGY-III	MC-III	LUNCH	BPPK	BATCH A- HDT LAB BATCH B- COLOGY-III LAB BATCH C- MC-III LAB		
TUE	HDT	QA	COLOGY-III		MC-III	BATCH A- COLOGY-III LAB BATCH B- MC-III LAB BATCH C- HDT LAB		
WED	HDT	BIOTECH	BPPK		COLOGY-III	BATCH A- MC-III LAB BATCH B- HDT LAB BATCH C- COLOGY-III LAB		
THU	MC-III	BPPK	HDT		QA	COLOGY-III	MC-III	LIBRARY/SPORTS
FRI	COLOGY-III	HDT	BPPK		BIOTECH	BPPK	TUTORIAL (HDT)	TUTORIAL (MC-III)
SAT	BIOTECH	MC-III	HDT		TUTORIAL (COL-III)	BIOTECH	QA	TUTORIAL (BPPK)

S. No	NAME OF THE FACULTY	DESIGNATION	NAME OF THE SUBJECT (Hrs)	DEPARTMENT
1.	Dr. M. Sowmya	Associate Professor	Medicinal Chemistry-III (5)	B. Pharm
2.	Mrs. Y. Anveshi Dhananjaya	Assistant Professor	Pharmacology-III (5)	B. Pharm
3.	Mrs. L. Divya Sri	Associate Professor	Herbal Drug Technology (5)	B. Pharm
4.	Mr. M. Suresh Kumar	Associate Professor	Biopharmaceutics & Pharmacokinetics (5)	B. Pharm
5.	Mr. S. Chandra Sekhar	Associate Professor	Pharmaceutical Biotechnology (4)	B. Pharm
6.	Mrs. K. Venkata Radhika	Assistant Professor	Quality Assurance (4)	B. Pharm
7.	Dr. M. Sowmya	Associate Professor	Medicinal Chemistry-III Lab (6)	B. Pharm
8.	Mrs. Y. Anveshi Dhananjaya	Assistant Professor	Pharmacology-III Lab (6)	B. Pharm
9	Mrs. L. Divya Sri	Associate Professor	Herbal Drug Technology Lab (6)	B. Pharm
10	Dr. M. Sowmya	Associate Professor	Medicinal Chemistry-III Tutorial(1)	B. Pharm
11	Mrs. Y. Anveshi Dhananjaya	Assistant Professor	Pharmacology-III Tutorial (1)	B. Pharm
12	Mrs. L. Divya Sri	Associate Professor	Herbal Drug Technology (HDT) Tutorial (1)	B. Pharm
13	Mr. M. Suresh Kumar	Associate Professor	Biopharmaceutics & Pharmacokinetics (BPPK) (1)	B. Pharm
14	Mr .R. Ramana	Librarian	Library (1)	B. Pharm
15	Mr. D. Koteswara Rao	Physical Director	Sports (1)	B. Pharm

Time-Table Incharge

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ESTD : 2005

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DEPARTMENT OF PHARMACY
CLASS TIME TABLE AY: 2021-22

CLASS: IV B.PHARM II SEM (PCI REGULATION)
(2017 Admitted Batch) **w.e.f: 22/03/2021**

Class Teacher: Mrs. B. ArunaBatch A: Roll 01-25 Batch B: Roll 26-50

DAY/ TIME	9:30-10:30	10:30–11:20	11:20–12:10	12:10 1:00	1:00 – 01:50	1:50 – 2:40	2:40 – 3:30	3:30 -4:20
MON	PV	SPP	AIT	LUNCH	GPAT	PROJECT		
TUE	BRM	PV	SPP		GPAT	PROJECT		
WED	SPP	BRM	PV		AIT	GPAT	PROJECT	
THU	AIT	BRM	PV		SPP	GPAT	PROJECT	
FRI	BRM	AIT	SPP		PROJECT/ LIBRARY	GPAT	PROJECT	
SAT	AIT	PV	BRM		PROJECT/ LIBRARY	GPAT	PROJECT	LIBRARY/ SPORTS

S. No	NAME OF THE FACULTY	DESIGNATION	NAME OF THE SUBJECT (Hrs)	DEPARTMENT
1.	Mr.M. Vasu	Assistant Professor	Biostatistics &Research Methodology (5)	B. Pharm
2.	Mrs. B. Meher Jyothi	Assistant Professor	Social & Preventive Pharmacy (5)	B. Pharm
3.	Mrs. N. Reshma	Assistant Professor	Pharmacovigilance (5)	B. Pharm
4.	Mrs. B. Aruna	Assistant Professor	Advanced Instrumentation Techniques (5)	B. Pharm
5.			GPAT (6)	B. Pharm
6.			PROJECT (7)	B. Pharm``
7.	Mr.R.Ramana	Librarian	Library (1)	B. Pharm
8.	Mr.D.Koteswara Rao	Physical Director	Sports (1)	B. Pharm

Time-Table Incharge

Principal

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Cherukupally (V), Bhogapuram Mandal
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DEPARTMENT OF PHARMACY
CLASS TIME TABLE AY:2020-21

CLASS:I M. Pharm I Sem Pharmaceutical Analysisw.e.f:22/02/2021

Day/ Time	9.00 - 10.00.	10.00 - 11.00	11.00 -12.00	12.00 -1.00	1.00 - 2.00	2.00 - 3.00	3.00 - 4.00
Mon	MPAT	FA	APA	LUNCH	PV	Library/Seminars	FA
Tue	APA	PV	MPAT		FA	MPAT	Library/Seminars
Wed	MPAT	PV	APA		FA	APA	PV
Thu	Seminar/Assignments						
Fri	Practical-I						
Sat	Practical-II						

S.NO	NAME OF THE FACULTY	DESIGNATION	NAME OF THE SUBJECT (Hrs)	DEPARTMENT
1.	Dr.M.B.V.Raju	Professor	Modern Pharmaceutical Analytical Techniques-(MPAT) (4)	M.Pharm
2.	MrsB.Chaitanya	Associate Professor	Advanced Pharmaceutial Analysis-(APA) (4)	M.Pharm
3.	Mrs.A.H.V.Santhoshi	Associate Professor	Pharmaceutical Validation-(PV) (4)	M.Pharm
4.	Mr.A.N.Srinivas	Associate Professor	Food Analysis-(FA) (4)	M.Pharm
5.	B.Poornima	Associate Professor	Assignments (1)	M.Pharm
6	Dr.M.B.V.Raju	Professor	Practical-I (6)	M.Pharm
7	MrsB.Chaitanya	Associate Professor	Practical-II (6)	M.Pharm
8	Mrs.A.H.V.Santhoshi	Associate Professor	Seminars (6)	M.Pharm
9.	Mr.R.Ramana	Librarian	Library (2)	M.Pharm

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DEPARTMENT OF PHARMACY
CLASS TIME TABLE AY:2020-21

CLASS:M. Pharm. I Sem Pharmaceuticsw.e.f: 22/02/2021

Day/ Time	9.00 - 10.00.	10.00- 11.00	11.00 -12.00	12.00- 1.00	1.00 - 2.00	2.00 - 3.00	3.00 -4.00.
Mon	MPAT	DDS	RA	LUNCH	MP	DDS	Library/Seminar
Tue	RA	MP	MPAT		DDS	MPAT	Library/Seminar
Wed	MPAT	MP	RA		MP	DDS	RA
Thu	Seminar/Assignments						
Fri	Practical-I						
Sat	Practical-II						

S.NO	NAME OF THE FACULTY	DESIGNATION	NAME OF THE SUBJECT (Hrs)	DEPARTMENT
1.	Dr. G.Prasanthi	Professor	ModernPharmaceutical Analytical Techniques (4)	M.Pharm
2.	Ms. Y.VishnuVandana	Associate Professor	Drug Delivery Systems (4)	M.Pharm
3.	Mr. M.Suresh Kumar	Associate Professor	Modern Pharmaceutics (4)	M.Pharm
4.	Mrs. B. Bhagyasri	Associate Professor	Regulatory Affairs (4)	M.Pharm
5.	Mr.P.Sandeep	Associate Professor	Assignments (1)	M.Pharm
6	Dr. G.Prasanthi	Professor	Practical-I (6)	M.Pharm
7	Ms. Y.VishnuVandana	Associate Professor	Practical-II (6)	M.Pharm
8	Mrs. B. Bhagyasri	Associate Professor	Seminars (6)	M.Pharm
9.	Mr.R.Ramana	Librarian	Library (2)	M.Pharm

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DEPARTMENT OF PHARMACY
CLASS TIME TABLE AY:2020-21

CLASS:M. Pharm I Sem Pharmaceutical Technologyw.e.f:22/02/2021

Day/ Time	9.00 - 10.00.	10.00- 11.00	11.00 -12.00	12.00- 1.00	1.00 - 2.00	2.00 - 3.00	3.00 - 4.00.
Mon	MPAT	DDS	RA	L U N C H	MP	DDS	Library/Seminar
Tue	RA	MP	MPAT		DDS	MPAT	Library/Seminar
Wed	MPAT	MP	RA		MP	DDS	RA
Thu	Seminar/Assignments						
Fri	Practical-I						
Sat	Practical-II						

S.NO	NAME OF THE FACULTY	DESIGNATION	NAME OF THE SUBJECT (Hrs)	DEPARTMENT
1.	Dr.M.Pavani	Professor	Modern Pharmaceutical Analytical Techniques-(MPAT) (4)	M.Pharm
2.	Mrs.M.K.Rekha	Associate Professor	Drug Delivery Systems-(DDS)(4)	M.Pharm
3.	Mrs.B.Sravani	Associate Professor	Regulatory Affairs-(RA) (4)	M.Pharm
4.	Mr.S.Ramakrishna	Associate Professor	Modern Pharmaceutics-(MP) (4)	M.Pharm
5.	Mr.S.ChandraSekhar	Associate Professor	Assignments (1)	M.Pharm
6	Dr.M.Pavani	Professor	Practical-I (6)	M.Pharm
7	Mrs.M.K.Rekha	Associate Professor	Practical-II (6)	M.Pharm
8	Mrs.B.Sravani	Associate Professor	Seminars (6)	M.Pharm
9.	Mr.R.Ramana	Librarian	Library (2)	M.Pharm

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DEPARTMENT OF PHARMACY
CLASS TIME TABLE AY:2020-21

CLASS:IM. Pharm I Sem Pharmacologyw.e.f:22/02/2021

Day/ Time	9.00 - 10.00.	10.00 - 11.00	11.00 - 12.00	12.00 -1.00	1.00 - 2.00	2.00 - 3.00	3.00 - 4.00.
Mon	MPAT	AP-I	CMP-I	**LUNCH**	PTSM-I	MPAT	Library/ Seminar
Tue	CMP-I	PTSM -I	AP-I		AP-II	PTSM -I	Library/ Seminar
Wed	MPAT	CMP-I	AP-I		CMP-I	AP-I	PTSM-I
Thu	**Seminar/Assignments**						
Fri	**Practical-I**						
Sat	**Practical-II**						

S.NO	NAME OF THE FACULTY	DESIGNATION	NAME OF THE SUBJECT (Hrs)	DEPARTMENT
1.	Dr.K.Murali Krishna	Professor	Modern Pharmaceutical Analytical Techniques-(MPAT)(4)	M.Pharm
2.	Mr.Ch.Madhu	Associate Professor	Cellular and Molecular Pharmacocology-I -(CMP-I) (4)	M.Pharm
3.	Mrs.B.Ramavathi	Associate Professor	Pharmacological and Toxicological Screening Method-I –(PTSM-I) (4)	M.Pharm
4.	Mrs.M.Madhavi Kumari	Associate Professor	Advanced Pharmacology-(AP) (4)	M.Pharm
5.	Ms.M.Divya	Assistant Professor	Assignments (1)	M.Pharm
6	Mrs.M.Madhavi Kumari	Associate Professor	Practical-III (6)	M.Pharm
7	Mr.Ch.Madhu	Associate Professor	Practical-IV (6)	M.Pharm
8	Mr.Ch.Madhu	Professor	Seminars (6)	M.Pharm
9.	Mr.R.Ramana	Librarian	Library (2)	M.Pharm

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DEPARTMENT OF PHARMACY
CLASS TIME TABLE AY:2020-21

CLASS:IM. Pharm. II Sem Pharmaceutical Analysisw.e.f: 31/05/2021

Day/ Time	9.00 - 10.00.	10.00 - 11.00	11.00 - 12.00	12.00- 1.00	1.00 - 2.00	2.00 - 3.00	3.00 - 4.00.
Mon	AIA	QCQA	MBAT	**LUNCH**	AIA	HCA	Library/Seminar
Tue	MBAT	AIA	QCQA		HCA	MBAT	QCQA
Wed	QCQA	HCA	AIA		Library/ Seminar	HCA	MBAT
Thu	**Seminar/Assignments**						
Fri	**Practical-III**						
Sat	**Practical-IV**						

S.NO	NAME OF THE FACULTY	DESIGNATION	NAME OF THE SUBJECT(Hrs)	DEPARTMENT
1.	Dr.M.B.V.Raju	Professor	Quality Control and Quality Assurance-(QCQA) (4)	M.Pharm
2.	Mrs. B.Chaitanya	Associate Professor	Advanced Instrumental Analysis-(AIA) (4)	M.Pharm
3.	Mrs.A.H.V.Santhoshi	Associate Professor	Modern Bioanalytical Techniques-(MBT) (4)	M.Pharm
4.	Mr.A.N.Srinivas	Associate Professor	Herbal and Cosmetic Analysis-(HCA) (4)	M.Pharm
5.	B.Poornima	Associate Professor	Assignments (1)	M.Pharm
6	MrsB.Chaitanya	Associate Professor	Practical-III (6)	M.Pharm
7	Dr.M.B.V.Raju	Professor	Practical-IV (6)	M.Pharm
8	Mrs.A.H.V.Santhoshi	Associate Professor	Seminars (6)	M.Pharm
9.	Mr.R.Ramana	Librarian	Library (2)	M.Pharm

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DEPARTMENT OF PHARMACY
CLASS TIME TABLE AY: 2020-21

CLASS:M. Pharm. II Sem Pharmaceuticsw.e.f: 31/05/2021

Day/ Time	9.00 - 10.00.	10.00 -11.00	11.00 -12.00	12.00-1.00	1.00 - 2.00	2.00 - 3.00	3.00 - 4.00.
Mon	MP	FD	CADD	LUNCH	MP	BPPK	Library/Seminar
Tue	CADD	MP	BPPK		CADD	FD	BPPK
Wed	FD	BPPK	CADD		Library/ Seminar	FD	MP
Thu	Seminar/Assignments						
Fri	Practical-III						
Sat	Practical-IV						

S. NO	NAME OF THE FACULTY	DESIGNATION	NAME OF THE SUBJECT (Hrs	DEPARTMENT
1.	Dr. G.Prasanthi	Professor	Computer Aided Drug Delivery System-(CADD) (4)	M.Pharm
2.	Ms. Y.VishnuVandana	Associate Professor	Molecular Pharmaceutics-(MP) (4)	M.Pharm
3.	Mr. M.Suresh Kumar	Associate Professor	Formulation Development-(FD) (4)	M.Pharm
4.	Mrs. B. Bhagyasri	Associate Professor	Advanced Biopharmaceutics and Pharmacokinetics-(BPPK) (4)	M.Pharm
5.	Mr.P.Sandeep	Associate Professor	Assignments (1)	M.Pharm
6	Ms. Y.VishnuVandana	Associate Professor	Practical-III (6)	M.Pharm
7	Dr. G.Prasanthi	Professor	Practical-IV (6)	M.Pharm
8	Mrs. B. Bhagyasri	Associate Professor	Seminars (6)	M.Pharm
9.	Mr.R.Ramana	Librarian	Library (2)	M.Pharm

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DEPARTMENT OF PHARMACY

CLASS TIME TABLE AY:2020-21

CLASS: IM. Pharm. II Sem Pharmaceutical Technology w.e.f : 31/05/2021

Day/Time	9.00 - 10.00.	10.00 - 11.00	11.00 - 12.00	12.00 - 1.00	1.00 - 2.00	2.00 - 3.00	3.00 - 4.00.
Mon	MP	CADD	FD	**LUNCH**	MP	BPPK	Library/ Seminar
Tue	CADD	FD	BPPK		CADD	FD	BPPK
Wed	MP	BPPK	CADD		Library/ Seminar	FD	MP
Thu	**Seminar/Assignments**						
Fri	**Practical-III**						
Sat	**Practical-IV**						

S.NO	NAME OF THE FACULTY	DESIGNATION	NAME OF SUBJECT (Hrs)	DEPARTMENT
1.	Dr. K Hema Naga Durga	Professor	Computer Aided Drug Delivery System-(CADD) (4)	M.Pharm
2.	Mrs.M.K.Rekha	Associate Professor	Molecular Pharmaceutics-(MP) (4)	M.Pharm
3.	Mrs.S Vijaya Lakshmi	Associate Professor	Advanced Biopharmaceutics and Pharmacokinetics-(BPPK) (4)	M.Pharm
4.	Mr.S.Ramakrishna	Associate Professor	Formulation Development-(FD) (4)	M.Pharm
5.	Mr.S.ChandraSekhar	Associate Professor	Assignments (1)	M.Pharm
6	Mrs.M.K.Rekha	Associate Professor	Practical-III (6)	M.Pharm
7	Dr. K Hema Naga Durga	Professor	Practical-IV (6)	M.Pharm
8	Mrs.S Vijaya Lakshmi	Associate Professor	Seminars (6)	M.Pharm
9.	Mr.R.Ramana	Librarian	Library (2)	M.Pharm

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DEPARTMENT OF PHARMACY
CLASS TIME TABLE AY:2020-21

CLASS:IM. Pharm. II Sem Pharmacologyw.e.f: 31/05/2021

Day/ Time	9.00 - 10.00.	10.00 - 11.00	11.00 - 12.00	12.00 -1.00	1.00 - 2.00	2.00 - 3.00	3.00 - 4.00.
Mon	AP-II	PTSM -II	PDD	**LUNCH**	CRP	AP-II	Library/ Seminar
Tue	PDD	AP-II	PTSM-II		AP-II	CRP	PTSM-II
Wed	PTSM-II	PDD	CRP		Library / Seminar	PDD	CRP
Thu	**Seminar/Assignments**						
Fri	**Practical-III**						
Sat	**Practical-IV**						

S.NO	NAME OF THE FACULTY	DESIGNATION	NAME OF THE SUBJECT(Hrs)	DEPARTMENT
1.	Dr.K.Murali Krishna	Professor	Pharmacological and Toxicological Screening Method-II -(PTSM-II) (4)	M.Pharm
2.	Mr.Ch.Madhu	Associate Professor	Cellular and Molecular Pharmacology-(CMP) (4)	M.Pharm
3.	Mrs.B.Ramavathi	Associate Professor	Principles of Drug Discovery-(PDD) (4)	M.Pharm
4.	Mrs.M.Madhavi Kumari	Associate Professor	Advanced Pharmacology-II (AP-II) (4)	M.Pharm
5.	Ms.M.Divya	Assistant Professor	Assignments (1)	M.Pharm
6	Mrs.M.Madhavi Kumari	Associate Professor	Practical-III (6)	M.Pharm
7	Mr.Ch.Madhu	Associate Professor	Practical-IV (6)	M.Pharm
8	Dr.K.Murali Krishna	Professor	Seminars (6)	M.Pharm
9.	Mr.R.Ramana	Librarian	Library (2)	M.Pharm

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DEPARTMENT OF PHARMACY PRACTICE
CLASS TIME TABLE AY: 2020-2021

CLASS:PHARM.D IYEAR (2021 ADMITTED BATCH) **W.e.f-22/02/2020**

CLASS TEACHER – Dr.D.Subhasri

DAY/TIME	9:30 - 10:30	10:30 – 11:20	11:20 – 12:10	12:10-1:00	1:00 – 01:50	1:50–2:40	2:40-3:30	3:30-4:20
MON	PIC	MBC	POC	LUNCH	HAP	LIBRARY/ SPORTS		
TUE	CEUTICS	POC	PIC		CEUTICS	CEUTICS LAB		
WED	POC	PIC	HAP		RM/RB	POC LAB		
THU	CEUTICS	POC	MBC		PIC	PIC LAB		
FRI	MBC	RM/RB	HAP		RM/RB	HAP LAB		
SAT	HAP	RM/RB	CEUTICS		MBC	MBC LAB		

S. No	NAME OF THE FACULTY	DESIGNATION	NAME OF THE SUBJECT(Hrs)	DEPARTMENT
1.	Dr.D. Subha Sri	Assistant Professor	Pharmaceutical Inorganic Chemistry-(PIC) (4)	Pharm. D
2.	Dr. Harini Priya	Assistant Professor	Pharmaceutical Organic Chemistry-(POC) (4)	Pharm. D
3.	Dr.M.S.V. Sudeep	Assistant Professor	Pharmaceutics (4)	Pharm. D
4.	Dr.S.Sravani Girija	Assistant Professor	Human Anatomy and Physiology-(HAP) (4)	Pharm. D
5.	Dr.S. Dhana Lakshmi	Assistant Professor	Medicinal Biochemistry-(MBC) (4)	Pharm. D
6.	Mr.A.Seshu	Assistant Professor	Remedial Mathematics-(RM) (4)	Pharm. D
7.	Mr.V.UmaSankar	Associate Professor	Remedial Biology-(RB) (4)	Pharm. D
8.	Dr.D. Subha Sri	Assistant Professor	Pharmaceutical Inorganic Chemistry Lab-(PIC) (3)	Pharm. D
9.	Dr. Harini Priya	Assistant Professor	Pharmaceutical Organic Chemistry Lab-(POC) (3)	Pharm. D
10.	Dr.M.S.V. Sudeep	Assistant Professor	Pharmaceutics Lab (3)	Pharm. D
11.	Dr.S.Sravani Girija	Assistant Professor	Human Anatomy and Physiology Lab-(HAP) (3)	Pharm. D
12.	Dr.S. Dhana Lakshmi	Assistant Professor	Medicinal Biochemistry Lab-(MCB) (1)	Pharm. D
13.	Mr.V.UmaSankar	Associate Professor	Remedial Biology –(RB) (4)	Pharm. D

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DEPARTMENT OF PHARMACY PRACTICE
CLASS TIME TABLE AY: 2020-2021

CLASS: PHARM.D IIYEAR (2020 ADMITTED BATCH) **W.e.f- 17/08/2020**
CLASS TEACHER – Dr. Harini priya

DAY/ TIME	9:30 - 10:30	10:30 11:20	11:20 – 12:10	12:10-1:00	1:00 – 01:50	1:50– 2:40	2:40- 3:30	3:30-4:20
MON	COG	PT-1	MB	LUNCH	COL -I	PT- 1 LAB		
TUE	MB	COL-I	PP		PT-1	COL-1	CP	TUTORIAL
WED	PT-1	PP	COG		CP	MB	PT-1	LIB/ SPORTS
THU	VISIT TO HOSPITAL							
FRI	COL -I	PP	CP	LUNCH	COG	COG LAB		
SAT	CP	COG	PP		MB	MB LAB		

S. No	NAME OF THE FACULTY	DESIGNATION	NAME OF THE SUBJECT(Hrs)	DEPARTMENT
1.	Dr. Harini Priya	Assistant Professor	Pharmacognosy-(COG) (4)	Pharm. D
2.	Dr.S.Sravani Girija	Assistant Professor	Pathophysiology-(PP) (4)	Pharm. D
3.	Dr.S. Dhana Lakshmi	Assistant Professor	Community Pharmacy-(CP) (4)	Pharm. D
4.	Dr.D. Subha Sri	Assistant Professor	Pharmaceutical Microbiology-(MB) (4)	Pharm. D
5.	Dr.B. Manoj Kumar	Associate Professor	Pharmacotherapeutics-I-(PT-I) (4)	Pharm. D
6.	S Murali Mohan	Assistant Professor	Pharmacology-I-(COL-I) (4)	Pharm. D
7.	Dr.A.Jyotsna	Assistant Professor	Pharmacognosy Lab-(COG) (3)	Pharm. D
8.	Dr.D. Subha Sri	Assistant Professor	Pharmaceutical MicrobiologyLab-(MB) (3)	Pharm. D
9.	Dr.B. Manoj Kumar	Associate Professor	Pharmacotherapeutics- I –Lab(PT-I) (3)	Pharm. D

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DEPARTMENT OF PHARMACY PRACTICE

CLASS TIME TABLE AY: 2020-2021

CLASS: PHARM.D IIIYEAR (2019 ADMITTED BATCH) **W.e.f-17/08/2020**
CLASS TEACHER: Mrs.CH.GEETHA

DAY/ TIME	9:30 – 10:30	10:30– 11:20	11:20 - 12:10	12:10 -1:00	1:00– 01:50	1:50– 2:40	2:40-3:30	3:30-4:20
MON	COL-II	PF	MC	LUNCH	PJ	MC LAB		
TUE	MC	PJ	COL-II		PT- II	PT- II LAB		
WED	MC	PT-II	PF		PA	PA LAB		
THU	PF	MC	PA		COL- II	PF LAB		
FRI	HOSPITAL VISIT							
SAT	PJ	PA	PT-II	LUNCH	PF	COL-II LAB		

S. No	NAME OF THE FACULTY	DESIGNATION	NAME OF THE SUBJECT(Hrs)	DEPARTMENT
1.	Dr.S. ArunSatya Dev	Professor	Medicinal chemistry-(MC) (4)	Pharm. D
2.	Mrs.Ch.Geetha	Assistant Professor	Pharmaceutical Analysis-(PA) (3)	Pharm. D
3.	Dr.V.C.Randeep Raj	Associate Professor	Pharmacotherapy –II-(PT-II) (3)	Pharm. D
4.	Dr.S. Dhana Lakshmi	Assistant Professor	Pharmaceutical Jurisprudence-(PJ) (3)	Pharm. D
5.	Mrs.B.Ramavathi	Assistant Professor	Pharmacology-II (COL-II) (3)	Pharm. D
6.	S Murali Mohan	Assistant Professor	Pharmaceutical Formulation-(PF) (3)	Pharm. D
7.	Dr.S. ArunSatya Dev	Professor	Medicinal chemistry Lab-(MC) (3)	Pharm. D
8.	Mrs.Ch.Geetha	Assistant Professor	Pharmaceutical Analysis Lab-(PA) (3)	Pharm. D
9.	Dr.V.C.Randeep Raj	Associate Professor	Pharmacotherapy -II Lab-(PT-II) (3)	Pharm. D
10.	Mrs.B.Ramavathi	Assistant Professor	Pharmacology-II Lab-(COL-II) (3)	Pharm. D
11.	S Murali Mohan	Assistant Professor	Formulation Lab-(PF) (3)	Pharm. D

Time Table Incharge **Principal**

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DEPARTMENT OF PHARMACY PRACTICE
CLASS TIME TABLE AY: 2020-2021

CLASS: PHARM.D IVYEAR (2018 ADMITTED BATCH) **W.e.f-17/08/2020**
CLASS TEACHER:S Murali Mohan

DAY/ TIME	9:30-10:30	10:30–11:20	11:20–12:10	12:10-1:00	1:00–01:50	1:50–2:40	2:40-3:30	3:30-4:20
MON	CP	BRM	CT	LUNCH	PT- III	CP LAB		
TUE	BPPK	CP	BRM		BPPK	HP LAB		
WED	PT-III	BPPK	HP		CP	BPPK LAB		
THU	BRM	PT- III	CT		HP	PT- III LAB		
FRI	HOSPITAL ROSTER							
SAT	HOSPITAL ROSTER							

S. No	NAME OF THE FACULTY	DESIGNATION	NAME OF THE SUBJECT(Hrs)	DEPARTMENT
1.	Mrs.Ch. Geetha	Assistant Professor	Biostatistics and Research Methodology-(BRM) (4)	Pharm. D
2.	Dr.V C Randeep Raj	Associate Professor	Clinical Pharmacy-(CP) (3)	Pharm. D
3.	Mr.V Uma Sankar	Associate Professor	Hospital Pharmacy-(HP) (2)	Pharm. D
4.	S Murali Mohan	Assistant Professor	Clinical Toxicology-(CT) (2)	Pharm. D
5.	Mr.P. Sandeep	Assistant Professor	Biopharmaceutics and Pharmacokinetics-(BPPK) (3)	Pharm. D
6.	Dr.T. Rushi	Assistant Professor	Pharmacotherapeutics – III-(PT-III) (3)	Pharm. D
7.	Dr.V C Randeep Raj	Associate Professor	Clinical Pharmacy Lab-(CP) (3)	Pharm. D
8.	Mr.V Uma Sankar	Associate Professor	Hospital Pharmacy Lab-(HP) (3)	Pharm. D
9.	Mr.P. Sandeep	Assistant Professor	Biopharmaceutics and Pharmacokinetics Lab-(BPPK) (3)	Pharm. D
10.	Dr.T. Rushi	Assistant Professor	Pharmacotherapeutics - III – (PT-III)Lab (3)	Pharm. D

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DEPARTMENT OF PHARMACY PRACTICE
CLASS TIME TABLE AY: 2020-2021

CLASS: PHARM.D VYEAR (2017 ADMITTED BATCH) **W.e.f -17/08/2020**
CLASS TEACHER: Dr.B.MANOJ KUMAR

DAY/TIME	9:30 - 10:30	10:30 – 11:20	11:20 – 12:10	12:10 1:00	1:00 – 01:50	1:50– 2:40	2:40- 3:30	3:30- 4:20
MON	HOSPITAL ROSTER							
TUE	HOSPITAL ROSTER							
WED	HOSPITAL ROSTER							
THU	PROJECT	CR	PKTDM	LUNCH	PKTDM	CR	CLERKSHIP	
FRI	CR	PKTDM	EM		EM	PKTDM	CLERKSHIP	
SAT	EM	CR	EM		CR	PROJECT	CLERKSHIP	

S. No	NAME OF THE FACULTY	DESIGNATION	NAME OF THE SUBJECT (Hrs)	DEPARTMENT
1.	Dr.M.S.V. Sudeep	Assistant Professor	Clinical Research–(CR) (5)	Pharm. D
2.	Dr.T. Rushi	Assistant Professor	Pharmacokinetics and Therapeutic Drug Monitoring(PKTDM) (4)	Pharm. D
3.	Dr.B. Manoj Kumar	Associate Professor	Pharmacoepidemiology (EM) (4)	Pharm. D
4.	Mr.V. Uma Sankar	Associate Professor	Clerkship (3)	Pharm. D
5.			Project (2)	Pharm. D

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MODERN PHARMACEUTICAL ANALYTICAL TECHNIQUES

COURSE FILE

Prepared by:

Dr. K.Murali Krishna,

Professor

Department of Pharmacology

(2020-2021)

ESTD. 2005

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DEPARTMENT OF PHARMACY

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COURSE FILE CONTENTS

1. Vision, Mission of the Institute
2. Program Educational Outcomes (PEOs)
3. Program Outcomes (POs)
4. Syllabus Copy
5. Roll list
6. Class Time tables and Individual Time tables
7. Lesson plan.
8. Teaching notes
9. Mid I Question paper, Scheme of evaluation and answer scripts
10. Mid II Question paper, Scheme of evaluation and answer scripts
11. Mid III Question paper, Scheme of evaluation and answer scripts
12. Internal and External marks
13. Result analysis
14. CO and PO attainment sheets
15. CO-PO-PSO mapping

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VISION AND MISSION

VISION:

To develop highly skilled professionals with ethics and human values.

MISSION:

1. To impart quality education with exposure to real world training.
2. To produce competent and highly knowledgeable biostats and analysts with positive approach.
3. To build self confidence among students which is an imperative prerequisite to face the challenges in future.

Quality Policy:

Avanthi institute of pharmaceutical sciences emphasizes the ethical ideals to innovateadvanced training by creating the best possible infrastructure through an engaging, activity-oriented teaching. It also uses the most updated information and biostatical knowledge toenhance a biostatical approach among the students, aiming for an effective and ambitiousadministration which is responsive in all the aspects.

Program Educational Objectives (PEOs)

PEO 1: Ethical Awareness: Graduates will be able to understand, appreciate and apply concepts about various aspects of regulations and ethical requirement for the usage of experimental animals, CPCSEA guidelines for laboratory animal facilities, and toxicity studies.

PEO 2: Domain Knowledge: Graduates should inculcate advanced theoretical and practical knowledge of the pharmacological education which will help them to perform exceptionally in academics and their professions.

PEO 3: Systems based approach: Graduates should develop novel approaches for minimizing and monitoring of adverse drug reactions to ensure safe use of drugs by providing practical inputs in pharmacokinetic studies of various drugs and formulations in animals to establish in-vitro and in-vivo correlations.

PEO 4: Social Awareness: Graduates should act responsibly towards environment, follow ethical principles, be able to comprehend, interpret and apply laws pertinent to all spheres of pharmaceutical and allied domains. imbibe the spirit of being an entrepreneur.

Program Outcomes (POs)

PO 1: Drug Expertise: Acquire knowledge on various classes of drugs and their mode of actions to unveil the remedies for maintainment

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PO 2: Analytical Reasoning: Identify assumptions and reveal the evidence-based reasons for the disease or disorder take place to select the type of relevant treatment.

PO 3: Experimental Ethics: Consider and follow ethics and guidelines specified by the authorities of various agencies and Government of India for animal congenial laboratory practice.

PO 4: Interdisciplinary engagement: Obtain skill oriented practical proficiency by exposing and utilizing the needs of pharmacy in all disciplines to emerge as potent researcher.

PO 5: Statistical Skills: Apply and analyze quantitative metrics to gain safety data on dosage, also to compare the effectiveness among experimental groups

PO 6: Professional Identity: Be committed and responsible person to play a proactive role with fidelity to community and empower society.

PO 7: Environment and sustainability: understand, protect and cooperate environmental concerns for sustaining biodiversity.

PO 8: Modern tool usage: Learn, select, apply appropriate methods, procedures, resources, and modern pharmacy-related computing tools with an understanding of the limitations.

PO 9: Intellectual Flexibility: Engage in critical thinking and gain insight to identify, design and formulate pharmaceutical products that are in need of current aspects by using material from natural sources.

PO 10: Lifelong learning: Understand and apply the concepts in day-to-day life activities for the benefit of self and for the welfare of society and its concerns.

Program Specific Outcomes (PSOs)

PSO 1: Research Expertise: Graduates should have comprehensive knowledge of designing, conducting, analysis, reporting and documentation of the preclinical and clinical research studies for effective pharmacotherapy of drugs.

PSO 2: Pharmacovigilance Expertise: Graduates will be able to apply and appraise regulatory, computational and informatics tools and ethical concepts in preclinical and clinical research for pharmaceutical and healthcare domain in relation to society.

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MODERN PHARMACEUTICAL ANALYTICAL TECHNIQUES

Syllabus Copy

Unit 1:UV-Visible spectroscopy: Introduction, Theory, Laws, Instrumentationassociated with UV-Visible spectroscopy, Choice of solvents and solvent effectand Applications of UV-Visible spectroscopy, Difference/ Derivativespectroscopy.

b. IR spectroscopy: Theory, Modes of Molecular vibrations, Sample handling,Instrumentation of Dispersive and Fourier - Transform IR Spectrometer, Factorsaffecting vibrational frequencies and Applications of IR spectroscopy, DataInterpretation.

c. Spectroflourimetry: Theory of Fluorescence, Factors affecting fluorescence(Characterestics of drugs that can be analysed by flourimetry), Quenchers,Instrumentation and Applications of fluorescence spectrophotometer.

d. Flame emission spectroscopy and Atomic absorption spectroscopy: Principle,Instrumentation, Interferences and Applications.

Unit 2. NMR spectroscopy: Quantum numbers and their role in NMR, Principle,Instrumentation, Solvent requirement in NMR, Relaxation process, NMR signalsin various compounds, Chemical shift, Factors influencing chemical shift, Spin-Spin coupling, Coupling constant, Nuclear magnetic double resonance, Brief outline ofprinciples of FT-NMR and 13C NMR. Applications of NMRspectroscopy.

Unit 3. Mass Spectroscopy: Principle, Theory, Instrumentation of Mass Spectroscopy,Different types of ionization like electron impact, chemical, field, FAB andMALDI, APCI, ESI, APPI Analyzers of Quadrupole and Time of Flight, Massfragmentation and its rules, Metastable ions, Isotopic peaks and Applications ofMass spectroscopy.

Unit 4. Chromatography: Principle, apparatus, instrumentation, chromatographicparameters, factors affecting resolution, isolation of drug from excipients, datainterpretation and applications of the following:

a) Thin Layer chromatography
b) High Performance Thin Layer Chromatography
c) Ion exchange chromatography
d) Column chromatography
e) Gas chromatography
f) High Performance Liquid chromatography
g) Ultra HighPerformanceLiquidchromatography
h) Affinity chromatography
i) Gel Chromatography

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Unit 5. Electrophoresis: Principle, Instrumentation, Workingconditions, factorsaffecting separation and applications of the following:

i. Paper electrophoresis ii. Gel electrophoresis iii. Capillary electrophoresis

iv. Zone electrophoresis v. Moving boundary electrophoresis vi. Iso electric focusing.

X ray Crystallography: Production of X rays, Different X ray methods, Bragg'slaw, Rotating crystal technique, X ray powder technique, Types of crystals andapplications of X-ray diffraction.

Unit 6. Potentiometry: Principle, working, Ion selective Electrodes and Application ofpotentiometry.

b. **Thermal Techniques:** Principle, thermal transitions and Instrumentation (Heatflux and power-compensation and designs), Modulated DSC, IIyper DSC,experimental parameters (sample preparation, experimental conditions, calibration,heating and cooling rates, resolution, source of errors) and their influence,advantage and disadvantages, pharmaceutical applications.

Text books

1. Spectrometric Identification of Organic compounds- Robert M Silverstein, 6th edition, John
2. Wiley & Sons, 2004.
3. Principles of Instrumental Analysis- Doglas A Skoog, F.James Holler, TimothyA.Nieman,5th edition, Eastern press, Bangalore, 1998.
4. Instrumental methods of analysis– Willards, 7th edition, CBS publishers.
5. Practical Pharmaceutical Chemistry – Beckett and Stenlake, Vol II, 4th edition, CBSPublishers, New Delhi, 1997.
6. Organic Spectroscopy- William Kemp, 3rd edition, ELBS, 1991.
7. Quantitative Analysis of Drugs in Pharmaceutical formulation – PD Sethi, 3rd Edition, CBSPublishers, New Delhi, 1997.

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Students Roll List

S No	Roll No	Student Name
M Pharmacy Pharmaceutical Technology		
1.	20T51S1601	Bandapu Anusha
2.	20T51S1602	Menda Roja
3.	20T51S1603	Sabbavarapu Parvathi
4.	20T51S1604	Kadiyam Sowjanya
5.	20T51S1605	Chintagunti Sai Lavanya
6.	20T51S1606	Sayyad Ashiya Parveen
M Pharmacy Pharmacology		
1.	20T51S0601	Kancharla Moulika
2.	20T51S0602	Majji Guna Sundari
3.	20T51S0603	Muminuz Zaman
M Pharmacy Pharmaceutics		
1.	20T51S0301	Ankamreddi Pavani
2.	20T51S0302	YendradlaHiranmai
3.	20T51S0303	Vutapalli Esther Rani
4.	20T51S0301	Tadi Sankeerthana
5.	20T51S0305	Korabu Maithili
6.	20T51S0306	Neelapu Guna Prasanth

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Unit-1

A. UV VISIBLE SPECTROSCOPY

Introduction to Electro Magnetic Radiation (EMR):

Light travels in a straight line, but phenomenon like interference, refraction, diffraction, etc. could not explain this. To explain these phenomena, light is supposed to travel in waves. Light or EMR is a form of energy that is transmitted through space at a constant velocity of $3 \times 10^8\ meter/second$. These radiations are said to have dual nature exhibiting both:

- Wave character
- Particle character or corpuscular theory

According to wave theory, light travels in the form of **waves**. This wave motion consists of oscillating *electric* (E) & *magnetic* (H) fields (vectors) directed perpendicular to each & perpendicular to the direction of the propagation of wave (Fig. 1).

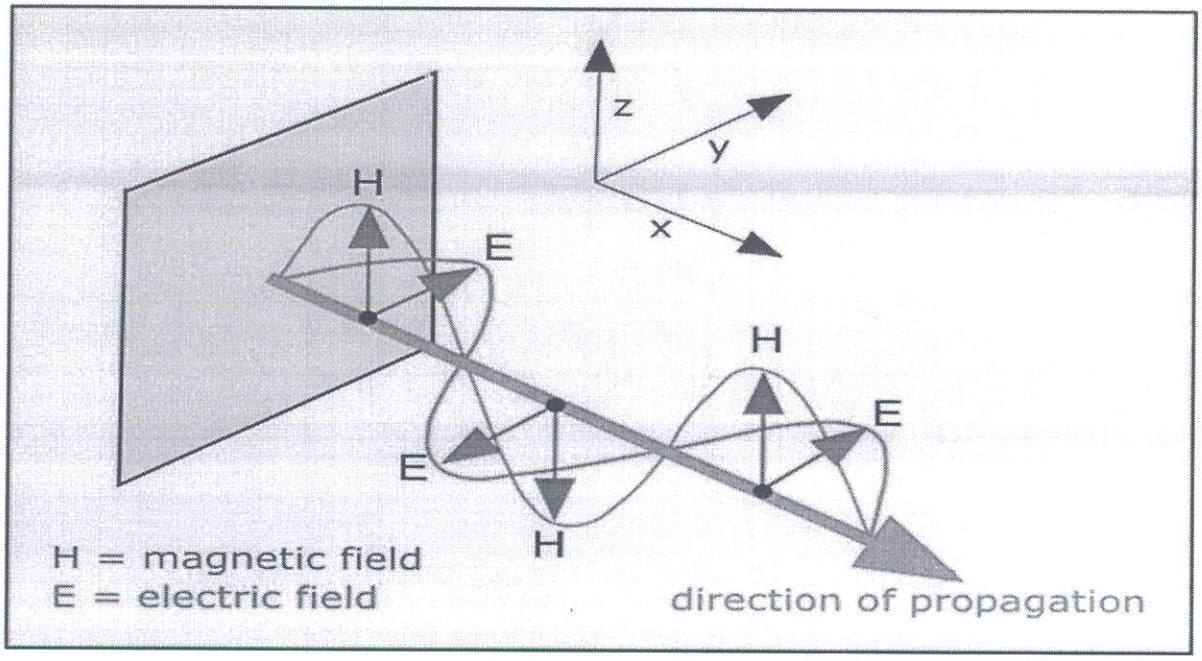

Fig. 1: Wave nature of light

Quantum theory of EMR:

- Quantum theory describes the EMR as consisting of a stream of energy packets, called **Photons** or **Quanta**, which travel in the direction of propagation of the beam with the velocity of light.
- Thus, during emission or absorption of light by chemical species, the energy changes take place only discretely always as integral multiples of small units of energy i.e. **photon**.
- The energy of the photon is proportional to the frequency of radiation, i.e. $E \alpha \nu$, or, $E = h\nu$,
  Where, h = Plank's constant = 6.626×10^{-27} erg.sec.
  The energy of a photon is called quantum of energy & this depends only on the frequency but not on the intensity of radiation.
- The waves are characterized by their **wavelengths** or **frequencies** or **wave numbers**.

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Spectroscopy:

- The word spectroscopy is derived from *spectrum* which means a band of different colours formed due to difference in wavelength and *skopin* means examination or evaluation. Thus, ***spectroscopy*** is the branch of science that deals with the examination or evaluation of spectrum. It is defined as the interaction between the matter & EMR. It deals with emission as well as absorption spectra.
- It is used to measure the energy difference between various molecular energy levels & to determine the atomic & molecular structures. The instruments used in such studies are called ***spectrophotometer***.
- If EMR (of certain wavelength range) are passed through the substance under analysis for sometimes, then radiations of certain wavelengths are absorbed by the substance. The wavelengths which are absorbed characterize some practical functional groups present in the compound or the compound itself. This dark pattern of lines which corresponds to the wavelengths absorbs is called ***Absorption spectrum***. After absorption, the transmitted light is analyzed by the spectrometer relative to the incident light of a given frequency. The absorbed energy may heat up the sample or is re-emitted.
- An emission spectrum is produced by the emission of radiant energy by an excited atom. The excitation of atoms can be brought about thermally (by heating the substance strongly) or electrically (by passing electric discharge through the vapours of the substance at a very low pressure). When an electric discharge is passed through the vapours of the substance, energy is absorbed & electrons in the ground state are promoted to Meta-stable states. When electrons from the Meta-stable state jump to the lower energy state, then some energy of definite frequency is released as radiation. If this radiation emitted is analyzed with the help of a spectroscope, an ***emission spectrum*** is observed.

Characteristics/Units of wave (Fig.2):

a. **Wavelength:** It is the distance between the adjacent crests or troughs in a particular wave. It is denoted by 'λ' (lambda). It can be expressed in Angstrom (^{0}A) or nanometer (nm) or millimicrons (mμ) or centimeter (cm) or micrometer (μm).
   1 nm = 10^{-9} m = 10^{-3} μm = 10 ^{0}A = 10^{-7} cm = 1 mμ
   Nanometer is frequently used in UV-Visible technique.

b. **Wave Number:** It is the reciprocal of wavelength & it is expressed in per centimeter; or it is defined as the total number of waves which can pass through a space of 1 cm. It is expressed as '$\bar{\nu}$ (nu bar)'. It is frequently used in IR technique.

c. **Frequency:** it is defined as the number of waves which can pass through a point in one second. It is expressed as ν (nu) in cycles per second or in Hertz (Hz).
   1 Hz = 1 cycle sec^{-1}
   Frequency α $\frac{1}{\text{wavelengt}}$ i.e., greater the ***wavelength***, smaller is the ***frequency***.
   Frequency, $\nu = \frac{c}{h}$ Where, c = velocity of EMR (light) = 2.998 x 10^{-8} cm/sec

d. **Energy**: Energy of a particular wave is calculated as
   $E = h\nu = \frac{hc}{h} = hc\bar{\nu}$ Where, h = Plank's constant = 6.626 x 10^{-27} erg. sec.

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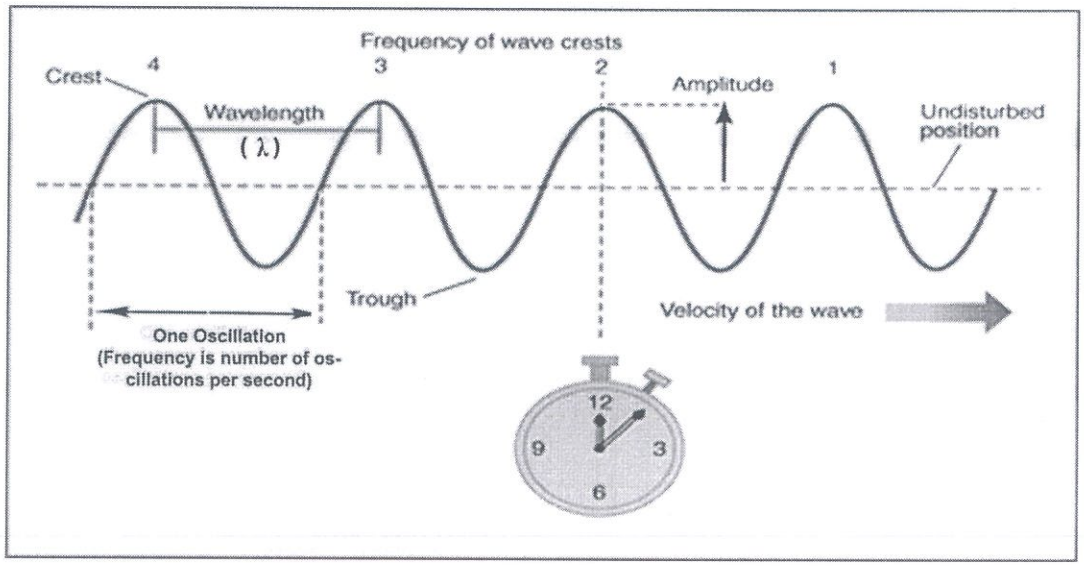

Fig. 2: Characteristics of wave

Electromagnetic spectrum:

- The electromagnetic spectrum, for most spectroscopic purposes, is considered to be consisting of region of radiant energy ranging from wavelengths of 10 m to 1 $x12^{-12}$ cm.
- When a molecule absorbs EMR, it can undergo various types of excitation. This excitation may be
  - Electronic excitation,
  - Rotation excitation,
  - Excitation leading to a change in nuclear spin,
  - Excitation resulting in bond deformation & so on.
- If the energy available approaches the ionization potential of the molecule, an electron may be ejected & ionization may occur.
- Since each mode of excitation requires a specific quantity of energy, the different absorptions appear in different regions of the electromagnetic spectrum.
- The various regions of electromagnetic spectrum are set out (Table:1 & Fig.3) & are labeled either according to the wavelength/ wave no. range used, or according to the type of the molecular energy levels involved, e.g. UV (electronic) spectra, IR (vibrational) spectra or RF (NMR) spectra.

Table-1: Various regions of electromagnetic spectrum

Type of Radiation	Wavelength	Wave no.	Type of molecular spectrum
RF	> 100 mm	$< 3 \times 10^9$ Hz	NMR (Spin orientation)
Microwave	1 – 100 mm	10 – 0.1 cm^{-1}	Rotational
Far IR	50 μm – 1mm	200 – 10cm^{-1}	Vibrational fundamental or rotational
Mid IR	2.5 μm – 50 μm	4000 – 667 cm^{-1}	Vibrational fundamental
Near IR	780nm – 2.5 μm	$(13 - 4) \times 10^3$ cm^{-1}	Vibrational (overtones)
Visible	380nm – 780nm	$(2.6 - 1.3) \times 10^4$ cm^{-1}	Electronic (valence orbital)
Near UV	200nm – 380nm	$(5 - 2.6) \times 10^4$ cm^{-1}	Electronic (valence orbital)
Vacuum UV	10nm – 200nm	$(10^2 - 5) \times 10^4$ cm^{-1}	Electronic (valence orbital)
X-rays	10pm – 10nm	10^9-10^6 cm^{-1}	Electronic (core orbitals)

Photons of electromagnetic radiation of different energies (frequencies or wavelengths) interact with molecules in a variety of ways:

1. X-rays can excite and eject inner shell electrons, causing ionization and bond fragmentation.
2. Ultraviolet (UV) radiation causes high energy electronic transitions and visible radiation induces low energy electronic transitions in molecules. The resulting excited states may relax via bond breakage or various radiative and non-radiative pathways.
3. Infrared (IR) radiation causes vibrations in molecular bonds, such as bond stretching, bond bending etc. Therefore, IR spectroscopy is often called vibrational spectroscopy.
4. Microwaves can cause the molecules to rotate in the gas phase. This is the subject matter of microwave or rotational spectroscopy.
5. Radio waves can induce resonance of atomic nuclei rotation in a strong magnetic field. This is the subject of nuclear magnetic resonance (NMR) spectroscopy.

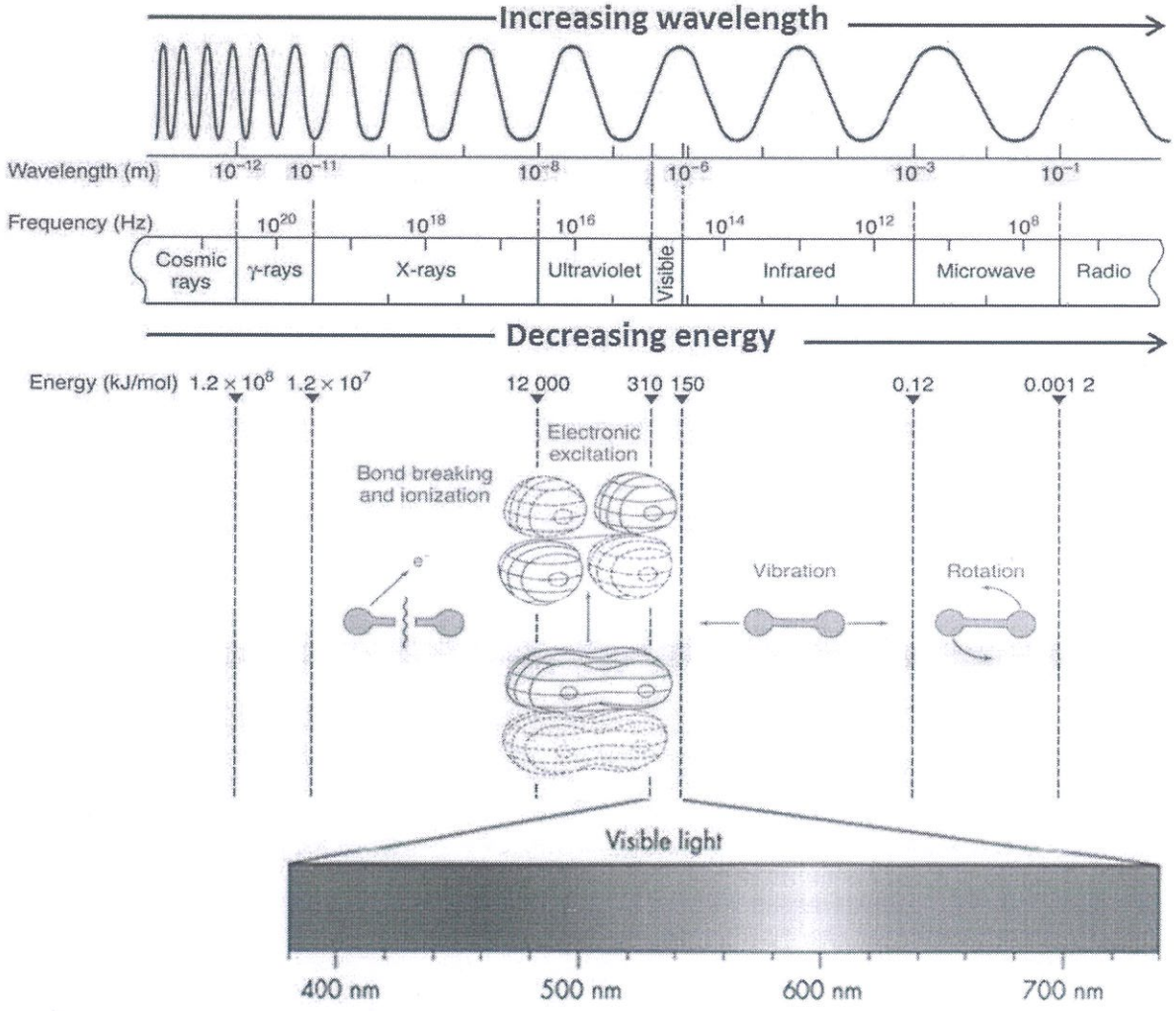

Fig.3: Electromagnetic radiation of different frequencies or wavelengths

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Absorption of EMR by organic molecules:

- When a molecule absorbs radiation, its energy increases in proportion to the energy of the photon as $E = h\nu$
- Since the energy absorbed by a molecule is quantized, there will not be continuous absorption by a molecule throughout a particular spectral range; instead the molecule absorbs those frequencies which will provide it with the exact quantity of energy (quantum theory) necessary to raise its normal energy level to a higher level or levels.
- Thus, when light radiations are passed through an organic compound or, when an organic molecule interacts with EMR, then electrons of the component atoms are excited. It may change its energy from E_1 to E_2 by absorption of radiation of frequency 'ν' so that, $E_2 - E_1 = \Delta E = nh\nu$, when, n = an integer.
- The lowest state of energy of an atom or molecule is called **ground state**. By absorbing one quantum of energy '**hν**', the molecule is promoted to the next higher level & is said to be in the 'b'. Similarly, absorption of more energy in integral multiples of hν, will result in further excitation to next higher energy levels i.e. **excited state**.
- Study of absorbed radiations from a continuous source that are utilized in raising the internal energy of a molecule constitutes **absorption spectroscopy**.
- In general, an absorption spectrum curve will consist of a series of peaks, each peak coinciding with a value of 'ν' which satisfies the relation ($E_2 - E_1 = nh\nu$).
- After absorption of energy, the excited species returns to the ground state by emitting the energies radiations. The study of this emitted radiation constitutes **emission spectroscopy**.
- The portions of EMR which do not satisfy relation may either simply pass through the matter or undergo **scattering** or **reflection** with or without change of wavelength.

When molecules absorb energy and get excited, then either of the following energy changes occurs.

a. Transition of an electron to high energy level,
b. Change in the intermolecular vibrations of the molecule,
c. Change of the moment of inertia of the molecule around its center of gravity,
d. Transitions between electronic levels are found in the UV & visible regions,
e. Transitions between vibrational levels, but within same electronic level in mid & near IR region,
f. Transitions between neighboring rotational levels in far IR & microwave regions.

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UV-Visible Spectroscopy

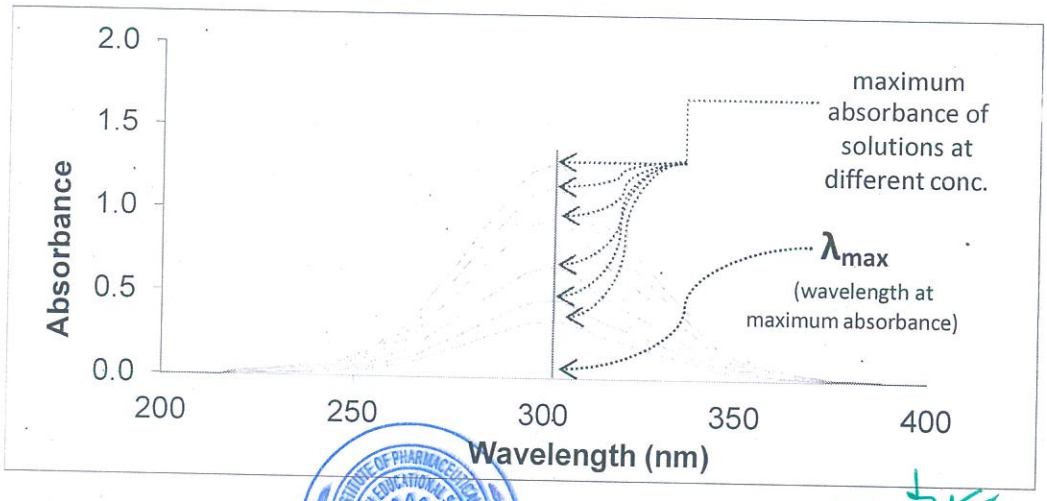
UV wavelength region ➔ 200nm – 380nm, Visible wavelength region ➔380nm – 780nm

- It is also known as **Electronic spectroscopy** since it involves the promotion of electrons (σ, π, n- electrons) from the ground state to the higher energy state.
- It very useful to measure the number of conjugated double bonds & also aromatic conjugation within the various molecules.
- It distinguishes between conjugated & non-conjugated systems, α, β- unsaturated carbonyl compounds from β, γ-analogues, homo annular & hetero annular conjugated dienes, etc.

Principle:

Since the energy levels of a molecule are quantized, the energy required to bring about the excitation is a **fixed quantity**. Thus, the EMR with only a particular value of frequency will be able to cause **excitation**. If the substance is exposed to radiation of some different value of frequency, energy will not be absorbed & thus, light radiation will not suffer any loss in intensity.

- When UV or Visible radiation is passed through a substance, absorption of energy results in the promotion of electron from the ground electronic state to the excited electronic state. The amount of absorption of energy depends upon **wavelength of the radiation** & the **structure of compound**.
- During the process of absorption, a large number of photon-molecule collisions are possible but only those collisions will cause absorption of energy in which the energy of the photon matches the energy difference between the ground & the excited electronic state of the molecule. The absorption of energy is quantized.
- **The wavelength at which maximum absorption of radiation takes place is called λ_{max}.** This λ_{max} is characteristic or unique for every substance & this is a qualitative aspect, useful in identifying the substance (Fig.4).
- λ_{max} is not usually affected by concentration of the substance. The absorbance of a solution increases with concentration of a substance, but there is no change in λ_{max} when concentration changes.



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Purpose to measure UV/VIS spectra:

There are five main reasons to measure UV/VIS spectra:

- UV/VIS spectra allow components present in the sample solution to be identified. More precisely, the position and, to some extent, the profile of the absorption peaks allow specific compounds to be identified. For example, organic compounds can be identified by their spectra, or solvent purity can be easily checked by UV/VIS spectroscopy.
- Absorption peaks can be used to quantify the investigated sample. For example, the sample concentration can be calculated from the absorbance value of the peak:

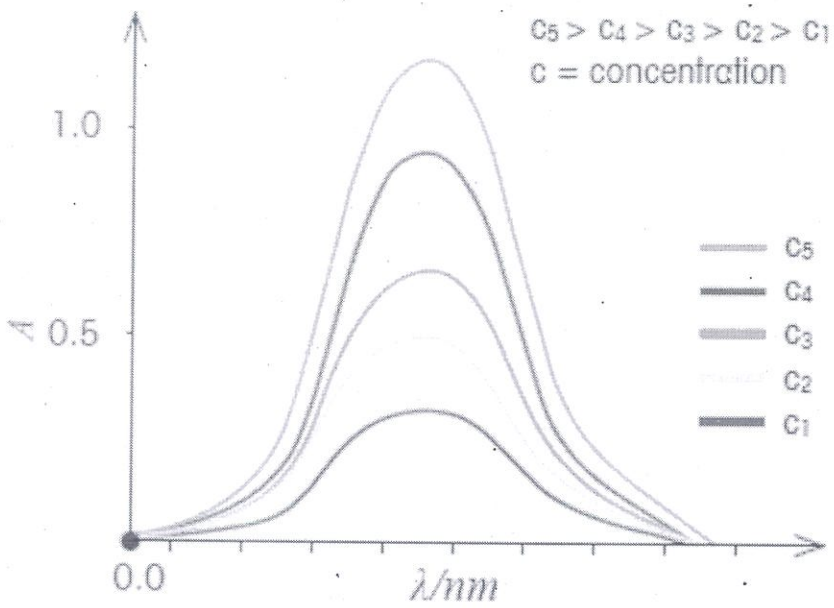

Fig. A higher concentration leads to higher absorbance value

- Based on the relationship between absorbance and sample concentration, UV/VIS spectroscopy is applied as a quantitative analytical technique in market segments such as e.g. Water Testing, Food and Beverages, Pharmaceutical, Chemical and Biotech Industry.
- The position of the peaks in the spectrum reveals information about the molecular structure of the sample. For example, specific functional groups of a molecular structure, such as carbon-oxygen, C=O, or carbon-carbon double bonds, C=C, absorb at specific characteristic wavelengths.
- The spectrum may reveal specific physical properties of the sample molecules. For instance, from the UV/VIS spectrum it is possible to: – calculate the extinction coefficient of the sample – calculate the melting point of proteins and nucleic acids by measuring the UV/VIS spectra at different temperatures – determine the rate of a reaction by monitoring the absorption spectra as a function of time (also known as kinetic measurements).
- Finally, position and profile of the peaks in the spectrum can give information about the microscopic environment of the sample molecules. As an example, the presence of impurities or other solvents in the sample solution has an effect on position and of the profile of the peaks. In other words, the peaks may be broader or have shifted due to impurities.

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Electronic transitions:

- **Theory**
  - ❖ When the molecule absorbs UV or visible light, its electron gets promoted from the ground state to the higher energy state.
  - ❖ In the ground state, the spins of the electrons in each molecular orbital are essentially paired.
  - ❖ In the higher energy state, if the spins of the electrons are ***opposite*** and ***unpaired***, then it is called as an **excited singlet state.**
  - ❖ On the other hand, if spins of the electrons in the excited state are ***parallel*** and ***unpaired***, it is called as an **excited triplet state**. The triplet state is always lower in energy than the corresponding excited singlet state. Therefore, triplet state is more stable as compared to the excited singlet state.
  - ❖ In the triplet excited state, electrons are farther apart in space & thus, electron-electron repulsion is minimized.
  - ❖ Normally the absorption of UV or visible light results in singlet ground state to excited singlet state transition, i.e. excitation proceeds with the retention of spins.
  - ❖ An excited singlet state is converted to excited triplet state with the emission of energy as light. The transition from the singlet ground state to excited triplet state is symmetry forbidden.
  - ❖ The higher energy states are designated as high energy molecular orbitals & also called as **anti-bonding orbitals.**
  - ❖ The higher probable transition due to absorption of quantized energy involves the promotion of one electron from the **highest occupied molecular orbital (HOMO)** to the **lowest available unfilled molecular orbital (LUMO).**
  - ❖ The higher is the energy gap, the lower is the wavelength of the light absorbed.
- **Types of Electronic Transitions (Fig.5)**

According to the molecular orbital theory, when a molecule is excited by the absorption of energy (UV or visible light), its electrons are promoted from a bonding orbital to an anti-bonding orbital. There are several types of electronic transitions available to a molecule including:

- ❖ The anti-bonding orbital which is associated with the excitation of σ-electron is called σ*-anti-bonding orbital. $\sigma \rightarrow \sigma^*$ transition takes place when α-electron promoted to anti-bonding (σ *) orbital.
- ❖ When a non-bonding electron (η) gets promoted to an anti-bonding sigma orbital (σ *), then it represents $\eta \rightarrow \sigma^*$ transition.
- ❖ Similarly, $\pi \rightarrow \pi^*$ transition represents the promotion of π-electrons to an anti-bonding π-orbital, (π*-orbital)
- ❖ Similarly, when a η-electron (non-bonding) is promoted to an anti-bonding π-orbital, it represents $\eta \rightarrow \pi^*$ transition.

The energy required for various transitions obey the following order:

$$\sigma \rightarrow \sigma^* > \eta \rightarrow \sigma^* > \pi \rightarrow \pi^* > \eta \rightarrow \pi^*$$

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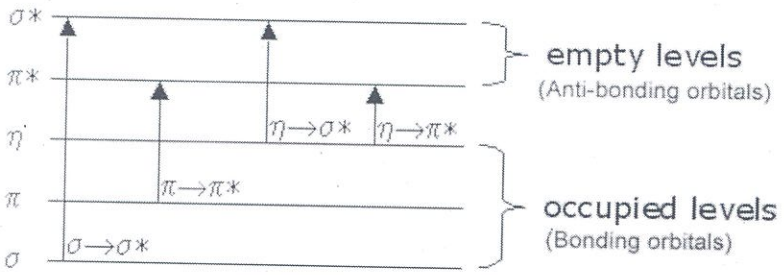


Fig. 5: Types of electronic transitions.

Let us consider various transitions involved in UV spectroscopy:

a. **σ → σ * transitions: (Fig. 6a)**
- It is a high energy process since α-bonds are very strong.
- It is observed with saturated compounds (especially hydrocarbons), in which all the valence shells electrons are involved in the formation of sigma bonds do not show absorption in the normal UV region, i.e. 120nm – 180nm. e.g. methane, ethane, propane, cyclopropane, etc.
- It requires radiation of very short wavelength. To study such high energy transitions, the entire path length must be evacuated, since oxygen begins to absorb strongly above 200nm.

b. **η → σ* transitions: (Fig. 6b)**
- It occurs in saturated compounds containing one hetero atom with unshared pair of electrons (η-electrons).
- E.g. saturated halides, alcohols, ethers, amine, etc.
- It requires comparatively less energy than that required for σ → σ* transitions.
- In saturated alkyl halides, the energy required for such a transition decreases with the increase in size of the halogen atom (or decrease in the electro-negativity of the atom).

c. **π → π* transitions: (Fig. 6c)**
- This type transitions occur in the unsaturated centers of the molecule; i.e. in compounds containing double or triple bonds & also in aromatics.
- Absorption usually occurs within the region of ordinary UV-spectrophotometer.
- The excitation of π-electron requires smaller energy & hence, transition of this type occurs at longer wavelength.
- A π-electron of a double bond is excited to π*-orbital. E.g. alkenes, alkynes, carbonyl compounds, cyanides, azo compounds, etc.
- This transition requires still lesser energy as compared to η→σ* transition.

d. **η → π* transitions: (Fig. 6d)**
- In this type, an electron of unshared electron pair on hetero atom gets excited to π*-anti-bonding orbital.
- This type of transition requires least amount of energy out of all the transitions, & hence occurs at longer wavelength.
- Absorption occurring at lower wavelength is usually intense. In simple cases, it is quite easy to tell whether the transition is η→π* or π→π* since the excitation coefficient for the former is quite low as compared to that of later. The exact electronic structure of the molecules in the excited state is not known but the electronic transition involves the redistribution of electrons within the molecule. E.g. aldehydes, ketones, nitro compounds, etc. contain both η→π* & π→π* transitions.

- *Conjugated π-bond system chromophores*
  - In the conjugated chromophores, the electrons jump between energy levels that are extended π orbitals, created by a series of alternating single and double bonds, often in aromatic systems.
  - E.g., azo compounds, pH indicators (Fig.7.), lycopene, β-carotene, and anthocyanins.
  - Lengthening or extending a conjugated system with more unsaturated bonds in a molecule will tend to shift absorption to longer wavelengths

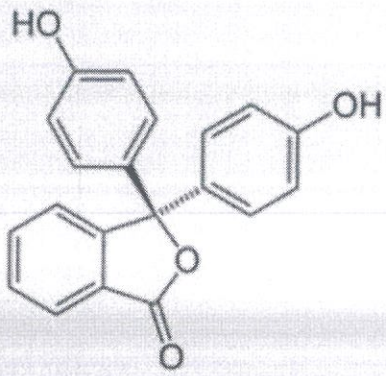
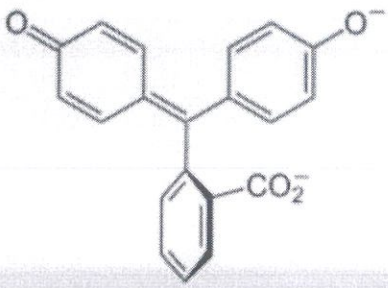
Structure		
pH	0–8.2	8.2–12.0
Conditions	acidic or near-neutral	basic
Color name	colorless	pink to fuchsia
Color		

Fig.7: Phenolphthalein changes structure & color in different medium

- *Metal complex chromophores*
  - The metal complex chromophores arise from the splitting of d-orbitals by binding of a transition metal to ligands.
  - Examples of such chromophores can be seen in chlorophyll, hemoglobin, hemocyanin, and colorful minerals such as malachite.

Auxochrome:

- An auxochrome can be defined as any group which does not itself acts as a chromophore but whose presence brings about a shift of the absorption band towards the red end of the spectrum (longer wavelength).
- These are covalently saturated groups with lone pair of electrons.
- The absorption at longer wavelength is due to the combination of a chromophore & an auxochrome to give rise to another chromophore. An auxochromic group is called as **color enhancing group**.
- Auxochromic group do not show characteristic absorption above 200 nm. Some common auxochromic groups are –OH, -OR, _NH_2, -NHR, -NR_2, -SH, etc.
- The effect of the auxochrome is due to its ability to extend the conjugation of a chromophore by the sharing of non-bonding electrons. Thus, a new chromophore results which has a different value of the absorption maximum as well as the extinction coefficient.

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In acidic solutions, a blue shift is caused and absorption takes place at short wavelength 225nm.

$\Rightarrow \lambda_{max} = 225nm, \varepsilon_{max} = 203$

NH_2 $\Rightarrow \lambda_{max} = 280nm, \varepsilon_{max} = 1430$

Mechanism: Hence, ($-NH_2$) amino group is an auxochrome. It involves the shift of absorption maximum towards shorter wavelength and may be caused by removal of conjugation in a system or by change of solvent.

- ❖ All auxochromic groups contain non-bonding electrons. Due to this, there is extension of conjugation of the chromophore by sharing the non-bonding electrons.

Spectral shifts (Fig.8):

Changes in chemical structure or the environment lead to changes in the absorption spectrum of molecules and materials. There are several terms that are commonly used to describe these shifts,

- Bathochromic effect,
- Hypsochromic effect,
- Hyperchromic effect,
- Hypochromic effect

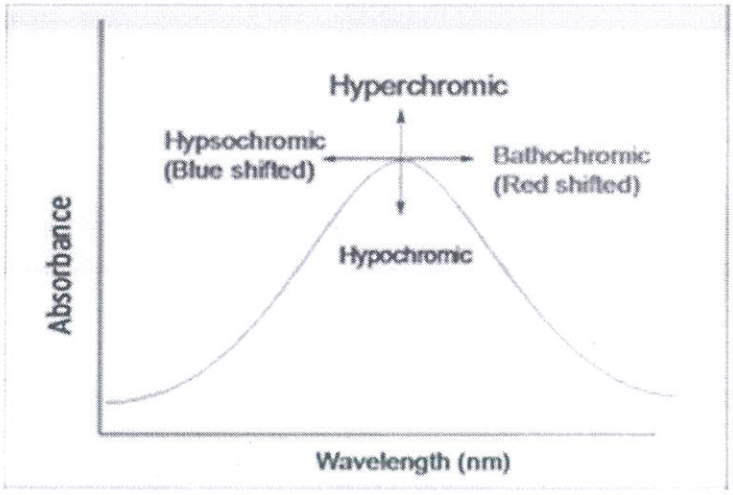

Fig. 8: Spectral shifts in UV-Visible range

a. Bathochromic shift:

- ➢ The absorptions of two or more chromophores which are separated by more than one bond are usually additive, but when chromophores are conjugated, i.e. separated by a single bond, pronounced effects are produced. The maximum absorption is shifted to longer wavelengths, thus bringing it into the working range of spectrophotometers.
- ➢ The effect, by virtue of which the absorption maximum is shifted towards longer wavelength due to the presence of an auxochrome or by the change of solvent, is called as **Bathochromic shift** or **Red shift**.

b. Hypsochromic shift:

- ➢ It is an effect by virtue of which the absorption maximum is shifted towards shorter wavelength. The absorption shifted towards shorter wavelength is called **Blue shift** or **Hypsochromic shift**.

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with the π-bond system of the benzene ring. But in acidic medium, aniline behaves as C_6H_5-NH_3^+ (anilinium ion) as the electron pair is no longer present & hence conjugation is removed, which causes ***blue*** shift & absorption occurs at shorter wavelength (λ_{max} = 203nm).

c. Hyperchromic shift:

- It is an effect due to which the intensity of absorption maximum increases, i.e. ε_{max} increases.

E.g. Pyridine => λ_{max} = 257 nm, ε_{max} = 2750

2-methyl pyridine => λ_{max} = 262 nm, ε_{max} = 3560

- The introduction of an auxochrome usually increases intensity of absorption.

d. Hypochromic shift:

- It is an effect due to which the intensity of absorption maximum decreases i.e. extinction coefficient, ε_{max} decreases.
- The introduction of group which distorts the geometry of the molecule causes **hypochromic effect**.

Biphenyl => λ_{max} = 250 nm, ε_{max} = 19000

2-methyl biphenyl => λ_{max} = 237 nm, ε_{max} = 10250

- It is due to the distortion caused by the methyl group in 2-methyl biphenyl.

Isoabsorptive points or Isobestic point (Fig. 9a & 9b):

- The wavelength of equal absorptivity of the two species (A & B), or same substance in two different mediums, that wavelength is known as ***isobestic point***.

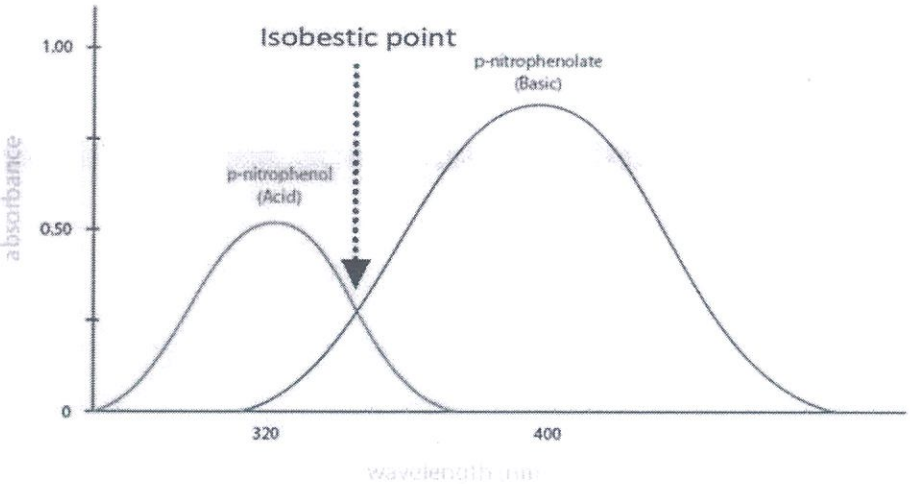

Fig. 9a: Spectra of p-nitrophenol in acidic and basic solution

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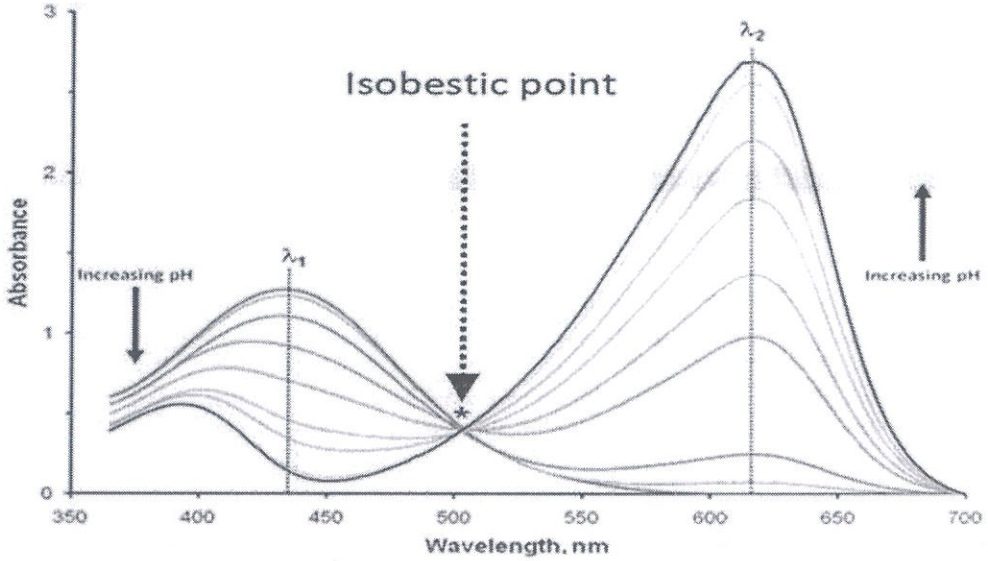

Fig. 9b: Spectra of the indicator bromothymol blue as a function of pH

Choice of Solvent used and effect of solvent on λ_{max}:

- A solvent is a liquid that dissolves another solid, liquid, or gaseous solute, resulting in a solution at specified temperature.
- The solvent use should be high purity, generally referred to as 'spectrograde'. Care should be taken to keep lint & dust from contaminating the final solutions.
- A good solvent should be transparent over the desired range of wavelengths. Usually solvents which do not contain conjugated system are most suitable for running the UV spectrum. E.g. commonly used solvents are water, 95% ethanol, n-hexane, cyclohexane.
- A solvent should be chosen so that it does not react chemically with the sample.
- Solvents can be broadly classified into two categories:
  - Polar
  - Non-Polar.
- A drug may show varied spectrum at particular wavelength in one particular condition but shall absorb partially at the same wavelength in another conditions.
- These appeared changes in the spectrum are exclusively due to various characteristic features namely-

  1. Nature of solvent
  2. Nature of absorption band
  3. Nature of the solute

Solvent effects:

- The solvent exerts a profound influence on the *quality* and *shape* of spectrum.
- The absorption spectrum of pharmaceutical substance depends practically upon the solvent that has been employed to solubilize the substance.
- A drug may absorb a maximum radiation energy at particular wavelength in one solvent but shall absorb partially at the same wavelength in another solvent.
- **Polarity plays an important role in the *position and intensity of absorption maximum of a*** particular chromophore.

solvents, a brownish color is obtained instead of purple color, because the absorption occurs at shorter wavelengths.

- Purified and certified solvents for spectroscopy should be used as we are looking for the "*smooth" absorbance curve of solvent.*
- Absorption bands of many substances are relatively sharper and may also exhibit fine structure when measured in solvents of low dipole moment.
- By increasing the polarity of the solvent, compounds like dienes & conjugated hydrocarbons do not experience any appreciable shift.

A suitable solvent for UV-spectroscopy should meet the following requirements.

- It should not itself absorb radiations in the region under investigation.
- It should be less polar so that it has minimum interaction with the solute molecules.
- The absorption maximum for the polar compounds is usually shifted with the change in the polarity of the solvents.
- If the chromophore involved in the transition is more polar in its ground state than in its excited state, then the ground state is more stabilized than the excited state by a more polar solvent due to solvation. Chromophores with $n \rightarrow \pi^*$ or $n \rightarrow \sigma^*$ transitions exhibit such behavior.
- The solvent molecules are oriented around the solute (chromophore) molecules to fit with the ground state charge distribution of the solute molecules. Hydrogen bonding or polar solvents interact more strongly with unshared electron pairs of the ground state molecule.
- On excitation, the charge distribution in such systems changes markedly and therefore, the solvent molecules would not have position and orientation to interact with the excited state charge distribution.
- Thus, the ground state of such solute molecules is more stabilized than the excited state. This widens the energy gap between the ground and excited states with increasing polarity of the solvents (Fig.9).
- Therefore, more energy is required for the $n \rightarrow \pi^*$ kind of electronic transition with increasing solvent polarity. This results in the shift of spectral peak positions towards shorter wavelength.
- On the other hand, if the excited state of the chromophore is more polar with respect to the ground state, then the excited state will be more solvated and more stabilized by a more polar solvent. This kind of property is observed in the case chromophores with $\pi \rightarrow \pi^*$ transitions.
- The π electron density is equally distributed in the ground state and the C nuclei are shielded whereas in the π^* excited state the C nuclei become electron deficient due to the electron promotion.
- This favors stronger interaction of the excited state molecule with more polar or hydrogen bonding solvents and thereby stabilizing the excited state more than the ground state.
- This decreases the energy gap between the excited and the ground states with increasing solvent polarity (Fig.9) which results in shift of absorption peak positions towards longer wavelengths.
- We may recall that a shift of the absorption peak position (λ_{max}) towards shorter wavelengths is called a blue shift or hypsochromic effect.
- On the other hand, a shift of the λ_{max} towards longer wavelength is termed as the red shift or bathochromic effect. When there is an increase in the absorption intensity, (i.e., absorbance) the effect is termed as hyperchromic effect. If there is a decrease in the absorption intensity, the effect is termed as hypochromic effect.

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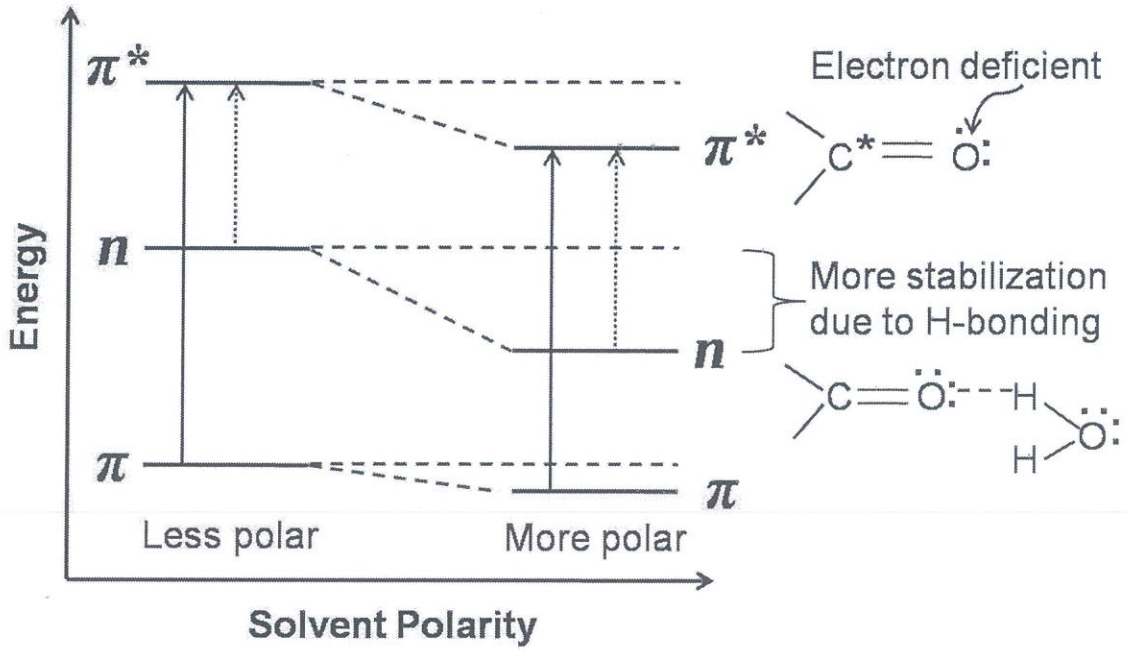

Fig.9: Effect of solvent polarity on n→π* and π →π* transitions.

- In short, π* orbitals are more stabilized by hydrogen bonding with polar solvents like water & alcohol. It is due to greater polarity of π* orbitals compared to π-orbital. Thus, small energy will be required for such a transition & absorption shows a red shift.
- If the group (carbonyl) is more polar in ground state than in the excited state, then increasing polarity of the solvent stabilizes the non-bonding electron in the ground state due to hydrogen bonding. Thus, absorption is shifted to shorter wavelength.
- If the group is more polar in excited state, then absorption is shifted to longer wavelength with increase in polarity of the solvent which helps in stabilizing the non-bonding electrons in the excited state.
  - Increase in polarity of solvents shifts η→ π* & η→ σ* to shorter wavelength,
  - Increase in polarity of solvents shifts π → π* to longer wavelength.

Example: *Effect of solvent polarity on spectrum of mesityl oxide (Table.2):*

Table.2:

Influence of Solvent on the UV λ_{max} and ϵ_{max} of the $n \longrightarrow \pi^*$ and $\pi \longrightarrow \pi^*$ Excitations of 4-Methyl-3-penten-2-one (Mesityl Oxide)*

$(CH_3)_2C{=}CH{-}\overset{\overset{O}{\|}}{C}{-}CH_3$

Solvent	$\pi \longrightarrow \pi^*$ Transition		$n \longrightarrow \pi^*$ Transition	
	λ_{max} (nm)	ϵ_{max} (liter mol^{-1} cm^{-1})	λ_{max} (nm)	ϵ_{max} (liter mol^{-1} cm^{-1})
Hexane	229.5	12,600	327	97.5
Diethyl ether	230	12,600	326	96
Ethanol	237	12,600	325	78
Methanol	238	10,700	312	74
Water	244.5	10,000	305	60

*From H.H. Jaffé and M. Orchin, Theory and Applications of Ultraviolet Spectroscopy, John Wiley & Sons, Inc., New York, 1962.

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Table.3: λ_{max} of different solvents in UV region

Solvent	λ of max. absorption
Water	191 nm
Ether	215 nm
Methanol	203 nm
Ethanol	204 nm
Chloroform	237 nm
Carbon tetrachloride	265 nm
Benzene	280 nm
Tetrahydrofuran	220 nm

Laws governing absorption of radiation:

Experimental measurements are usually made in terms of transmittance (T), which is defined as: $T = \frac{I_t}{I_0}$, where I_t is the light intensity after it passes through the sample and I_0 is the initial light intensity.

The relation between A and T is: $A = \log\frac{1}{T} = -\log T = -\log\frac{I_t}{I_0}$

Absorption of light by a sample:

There are two laws which govern the absorption of light by the molecules. These are:

1. Beer's law, 2. Lambert's Law

1. Beer's Law: This law states that, "when a beam of monochromatic radiation is passed through a solution of an absorbing substance, the rate of decrease of intensity of radiation with concentration of the absorbing solution is proportional to the intensity of incident radiation as well as the concentration of the solution."

i.e, $-\frac{dI}{dC} \alpha I$

or, $-\frac{dI}{dC} = K.I$ (where K = proportionality constant)

or, $-\frac{dI}{I} = K.dC$ ---------**equ^n. 1**

Let, when concentration = 0, then $I = I_0$ (intensity of incident light)

& when concentration = c, then $I = I_t$ (intensity of transmitted light)

I_0 I 0

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or, $-[\ln I]_{I_0}^{It} = K[C]_0^c + b$-------- **equⁿ. 2**

When 'c' = 0, intercept 'b' = 0

Thus, $-[\ln I_t - \ln I_0] = K[c-0] + 0$

or, $-\ln I_t + \ln I_0 = Kc$

or, $\ln I_0 - \ln I_t = Kc$

or, $\ln \frac{I_0}{I_t} = Kc$

or, $\frac{I0}{I_t} = e^{Kc}$, Or, $\mathbf{I_0 = I_t e^{Kc}}$---------- **equⁿ. 3**

or, $\frac{It}{I_0} = e^{-Kc}$,

or, $\mathbf{I_t = I_0 e^{-Kc}}$

2. Lambert's Law: It states that, "when a beam of monochromatic radiation passes through a homogenous absorbing medium, the rate of decrease of intensity of radiation with thickness (path length) of the absorbing solution is proportional to the intensity of incident radiation."

i.e, $-\frac{dI}{dt} \alpha I$

or, $-\frac{dI}{dt} = K.I$ (where K = proportionality constant)

or, $-\frac{dI}{I} = K.dt$ -------- **equⁿ. 4**

Let, when pathlength = 0, then, $I = I_0$ (intensity of incident light)

& when pathlength = t, then, $I = I_t$ (intensity of transmitted light)

By integrating the **equⁿ.4**, $\int_{I_0}^{I_t} -\frac{dI}{I} = \int_0^c K.dt$

or, $-[\ln I]_{I_0}^{It} = K[t]_0^t + b$ -------**equⁿ. 5**

When 't' = 0, intercept 'b' = 0

Thus, $-[\ln I_t - \ln I_0] = K[t-0] + 0$

or, $-\ln I_t + \ln I_0 = Kt$

or, $\ln I_0 - \ln I_t = Kt$

or, $\ln \frac{I_0}{I_t} = Kt$

or, $\frac{I0}{I_t} = e^{Kt}$, Or, $\mathbf{I_0 = I_t e^{Kt}}$---------- **equⁿ. 6**

or, $\frac{It}{I_0} = e^{-Kt}$,

or, $\mathbf{I_t = I_0 e^{-Kt}}$

by combining equⁿ. 3 & 6, we get

$\mathbf{I_0 = I_t e^{Kct}}$ --------- equⁿ. 7

The above equⁿ. can also be written by changing the natural logarithm to the base 10

$\mathbf{I_0 = I_t 10^{act}}$, where 'a' = extinction coefficient = K/2.303

or, $\frac{I0}{I_t} = 10^{act}$

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We know, transmittance (T) is expressed in terms of %T, $T = \frac{I_t}{I_0}$ &

absorbance $A = log\frac{1}{T} = -\log T = -\log(\frac{I_t}{I_0}) = \log(\frac{I_0}{I_t}) = act = \varepsilon ct$

Where ε = molecular extinction coefficient or molar absorptivity,

c = concentration of solution in moles/liter,

t = path length of the sample medium (usually 1cm)

or, $\varepsilon = \frac{A}{ct}$

or, $\varepsilon = E_{1cm}^{1\%} \times \frac{\text{Molecualr weigh}}{10}$

Where, $E_{1cm}^{1\%}$= absorbance of 1% w/v solution using a path length 1 cm, which is constant for each substance.

VISIBLE SPECTROSCOPY & COLORIMETRY:

- It is concerned with the study of absorption of visible radiation whose wavelength ranges from 380nm – 780nm.
- All coloured substances absorb in this wavelength region in different manner.
- Colourless solutions are converted to coloured solution by reacting with chemicals called as '**chromogenic reagent**' and the involved reaction is called as '**chromogenic reaction**'.
- The absorbing capacity of a coloured substance is directly proportional to the amount of desired constituent.

Properties of colored system:

- Sensitivity: Solution should be intensely colored & hence an easily detectable change in intensity can be obtained by small changes in the concentration.
- Stability: Intensity of color should remain constant for a long time.
- Specificity: Only desired constituent should develop a color.
- Conformity of Beer's law: The measurement may be facilitated for a single or poly-component system, if Beer's law is obeyed by the colored solution.

Instrumentation (Table.4):

UV or visible spectrophotometer / colorimeter consist of following apparatus as per requirement / maker.

- Source of light/ radiation
- Filter / monochromator (converts polychromatic light to monochromatic light).
  - Monochromator (Entrance slit, collimator, Prism/Grating, collimator, exit slit)
- Sample cell
- Detector

Source of Light

- Tungsten filament lamps and Hydrogen-Deuterium lamps are most widely used and suitable light source as they cover the whole UV region.
- Tungsten filament lamps are rich in red radiations; more specifically they emit the radiations of 375 nm, while the intensity of Hydrogen-Deuterium lamps falls below 375 nm.

Monochromator

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- The radiation emitted from the primary source is dispersed with the help of rotating prisms.
- The various wavelengths of the light source which are separated by the prism are then selected by the slits such the rotation of the prism results in a series of continuously increasing wavelength to pass through the slits for recording purpose.
- The beam selected by the slit is monochromatic and further divided into two beams with the help of another prism.

Sample and reference cells

- One of the two divided beams is passed through the sample solution and second beam is passé through the reference solution.
- Both sample and reference solution are contained in the cells.
- These cells are made of either silica or quartz. Glass can't be used for the cells as it also absorbs light in the UV region.

Detector

- Generally, two photocells serve the purpose of detector in UV spectroscopy.
- One of the photocell receives the beam from sample cell and second detector receives the beam from the reference.
- The intensity of the radiation from the reference cell is stronger than the beam of sample cell. This results in the generation of pulsating or alternating currents in the photocells.

Amplifier

- The alternating current generated in the photocells is transferred to the amplifier.
- The amplifier is coupled to a small servometer.
- Generally current generated in the photocells is of very low intensity, the main purpose of amplifier is to amplify the signals many times so we can get clear and recordable signals.

Recording devices

- Most of the time amplifier is coupled to a pen recorder which is connected to the computer.
- Computer stores all the data generated and produces the spectrum of the desired compound.

Table.4: Instruments used in UV-Visible Spectrophotometer

Apparatus	Colorimeter	Spectrophotometer	
		Visible	UV
Source of radiation	Tungsten lamp, carbon arc lamp	Tungsten lamp, carbon arc lamp	Hydrogen lamp, deuterium lamp, xenon lamp, mercury arc lamp
Filters/ monochromators	Absorption filter, interference filter	Prism type monochromator (Dispersive / Refractive, Littrow / Reflective type)	Grating type monochromator (Diffraction, Transmission)
Sample cell	Cylindrical Glass/plastic type	Rectangular glass type	Rectangular quartz type
Detector	Barrier layer cell / photo voltaic cell	Phototubes / photo emissive cells, Photomultiplier tubes, Silicon Photodiode	Phototubes / photo emissive cells, Photomultiplier tubes, Silicon Photodiode

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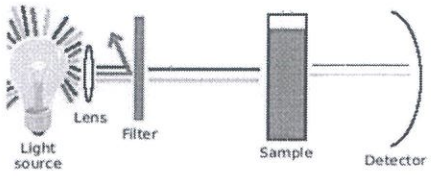

Fig.10: Single beam colorimeter

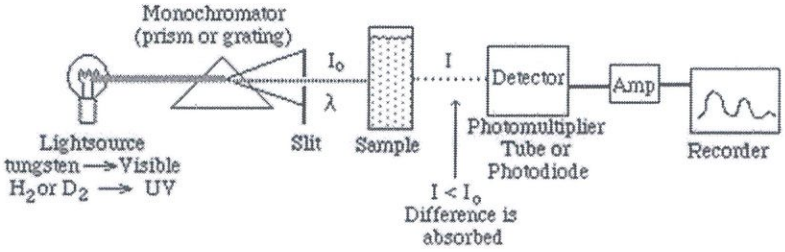

Fig.11: Single beam spectrophotometer

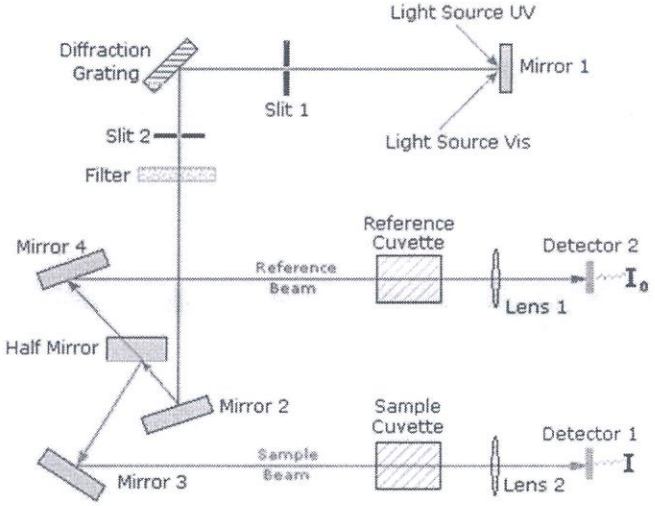

Fig.12: Double beam spectrophotometer

Fig. 13: Cuvette-based single-beam array spectrophotometer

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Deviation of Beer's law (Fig.14):

- A system is said to obey Beer's law, when a plot of absorbance Vs concentration gives a straight line. The straight line is obtained by using line of best fit or method of least squares or by joining the maximum no. of points in such a way that positive & negative errors are balanced or minimized.
- When a straight line is not obtained i.e. non-linear curve is obtained in a plot of concentration Vs absorbance i.e. called as Beer's deviation; that may be positive or negative deviation.
- Positive deviation => when a small change in concentration produces greater change in absorbance.
- Negative deviation => when a large change in concentration produces small change in absorbance.

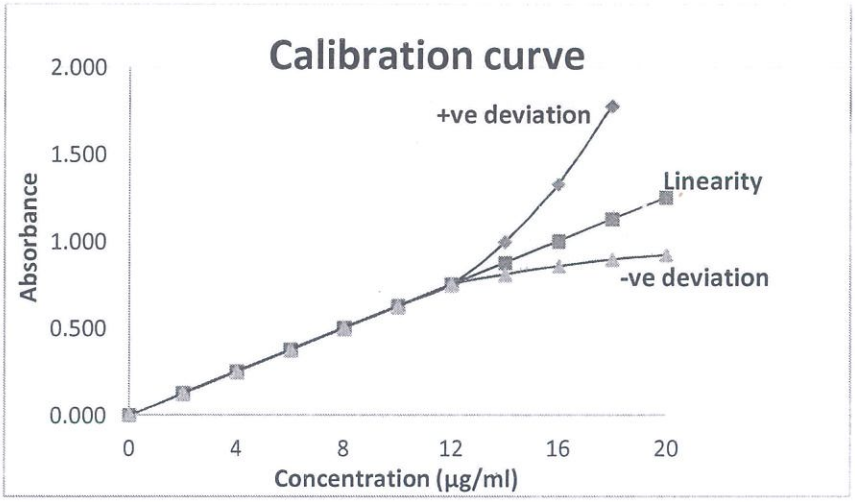

Fig.14: Calibration curve of a chemical in different solution

Factors involved for deviation:

ii. Instrumental -
   a. Stray radiation
   b. Improper slit width
   c. Fluctuation in single beam
   d. Use of non-monochromatic light

iii. Physiochemical changes in solution –

- Association => Methylene blue at concentration 10^{-5} present as monomer form and absorbs at λ_{max} 660nm, but above concentration 10^{-4} present as dimer & trimer form and absorbs at λ_{max} 600nm.
- Dissociation => $K_2Cr_2O_7$ in higher concentration solution orange in color & shows λ_{max} 450nm where as in lower concentration yellow solution & absorbs at λ_{max} 410nm.

$$Cr_2O_7^{2-} + H_2O \leftrightarrow 2HCrO_4^{2-} \leftrightarrow 2H^+ + 2CrO_4^{2-}$$

Orange yellow

- Ionization (change in pH)
- Faulty development of colour (incompletion of reaction), shows instability in color. Eg: determination of Fe using thioglycolic acid before completion of reaction.
- Refractive index at higher concentration.

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Applications of UV-Visible spectroscopy:

- *Detection of functional groups:* To detect the presence or absence of chromophore. The absence of a band at particular wavelength may be regarded as an evidence for the absence of a particular group in the compound. If the spectrum is transparent above 200nm, it shows the absence of (i) conjugation, (ii) a carbonyl group (aldehyde & ketones), (iii) benzene or aromatic compounds, (iv) bromo or iodo atoms.
- *Extent of conjugation:* The extent of conjugation in polynes R-$(CH=CH)_n$-R can be estimated. Addition in un-saturation with the increase in the number of double bonds (increase in the value of n) shifts the absorption to longer wavelength.
- *Qualitative analysis / Identification of an unknown compound:* An unknown compound can be identified by comparing its spectrum with the known spectra. If the two spectra coincide, the two compounds must be identical. If two spectra do not coincide, then the expected structure is different from the known compound.
- UV/VIS spectroscopy is used as a tool to identify if the analyte is pure and did not undergo decomposition. For example, this technique is used for quality control of incoming raw material, and for the purity check of biologically relevant compounds such as the nucleic acids, DNA and RNA. Additionally, the melting point of DNA can be determined by recording its UV/VIS spectrum at different temperatures. Finally, by means of UV/VIS spectroscopy it is possible to differentiate between saturated and unsaturated fatty acids present in olive oil, and thus to monitor its quality.
- *In food & beverage industry:* To monitor and improve product quality and consistency. The influence of packing material and stabilizers as well as chemical deterioration and degradation processes can also be observed with this method. A typical application in this market segment is the check for the purity of olive oil, which enables the product to be classified as "Extra Virgin", "Virgin", or simply "Olive Oil". Standards are in place for the evaluation of olive oil based on the absorbance characteristics of certain molecules in the UV/VIS spectrum. Olive oil contains about 98% triglycerides. Unsaturated fatty acids in the oil are susceptible to breakdown and oxidation. The oxidation of free fatty acids causes the formation of peroxides. This leads to rancidity and degradation of the olive oil over time. Beside other parameters, this effect is evaluated by the conjugated di-enes and tri-enes of unsaturated fatty acids (conjugated C=C double bonds) which absorb in the range of 230 to 270 nm.
- *In chemical industry:* For the determination of the purity of organic solutions. Additional peaks appearing at specific wavelengths can be observed due to impurities in the sample. An example in the chemical industry is the purity control in alcohol. Alcohol can be contaminated by benzene, which absorbs light at 280 nm, whereas alcohol absorbs at 210 nm. The measurement of the UV/VIS spectrum can easily tell if the sample is contaminated if an extra peak is present at 280 nm.
- *Distinction in conjugated & non-conjugated compounds:* It also distinguishes between a conjugated & a non-conjugated compound.
- *Structure elucidation of organic compounds.*
- *Determination of pKa value of indicators:* pKa = pH - [log (ionized/unionized)].
  The value of log (ionized/unionized) can be determined spectrophotometrically i.e. concentration Vs. absorbance at different pH & from the equation pKa can be calculated.
- *Quantitative analysis:*
  - Using ε_{max} values ($E^{1\%}_{1cm}$)

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❖ Calibration curve method

- Based on the Lambert-Beer Law, the concentration of a compound in a solution can be determined quantitatively by UV/VIS spectroscopy. To perform that, a calibration line is first determined by measuring the absorption of several standard solutions of known concentration. In this way, the concentration of samples such as, DNA, RNA, proteins, carbohydrates or organic compounds can be determined.
- The linear relationship between absorbance and concentration of a sample opens the door for a variety of quantitative analyses.
- To determine an unknown concentration of a sample solution by UV/VIS spectroscopy, a calibration line must first be created. This is done by measuring the light absorption of several standard solutions of different, known concentrations at a predefined, fixed wavelength. In the following example, 5 standard solutions of increasing concentrations were measured at a predefined wavelength:

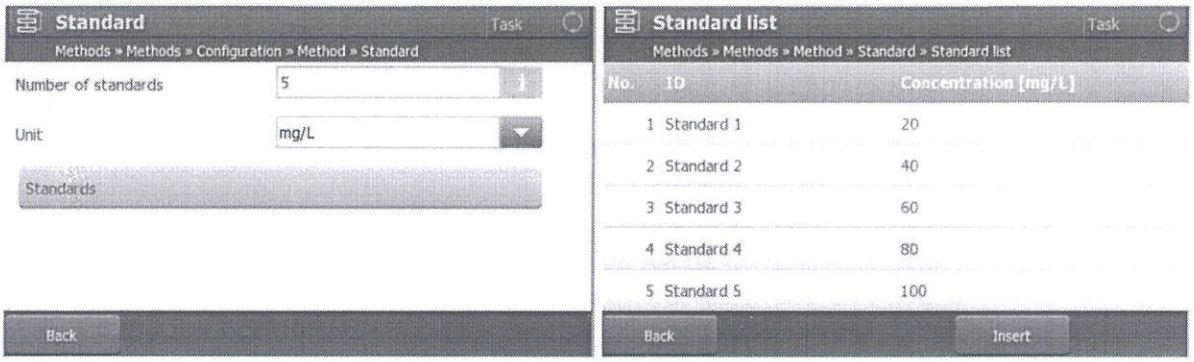
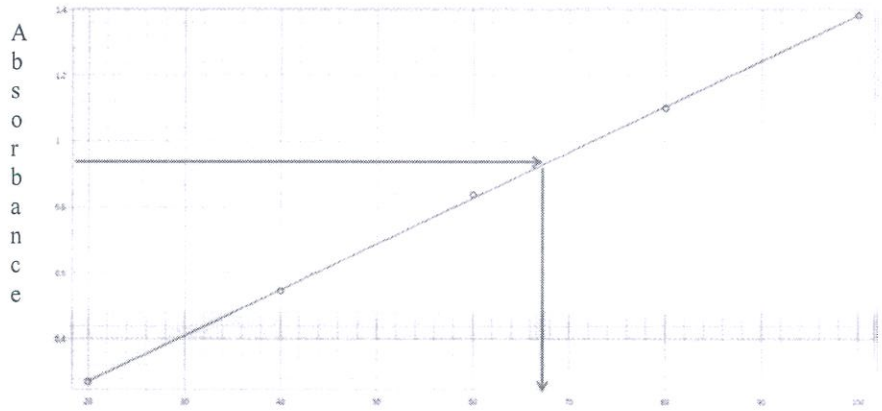


Fig. : The calibration step and the standard list to determine the calibration line are indicated on the instrument display

- A calibration line was obtained by plotting the absorbance values as a function of the concentration. Finally, a linear regression of the measured values gives the calibration line:



- Using the calibration line, an unknown sample can now be determined from its absorbance.

- *Determination of molecular weight*
- *Chemical kinetics:* Zero order, 1st order, 2nd order reaction
- *Assay of pharmaceutical substances*
- *Keto-enol tautomerism.*

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C. FLUORIMETRY / FLUORESCENCE SPECTROSCOPY

Fluorescence: It is a phenomenon of emission of radiation when the molecules are excited by radiation at certain wavelength.

Fluorimetry: It is measurement of fluorescence intensity at a particular wavelength with the help of a filter fluorimeter or a spectrofluorimeter.

Principle:

- Molecule contains σ electrons, π electrons and nonbonding (n) electron.
- The electrons may be present in bonding molecular orbital. It is called as highest occupied molecular orbital (HOMO). It has lest energy and more stable.
- When the molecules absorb radiant energy from a light source, the bonding electrons may be promoted to anti bonding molecular orbital (LUMO). It has more energy and hence less stable.

The process of promotion of electrons from HOMO to LUMO with absorption of energy is called as excitation.

- **Singlet state**: a state in which all the electrons in a molecule are paired ↓↑
- **Doublet state**: a state in which un paired electrons are present ↓ or ↑
- **Triplet state**: a state in which unpaired electrons of same spin present ↑ ↑
- **Singlet excited state**: a state in which electrons are unpaired but of opposite spin like ↑ ↓ (un paired and opposite spin)

When light of appropriate wavelength is absorbed by a molecule the electrons are promoted from singlet ground state to singlet excited state. Once the molecule is in this excited state, relaxation can occur via several processes by emission of radiation. The processes can be the following

1) Collisional deactivation

2) Fluorescence

3) Phosphorescence

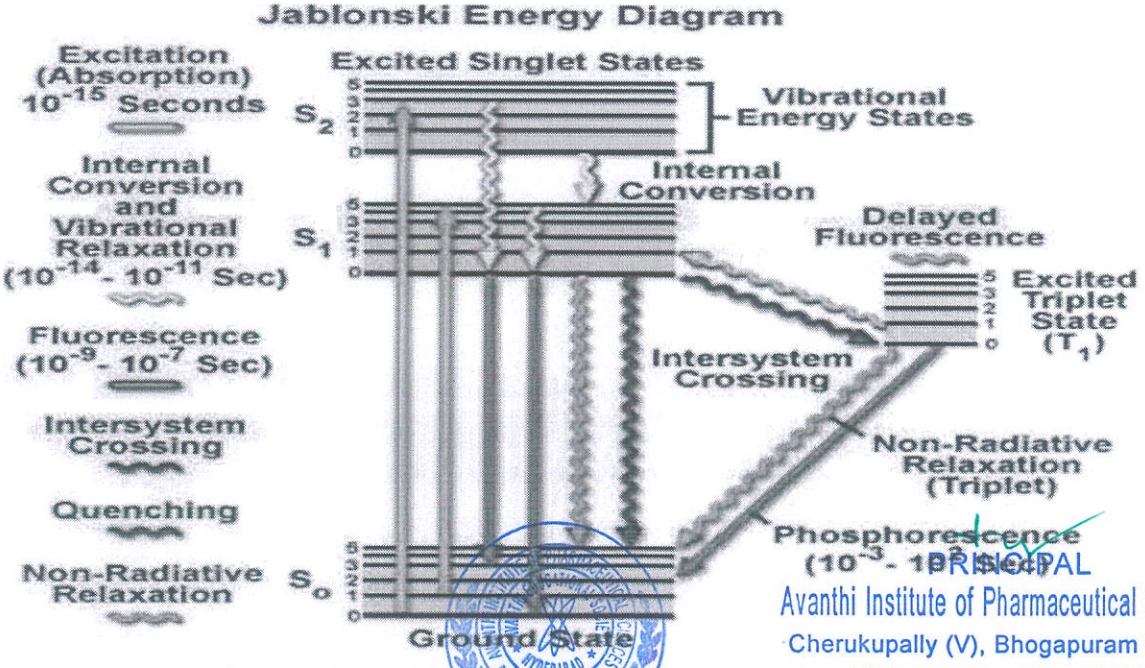

Fig.15: Calibration curve of a chemical in different solution

Collisional deactivation: In which entire energy lost due to collision de activation and no radiation emitted.

Fluorescence: excited singlet state is highly unstable. Relaxation of electrons from excited singlet to singlet ground state with emission of light.

Phosphorescence: At favorable condition like low temperature and absence of oxygen there is transition from excited singlet state to triplet state which is called as inner system crossing. The emission of radiation when electrons undergo transition from triplet state to singlet ground state is called as phosphorescence.

Internal conversion: Intermolecular process by which a molecule passes to a lower energy electronic state without emission of light. Overlap of vibrational energy levels in two electronic energy levels.

External conversion: Deactivation of an excited electronic state by interaction and energy transfer between the excited molecule and solvent or other solutes.

Intersystem crossing: Process in which spin of an excited electron is reversed and change in multiplicity results. Most common when vibrational manifold overlap exists and when the molecule has a heavy atom substituent (e.g., Br, I).

Factors affecting fluorescence intensity:

1. Concentration
2. Quantum yield of fluorescence
3. Intensity of incident light
4. Adsorption
5. Oxygen
6. pH
7. Temperature& viscosity
8. Photodecomposition
9. Quenchers
10. Scatter

1. Concentration:

Fluorescence intensity is proportional to concentration of substance only when the absorbance is less than 0.02

We know, Absorbance 'A' = log I_o/I_t, Or, A= abc

I_o=intensity of incident light

I_t=intensity of transmitted light

a= absorptivity of constant

b= Pathlength

c= concentration

2. Quantum yield of fluorescence (ϕ):

- (ϕ) = number of photons emitted/number of photons absorbed
- It is always less than 1.0 since some energy is lost by radiation less pathways (Collisional, Intersystem Crossing, Vibrational Relaxation)

3. Intensity of incident light:

Increase in the intensity of incident light on the sample fluorescence intensity also increases.

4. Adsorption: Adsorption of sample solution in the container may leads to a serious problem.

5. Oxygen: Oxidation of fluorescent species to a non-fluorescent species, quenches fluorescent

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6. pH: Alteration of pH of a solution will have significant effect on fluorescence. E.g., Aniline in alkali medium gives visible fluorescence but in acidic condition gives fluorescence in visible region.

7. Temperature and viscosity:

- Temperature increases can increase the collisional de activation, and reduce fluorescent intensity.
- If viscosity of solution is more the frequency of collisions are reduced and increase in fluorescent intensity.

8. Photochemical decomposition: Absorption of intense radiation leads to photochemical decomposition of a fluorescent substance to less fluorescent or non-fluorescent substance.

9. Quenchers:

- Quenching is the reduction of fluorescence intensity by the presence of substance in the sample other than the fluorescent analyte.
- Quenching is following types:
  - *Inner fluorescent effect.* Absorption of Incident (UV) light or emitted (fluorescent) light by primary and secondary filters leads to decrease in fluorescence intensity.
  - *Self-quenching:* At low concentration linearity is observed, at high concentration of the same substance increase in fluorescent intensity is observed. This phenomenon is called self-quenching.
  - *Collisional quenching: C*ollisions between the fluorescent substance and halide ions leads to reduction in fluorescence intensity.
  - *Static quenching:* This occurs because of complex formation between the fluorescent molecule and other molecules. Ex: caffeine reduces fluorescence of riboflavin.

10. Scatter: Scatter is mainly due to colloidal particles in solution. Scattering of incident light after passing through the sample leads to decrease in fluorescence intensity.

Instrumentation:

1) Source of light:

- ***Mercury vapor lamp:*** Mercury vapor at high pressure give intense lines on continuous background above 350nm.low pressure mercury vapor gives an additional line at 254nm.it is used in filter fluorimeter.
- ***Xenon arc lamp:*** It give more intense radiation than mercury vapor lamp. it is used in spectrofluorimeter.
- ***Tungsten lamp:*** If excitation has to be done in visible region this can be used. It is used in low cost instruments.

2) Filters and Monochromators:

- **Filters:** These are nothing but optical filters work on the principle of absorption of unwanted light and transmitting the required wavelength of light. In inexpensive instruments fluorimeter primary filter and secondary filter are present.
  - *Primary filter:* Absorbs visible radiation and transmit UV radiation.
  - *Secondary filter*: Absorbs UV radiation and transmit visible radiation.
- **Monochromators:** They convert polychromatic light into monochromatic light. They can isolate a specific range of wavelength or a particular wavelength of radiation from a source.
  - *Excitation monochromators:* Provides suitable radiation for excitation of molecule.

3) Sample cells: These are meant for holding liquid samples. These are made up of quartz and can have various shapes ex: cylindrical or rectangular etc.

4) Detectors: Photometric detectors are used. They are

- ***Barrier layer /photovoltaic cell:***
  - It is employed in inexpensive instruments. For ex: Filter Fluorimeter.
  - It consists of a copper plate coated with a thin layer of cuprous oxide (Cu_2O). A semi-transparent film of silver is laid on this plate to provide good contact.
  - When external light falls on the oxide layer, the electrons emitted from the oxide layer move into the copper plate.
  - Then oxide layer becomes positive and copper plate becomes negative.
  - Hence an emf develops between the oxide layer and copper plate and behaves like a voltaic cell. So, it is called photovoltaic cell.
  - A galvanometer is connected externally between silver film and copper plate and the deflection in the galvanometer shows the current flow through it.
  - The amount of current is found to be proportional to the intensity of incident light
- ***Photomultiplier tubes (PMT):***
  - These are incorporated in expensive instruments like spectrofluorimeter. Its sensitivity is high due to measuring weak intensity of light.
  - The principle employed in this detector is that, multiplication of photoelectrons by secondary emission of electrons.
  - This is achieved by using a photo cathode and a series of anodes (Dyanodes). Up to 10 dyanodes are used. Each dyanode is maintained at 75 - 100V higher than the preceding one.
  - At each stage, the electron emission is multiplied by a factor of 4 to 5 due to secondary emission of electrons and hence an overall factor of 106 is achieved.
  - PMT can detect very weak signals, even 200 times weaker than that could be done using photovoltaic cell. Hence it is useful in fluorescence measurements.
  - PMT should be shielded from stray light in order to have accurate results.

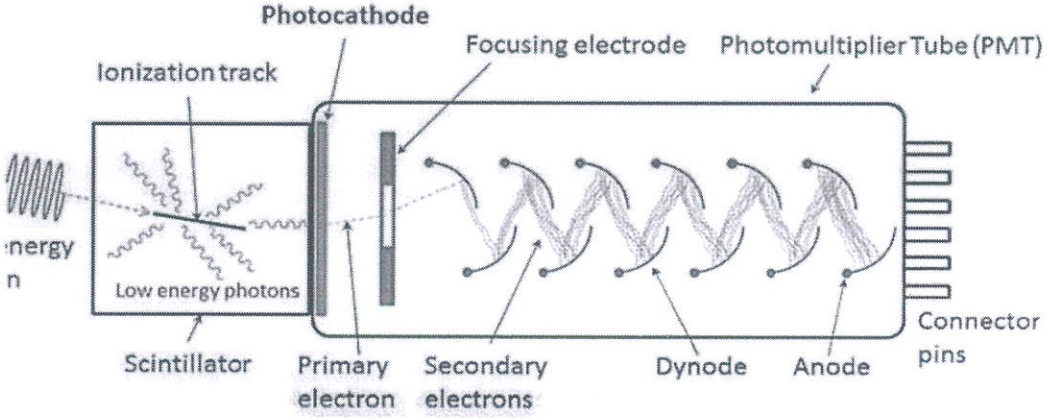

Fig.16: Schematic diagram of Photo Multiplier Tube (PMT)

Instruments:

The most common types are:

- Single beam (filter) fluorimeter

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- ***Single beam (filter) fluorimeter***
  - It contains tungsten lamp as a source of light and has an optical system consists of primary filter.
  - The emitted radiations are measured at 900 by using a secondary filter and detector. Primary filter absorbs visible radiation and transmit UV radiation which excites the molecule present in sample cell.
  - Instead of 90 if we use 180 geometry as in colorimetry secondary filter has to be highly efficient otherwise both the unabsorbed UV radiation and fluorescent radiation will produce detector response and give false result.
  - Single beam instruments are simple in construction cheaper and easy to operate.
- ***Double beam fluorimeter***
  - It is similar to single beam except that the two incident beams from a single light source pass through primary filters separately and fall on another reference solution. Then the emitted radiations from the sample or reference sample pass separately through secondary filter and produce response combinedly on a detector.

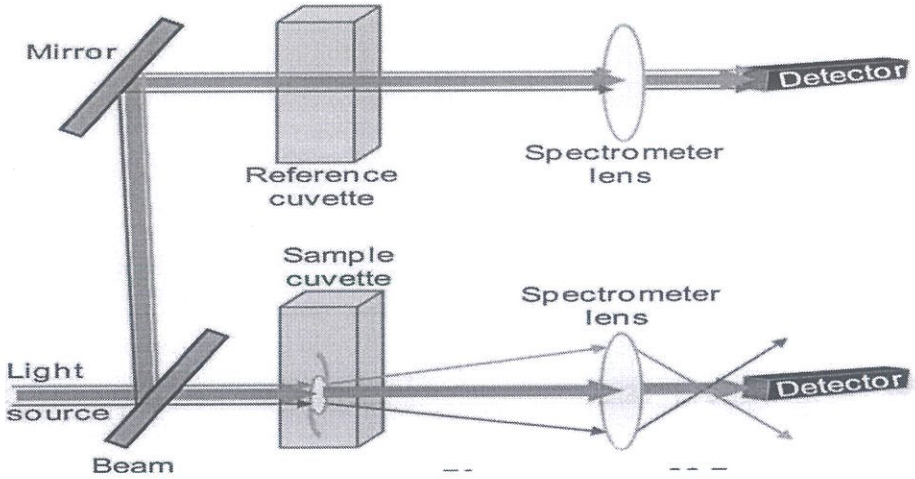

Fig.17: Double beam fluorimeter

- ***Spectrofluorimeter:***

  □ In this primary filter in double beam fluorimeter is replaced by excitation monochromator and the secondary filter is replaced by emission monochromator.

  □ Incident beam is split into sample and reference beam by using beam splitter.

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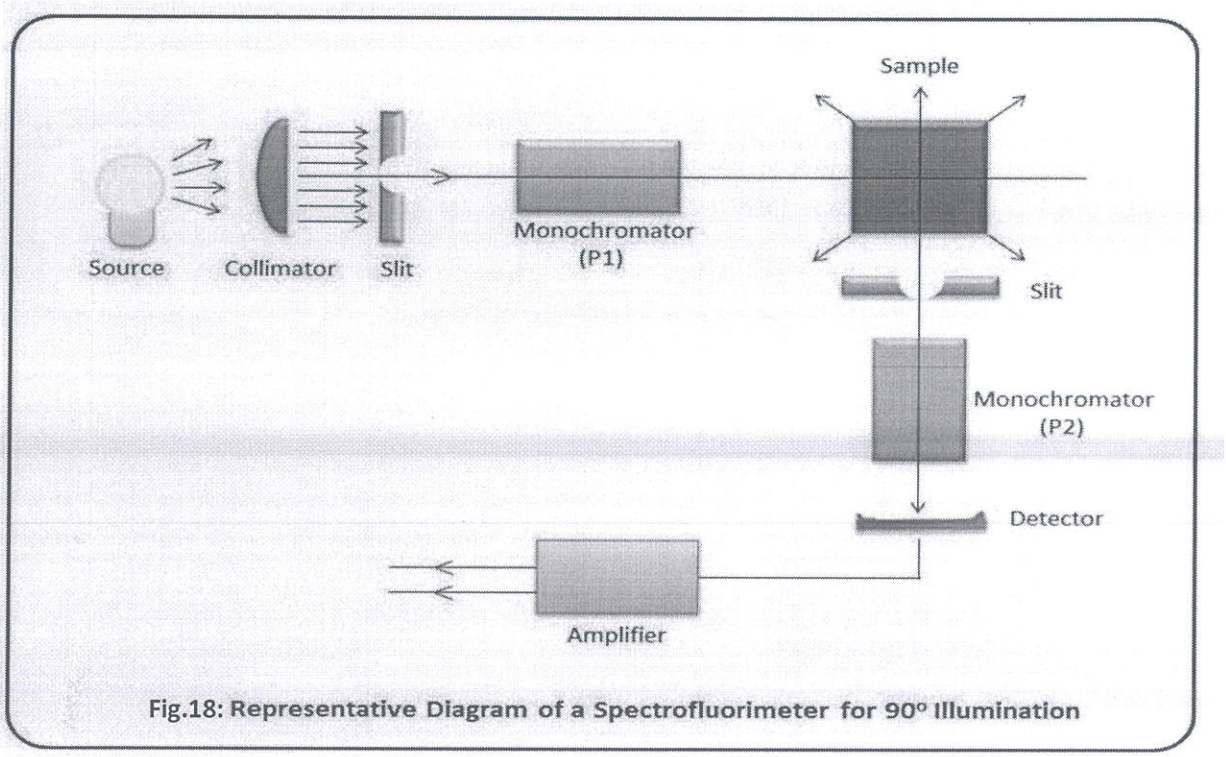

Fig.18: Representative Diagram of a Spectrofluorimeter for 90° Illumination

Applications:

- Fluorimetric methods are not useful in qualitative analysis and much used in quantitative analysis.
- Determination of inorganic substances. Al^{3+}, Li^{+}, Zn^{2+}
- Determination of thiamine HCl.
- Determination of phenytoin.
- Determination of indoles, phenols, & phenothiazines
- Determination of napthols, proteins, plant pigments and steroids.
- Fluorimetry, nowadays can be used in detection of impurities in nanogram level better than absorbance spectrophotometer with special emphasis in determining components of sample at the end of chromatographic or capillary column.
- Determination of ruthenium ions in presence of other platinum metals.
- Determination of boron in steel, aluminum in alloys, manganese in steel.
- Determination of boron in steel by complex formed with benzoin.
- Estimation of cadmium with 2-(2 hydroxyphenyl) benzoxazole in presence of tartarate.
- Respiratory tract infections.

S.No	Name of the compound	Experimental conditions/ PH	Emission Wavelength (nm)
1	Adrenaline	1	335
2	Cynacobalamine	7	305
3	Riboflavin	6	520
4	Morphine	7	350
5	Hydrocortisone	Acidic	520

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UNIT –I
CHAPTER-1
B. INFRARED (IR) SPECTROSCOPY

Learning Outcome(s):

After studying the chapter, the students will be able to:

1. Define infrared spectroscopy
2. Describe the principle involved in IR measurements
3. Enumerate the factors that affect vibrational frequencies
4. Remember the difference between "Finger print region" and "Group region"
5. Explain the instrumental components and their working
6. Apply the knowledge in pharmaceutical quality control

Introduction

The infrared (IR) spectroscopy deals with the study of absorption of infrared radiation by chemical compounds.

The IR radiation corresponds to the region between visible and microwave region of electromagnetic spectrum.

The IR spectrum is mainly used to determine the functional groups present in a compound and elucidate the structure of compound.

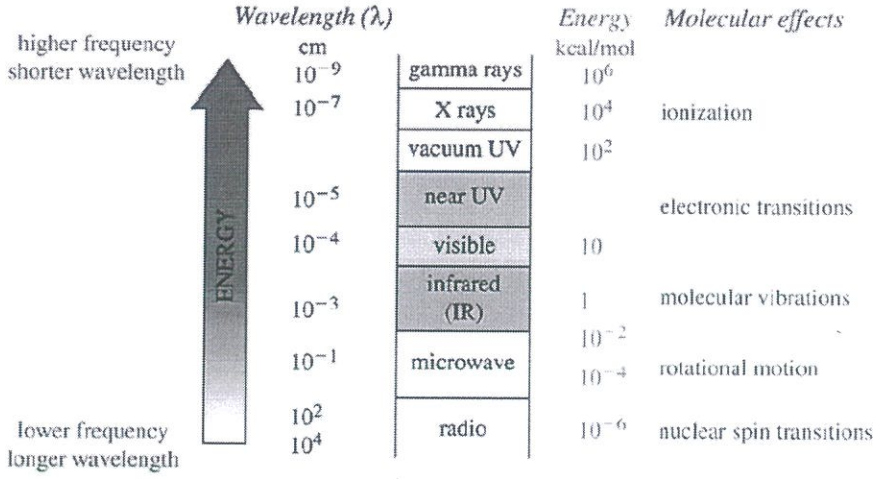

Fig.1. Various wavelength ranges of electromagnetic radiations (EMR)

Principle

The energy of a molecule=Electronic energy + Vibrational energy + Rotational energy

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Different compounds when absorb infrared radiation give rise to vibrational transitions characteristic to the molecular structure and those transitions are recorded as IR Spectra.

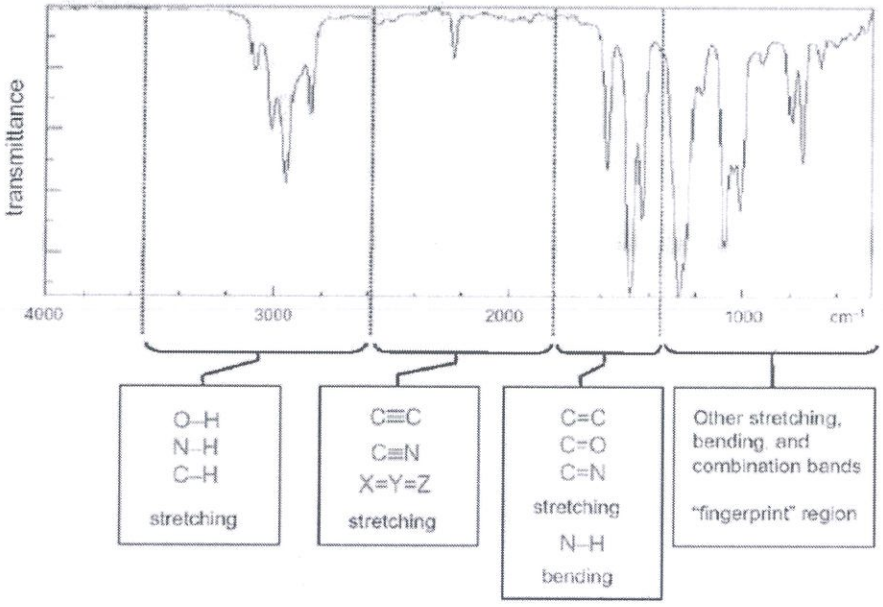

Fig.2. Typical IR spectrum depicting regions of absorption

The infrared range covers from 14,290—200 cm^{-1}.

It is further subdivided into three regions:

1. Near IR region: 14290—4000cm $^{-1}$ (0.75 to 2.5μ)
2. Mid IR region: 4000—666cm $^{-1}$(25 to 2.5μ)
3. Far IR region:700— 200cm $^{-1}$(25 to 1000μ)

Out of these three regions the Mid IR region is widely used in pharmaceutical studies.

Overall, the IR region is broadly divided into:

Finger print region (400-1500cm $^{-1}$): This region of IR spectrum provides characteristic peaks for different part of a molecule and helps in qualitative identification of compounds.

Group frequency region (4000—1500cm $^{-1}$): Peaks with respect to different functional groups are observed in this region. Table 1 enlists various functional groups and their corresponding frequency regions.

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Table 1. Characteristic IR frequencies of some known functional groups

Functional group	Vibration Type	Freequency(cm-1)
ALCOHOL		
O-H	(stretch, H-bonded)	3200-3600
O-H	(stretch, free)	3500-3700
C-O	(stretch)	1050-1150
ALKANE		
C-H	stretch	2850-3000
-C-H	bending	1350-1480
ALKENE		
=C-H	stretch	3010-3100
=C-H	bending	675-1000
C=C	stretch	1620-1680
ALKYL HALIDE		
C-F	stretch	1000-1400
C-Cl	stretch	600-800
C-Br	stretch	500-600
C-I	stretch	500
ALKYNE		
~~C-H~~	stretch	3300
⎯C≡C⎯	stretch	2100-2260
AMINE		
N-H	stretch	3300-3500
C-N	stretch	1080-1360
N-H	bending	1600
AROMATIC		
C-H	stretch	3000-3100
C=C	stretch	1400-1600
CARBONYL		
C=O	stretch	1670-1820
ETHER		
C-O	stretch	1000-1300
NITRILE		
C-N	stretch	2210-2260
NITRO		

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N-O	stretch	1515-1560 & 1345-1385

Principle

Molecules consist of atoms or group of atoms that are connected by bonds which are analogous to springs. These bonds are flexible in nature in the molecules and they move continuously to gain vibrations having some frequency. This frequency of vibration is characteristic to the different parts of the molecule and hence, it can be called as the ***natural frequency of vibration.*** When we apply an external infrared frequency and it matches the natural frequency of vibration within a molecule the applied energy is then absorbed by the molecule and an infrared peak is observed. These peaks are characteristic to different functional group and parts of the molecule and they are unique for every molecule. Hence the IR spectroscopy is considered as the fingerprint analysis of a molecule.

The IR region is measured in terms of Wavenumber and it is expressed as:

"It is the number of waves present per cm i.e. Wavenumber = 1/Wavelength (μm) × 10^4

A compound can be analyzed by IR radiation only if:

1. There is a change in dipole movement
2. There should be a resonance in applied and natural IR frequency

Fundamental modes of vibrations in a polyatomic molecule

There are mainly two types of vibrations that are present within a molecule.

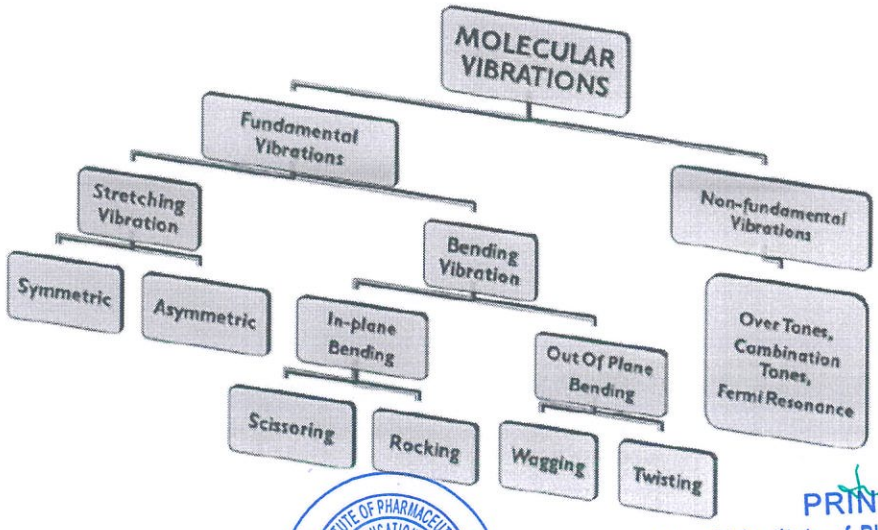

Fig. 3. Overall classification of molecular vibrations

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They are:

1. Stretching vibration: In stretching vibration, the length of a bond is changed i.e. either increased or decreased. It is of two types:

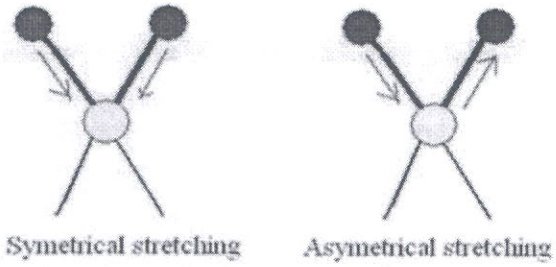

Fig.4. Types of stretching vibrations

A] Symmetrical stretching: Here the two bonds increase or decreases in length in a symmetric pattern.

B] Asymmetrical stretching: Here when one bond length increases the other ones decreases.

2. Bending vibration:

Bending vibrations are of two sub-types.

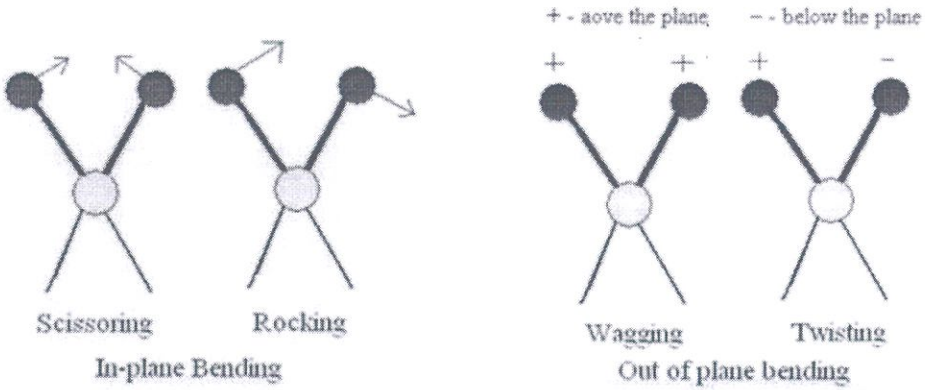

Fig. 5. Types of bending vibrations

A] In plane bending and we Out-of-plane bending:

When there is a change in bond angle during the vibration it is called is in plane bending and the bending of bonds occur within a plane. The implant bending can be again of two subtypes known as scissoring where the bond angle decreases and rocking with the bond angle is unaltered however both the bond moves within the same plane. In case of out of plane bending the bending occurs in different planes of the molecule and is again subdivided into two types.

(a) Wagging where both atoms move to one side of the plane and

(b) Twisting where one atom remains above the plane whereas the other one below the plane.

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The total number of fundamental vibrations for any given polyatomic molecule having "n" number of atoms can be determined using the expression:

A] 3n- 6 for the nonlinear molecule

B] 3n- 5 for the linear molecule

However, few other kinds of vibrations can also be found in infrared spectrum known as overtones, combination bands, difference bands and Fermi resonance.

- The ***overtone*** vibrations occur at twice or thrice the value of fundamental vibrations.
- ***Combination bands*** are the bands that result because of coupling of fundamental frequencies
- ***Difference bands*** are noticed at the frequency which is actually the difference of two bands.
- ***Fermi resonance*** bands are produced because of coupling between fundamental vibration and an overtone or because of a combination band.

According to the expression stated above for linear or non-linear molecules it is very difficult to obtain the predicted number of vibrations. There may be a variation in the predicted number of bands and observed number of bands due to:

1] More number of bands may be produced due to:

- Overtones
- Combination bands

2] Less bands may be obtained:

- When a vibration doesn't involve a change in dipole moment
- When the fundamental bends fall outside the region of 4000 to 400 cm^{-1}
- When the bands are too weak to be observable
- When the vibrations occur very close to each other such that they coalesce
- In a symmetrical molecule many absorptions with same frequency produce a degenerate band

Sample handling

The sample cells are usually made up of transparent ionic substances such as sodium chloride (NaCl) or potassium bromide (KBr). However, KBr is preferred because of its compatibility with the instrumental measurement process. The infrared samples can be considered of three forms such as:

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Liquids:

- A drop of liquid is placed within the KBr plates with the thickness less than 0.01 mm.
- Around 1-10mg of sample is required to prepare the solution.
- Aqueous solutions are not preferred as they tend to dissolve the sample cells so the solvent should be anhydrous and mostly organic solvents such as chloroform is preferred.

Solid solutions:

- To prepare a solid solution 1 to 10 mg volumes of 0.1 to 1.0 ml of 0.05 to 10% solution are required for placement within a cell of 0.1 to 1mm thickness.
- CCl_4 is used for this purpose which absorbs strongly at 785 cm^{-1}.
- Care should be taken to avoid solution combinations that react instantaneously.

Solids:

- The solid samples can be prepared using pressed pellet technique where the sample is placed in KBr pellets are prepared in form of thin transparent layer using a hydraulic press.
- However, as KBr is hygroscopic in nature care should be taken to minimise its atmospheric exposure.
- Another technique called as Nuzol-Mull technique (popularly called as Mull Technique) may be used where the mixing up of the sample with a mineral oil (Nujol) is done and afterwards a thin film of the liquid can be applied on the liquid sample cell for measurements.

Factors effecting vibrations:

Following are the factors that affect vibrational frequencies in a molecule

A] Coupled vibration

- ✓ An isolated C-H bond has only one stretching vibration frequency where as methylene group shows two stretching vibrations both symmetrical and asymmetrical.
- ✓ Because of mechanical coupling or interaction between CH stretching vibrations in the CH_2 group.
- ✓ Asymmetric vibrations develop at higher frequency or wave numbers than stretching vibrations
- ✓ Such vibrations are called coupled vibrations because these vibrations occur at different frequency then the required for an isolated CH stretching

B] Fermi resonance

- ✓ Coupling of two fundamental vibration modes produces 2 new modes of vibration.

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- ✓ With frequencies higher and lower than the observed in absence of interaction.
- ✓ This interaction takes place between fundamental vibrations and overtones or combination tone vibration and they are collectively called us Fermi resonance.
- ✓ In Fermi resonance molecule transfer energy from fundamental vibrations into overtone or combination level and back.
- ✓ The resonance pushes the two levels apart and mixes their character and each level has some amount of fundamental and some amount of overtone or combination tone characters.

C] Electronic effects

- ✓ Changing the absorption frequencies for a particular group takes place when the substituent in the neighbourhood of the particular group is changed.
- ✓ They include
  - Inductive effect: Inclusion of alkyl group gives +ve Inductive effect producing decreased absorption frequency. Adding an electronegative atom or group produces –ve inductive effect leading to increased absorption frequency.
  - Mesomeric effect: It produces lengthening or weakening of a bond leading to lowering of absorption frequency.
  - Field effect: In ortho substituted compounds, the lone pair of electrons on two atoms influence each other through space interactions and change the vibrational frequencies of both the groups. Example: Ortho halo acetophenone. This is called field effect.

D] Hydrogen bonding

- ✓ It occurs in any system having a proton donor group and a proton acceptor. If theS-orbital of the proton effectively overlaps the P or π orbital of the acceptor group.
- ✓ The stronger the hydrogen bond, the longer the OH bond, the lower the vibration frequency and broader and more intense will be the absorption.
- ✓ Intermolecular bonds produce broad bands whereas intramolecular hydrogen bonds produce sharp and well defined bands.

Instrumentation

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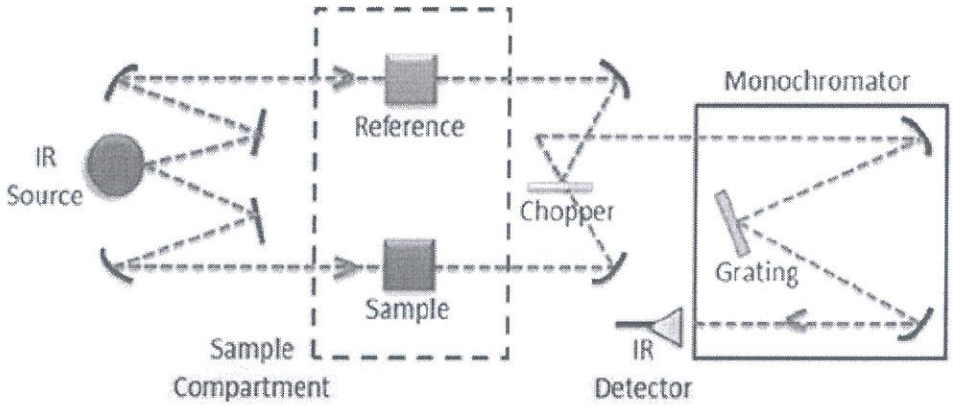

Fig. 6. Schematic representation of IR spectrometer

Sources of radiation

- The source of energy should produce very narrow beam of IR radiation
- The radiation should be intense enough to detect the analyte
- It should be steady
- It should cover the desired wavelength range

Following are some of the sources of IR radiation used in IR spectrophotometer:

1.Incandescent lamp

- This lamp is particularly used in near IR instruments. However, it is least preferred over other sources as it has a low spectral emission.

2. Nernst Glower

- It contains a hollow rod composed of rare earth oxides such as is it zirconia, yttria and thoria.
- It is in non-conducting at room temperature and requires heating by external means to bring it to a conducting state.
- The glower is heated to a temperature within the range of 1000-1800° C.
- It gives a maximum radiation of 7100 cm^{-1}
- It has a disadvantage of frequent mechanical failure

3.Globar source

- It is a rod prepared from centred Silicon carbide
- it is heated up to a temperature between 1300-1700°C
- it emits maximum radiation at 5200cm^{-1}

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- It has a disadvantage that its radiation is less intense then Nernst glower

4. Mercury arc lamp

- It is a device made up of quartz-jacketed tube containing mercury vapour inside it at a pressure greater than 1 atmosphere.
- It is highly effective in the far-IR region where the other sources of radiation fail to provide continuous radiation.

Wavelength selectors

- They help in selecting a continuous IR radiation in the desired wavelength region.
- They generally contain a chopper and a complex system of monochromators.
- The choppers are generally used to enhance the signal to noise ratio of the instrument and they also moderate the intensity of radiation that reaches to the detector.
- The monochromator is used to select it desired frequency of radiation which will be then allowed to incident on the detector.
- These monochromators are of two types:

1. Prismatic monochromator: They are made up of glass/quartz and coated with alkyl halides.

   A] Mono Pass (Radiation passes only once through the prism)

   B] Double Pass (Radiation passes twice through the prism)

2. Grating monochromator: They are grooves made up of aluminium and provide better dispersion of radiation than prisms.

   A] Reflection gratings

   B] Transmittance grating

Detectors

1. Golay cell

- It contains a small metal cylinder which is closed which is closed by black metal plate at one end and buy a flexible metal die programme at the other end
- The cylinder is filled with xenon and sealed.
- When IR radiation is allowed to fall on the black metal plate it heats the gas which expands it.
- The signal detected by the photo tube is then modulated according to the power of radiant beam.

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2. Bolometer

- It is made up of a thin metal conductor.
- When radiation falls on this conductor its temperature changes as the resistance of a metallic conductor changes with temperature the degree of change in resistance is regarded as the measurer amount of radiation that is incident on the bolometer.
- It follows the principle of Wheatstone bridge.
- When there is no radiation incident on the bolometer the bridge remains balanced and in case a radiation is incident on the bolometer the bridge becomes unbalanced due to the changes in electrical resistance and there is a flow of current through the galvano meter.

3. Thermocouple

- It is based on the principle that electric current flows when there are two dissimilar metal wires connected together at both the ends and a temperature difference is present between the two ends.
- The end exposed to the IR spectrometer is called the Hot junction.
- To increase the energy gathering efficiency it is usually made up of black body.
- The other connection i.e. Cold junction is thermally insulated and carefully protected from stray light.
- The electricity flowing through is directly proportional to the energy difference between the two connections.

4. Thermistor

- Thermistors are usually made up of fused mixture of metallic oxides.
- As the temperature of the mixture increases its electrical resistance decreases and accordingly the measurements are performed in the higher spectrophotometer.

5. Pyroelectric detector

- The pyroelectric detector is a thermal sensor of infra-red radiation requiring no bias.
- While in principle a pure capacitor (hence theoretically noiseless), the detector has a varying noise contribution as a function of frequency due to a load resistor, series loss resistance, and amplifier.
- The actual sensor is a pyroelectric crystal exhibiting spontaneous polarization.
- The spontaneous polarization and dielectric constant of the crystal are temperature-dependent.

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- A change in incident power raises the detector temperature causing an electric charge to appear across the electrode surfaces cut perpendicular to the crystal's ferroelectric axis.
- The evacuated detector package incorporates an electroded flake of triglycine sulfate mounted on a substrate of low thermal and electrical conductivity, a field effect transistor, load resistor, and an infrared transparent window.

Applications

IR spectroscopy is applied for qualitative as well as quantitative analysis of drugs in Pharmaceutical industry.

- It is used for identification of drug substances
- It identifies the impurities present in a drug sample
- It helps in study of hydrogen bonding both intermolecular and intramolecular type
- It is widely used in study of polymers
- It helps determining issue of *Cis- Trans* isomers present in a mixture of compounds
- It elucidates reaction mechanisms
- It is a great tool investigation of rotational isomerism
- It identifies functional groups present in any sample
- It estimates relative stability of confirmation
- It distinguishes between Sis and trance I so much
- It can predict the keto-enol tautomerism
- It helps in establishing quality of tea leaves

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D. FLAME PHOTOMETRY

Learning Outcome(s):

After studying the chapter, the students will be able to:

1. Define flame photometry
2. Describe the principle involved in flame photometry
3. Enumerate the interferences that affect flame photometric measurements
4. Explain the instrumental components and their working
5. Apply the knowledge in pharmaceutical quality control of drugs having metallic ions

Principle

Flame photometry is a type of atomic emission spectroscopy where atomic emission is measured using a spectrophotometer when a metallic space is introduced into the flame. The metal salt is burnt emitting certain colour wavelength and this instrument is based on measurement of intensity of colour generated by different elements. Each metal gives characteristic colour and the intensity of colour depict the amount or quantity of metal present. Hence, we identify the metal present in the unknown sample with respect to the colour developed. It was first developed by Murray Nelson A. in 1955 and he received a patent for the Flame Photometry in 1958.

The detailed principle can be summarised as:

- A liquid sample containing metal salt solution is introduced into a flame.
- The solvent is then vaporised leaving particles of solid salt.
- The salt is vaporized into the gaseous state.
- These gaseous molecules dissociate to give the neutral atoms which are converted into the unstable excited atoms using the thermal energy of the flame.
- These excited atoms emit photons while returning to the lower energy state.
- Measurement of emitted photons forms the basis of flame photometry using a photomultiplier tube detector.

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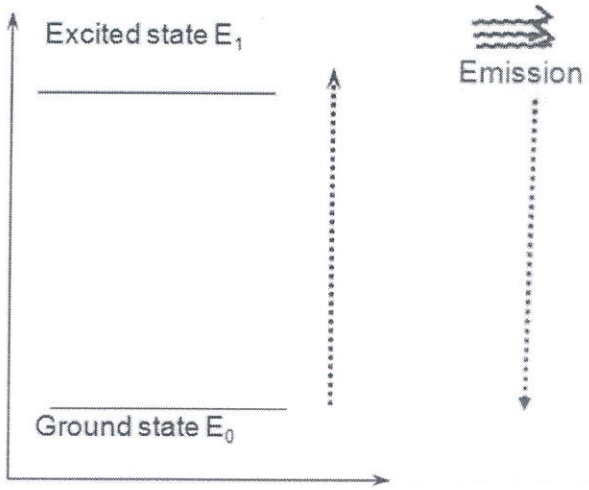

Fig.1. Atoms reaching excited state due to thermal energy and returning to ground state after emitting colour radiation

The intensity of the radiation emitted depends upon the proportion of thermally excited atoms which depends upon the temperature of the flame.

Fraction of free atoms thermally excited= $N^*/ N_0 = Ae^{-\Delta E/kT}$

Where N^* is number of atoms in excited state, N_0 is number of atoms in ground state, A is constant for element and ΔE is the difference in energy level of excited and ground state atom, k is known as Boltzmann constant and T is the flame temperature.

The particular wavelength of light emitted during the process depends on the difference in energy levels of the atom in excited and ground state as each element bears specific specific excited and ground state energy levels. The wavelength of radiation is also characteristic for different elements. A typical summary of such wavelength can be found in Table 1.

Table 1: Typical colours and wavelengths for different metal elements

Element	Colour	Wavelength(nm)
Sodium	Yellow	589
Potassium	Violet	767
Calcium	Orange to brick red	442 to 626
Lithium	Red	670

The wavelength of the radiation emitted can be given by the following expression:

Wavelength of light emitted (Lambda) = $hc/ E_2 - E_1$

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Where h = Plank's constant, c= Velocity of light, E_2 and E_1 = energy levels of excited in ground state, respectively.

The intensity of radiation emitted dependent on the concentration of the element present in the solution. With high concentration the flame intensity is more and with low concentration the intensity is less.

Interferences

The flame photometry has several limitations which needs critical attention.

1] The temperature of measurement is not high enough to excite transition metals. Hence, it is only selective towards detecting alkaline earth metals.

2] The relatively low energy available in the flame leads to relatively low intensity of the radiation arising from the metal atoms.

3] Low temperature renders to cause interference and the stability of the flame and aspiration conditions are affected.

4] Higher chances of unavoidable interference by other elements.

Out of the several limitations of flame photometry, the various types of interferences needs sufficient knowledge in order to minimise their incident and to know the proper cause behind the interference.

The interferences can be of three types. They are:

1] Spectral interference: When two elements present similar spectra which are overlapping each other and both emit radiation at same particular wavelength it is known as spectral interference / cation-cation interference / molecular spectral interference.

Example:

- Na and K mixtures interfere with each other.
- Al interferes with emission lines of Ca and Mg

Solution:

- Extraction of interfering material
- Calibration curve of interfering material
- Use of gratings instead of prisms or filters in the instrument

Also, there is another type of spectral interference where the spectral lines of two or more elements are close enough but they do not overlap each other.

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Solution:

- The problem can be reduced by increasing the resolution of the spectral isolation system.

2] Vaporization interference: This type of interference is caused due to presence of acids which affects the dissociation with other metals. Also, high viscosity presents interferences in vaporization process affecting the overall atomization process.

Solution:

- Suitable flames/burners/atomisers and additives can be chosen.
- Addition of Strontium/Lanthanum as ionization suppressant for phosphate ions.
- Addition of EDTA to mask ca ions along with phosphates.

3] Ionisation interference: High temperature flames cause ionization of some of the metal atoms present in both ground and excited state decreasing overall method sensitivity.

Solution:

- Addition of easily ionizable ions Cs, Sr, K which have low ionization potential and ionized over the analyte elements.

Instrumentation

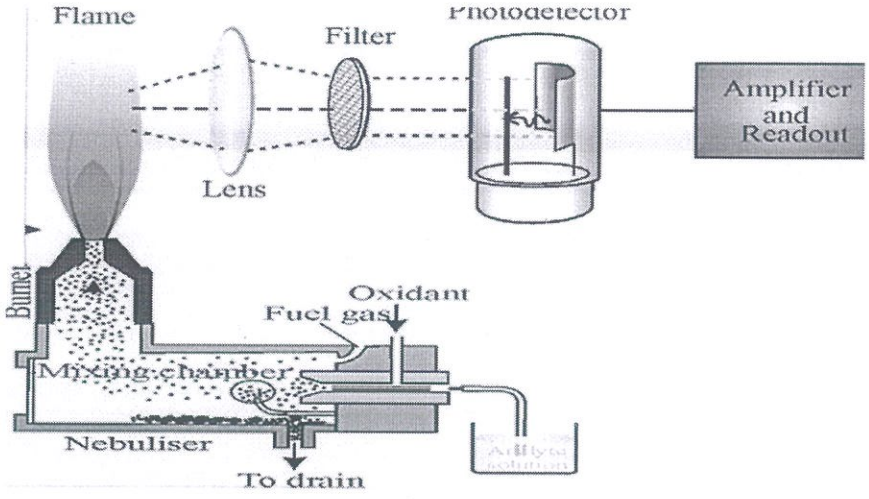

Fig.2. Typical instrumental set up for a flame photometer

The flame photometric instrumentation consists of:

Sample delivery system:

- The sample delivery system contains sample holder and a nebuliser.
- Nebulizer is a part of sample delivery system in which the liquid droplets of comparatively larger size are broken or converted into smaller size.

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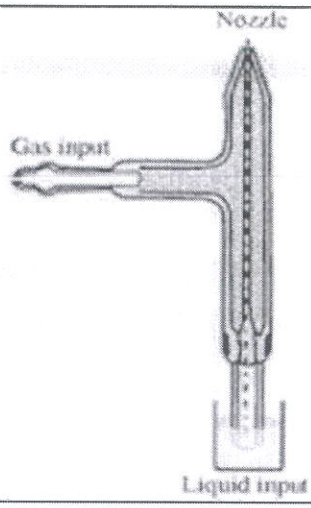
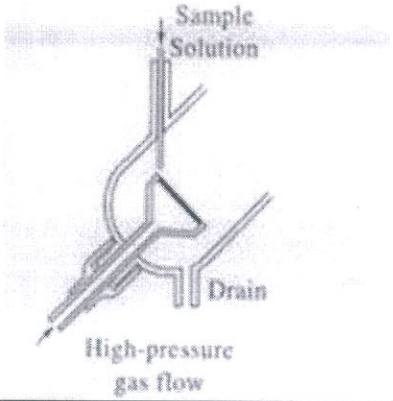
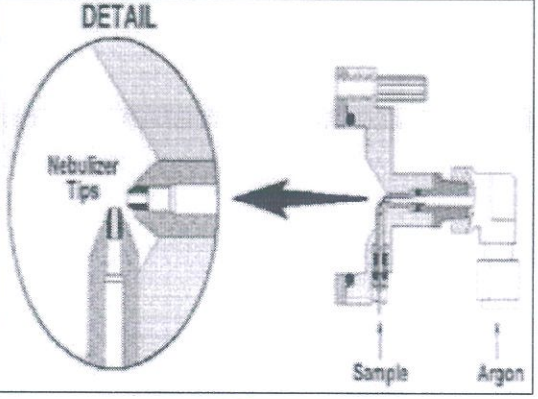
- The process of conversion of sample into a mist of very fine droplets through the aid of jets of compressed gas is called his nebulization.
- Hence, this part of the sample delivery system is called as nebuliser.

The nebulisers are mainly of three types:

1] Pneumatic nebulizers

The pneumatic nebulizers are of four types:

A] Concentric tubes	
B] Fritted disc	
C] Cross flow	

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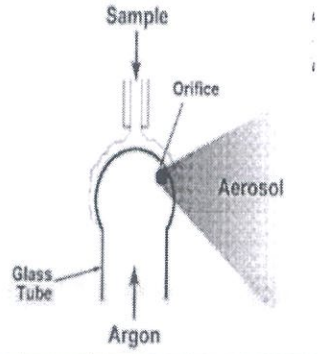
D] Babington	

2] Electro-thermal vaporizers

An electrothermal vaporiser contains an evaporator present in a closed chamber through which an inert gas carries the vaporise sample into the atomiser.

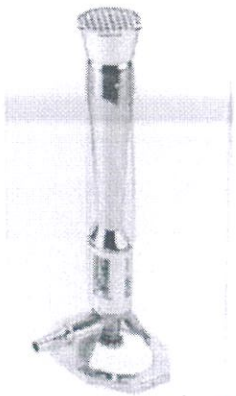
3] Ultrasonic nebulizers

The sample is pumped onto the surface of a vibrating piezoelectric crystal. The resulting mist is denser and more homogeneous than pneumatic nebulizers.

2] Burner and flame

Different types of burners are used to convert the fine droplets of sample solution into the neutral atoms which further due to the high heat or temperature of the flame are excited finally these excited atoms emit radiation of characteristic wavelength and colour.

The following types of burners are commonly used in a flame photometer:

Name of burner	Construction & Working
1] Mecker burner: This was the first type of burner used in flame photometry. It generally works with aid of natural gas and oxygen as the fuel and oxidant. The temperature produced in the flame is very low and results low excitation energy. Hence, it is not used widely.	

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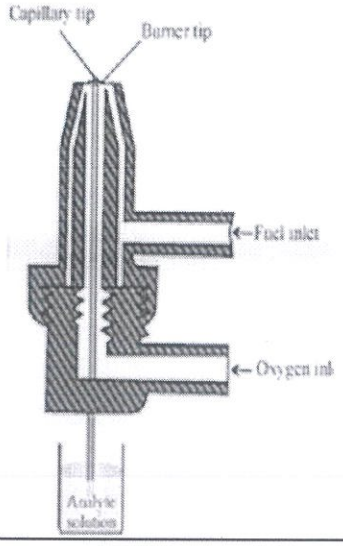
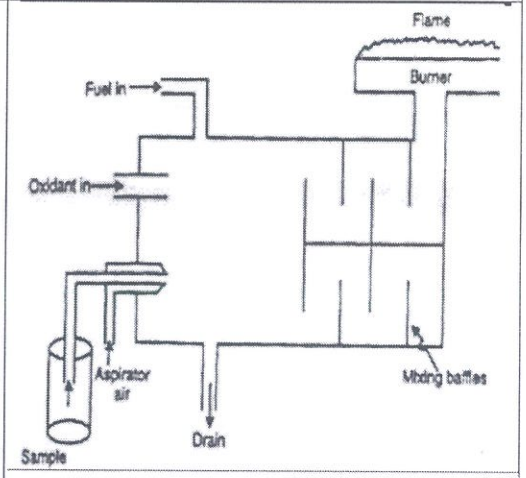
2] Total Consumption burner:

Due to high pressure of fuel (hydrogen) and oxidant (oxygen) the sample solution is aspirated through a capillary and burned at the tip of burner. It has advantage over others as the entire consumption of sample takes place during the during the process of measurement. But it produces non-uniform flame and turbulent.

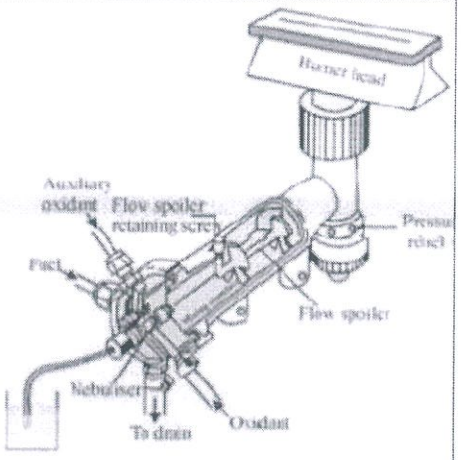


3] Premix burner:

In this type of burner the sample and fuel-oxidant are thoroughly mixed before aspiration and reaching to the flame. The advantage of this type of burner is uniformity of flame produced. However, it has a disadvantage that heavy loss of mixture up to 95% occurs during the process.



4] Lundengarph's burner: In this particular burner the sample and aid are mixed in a chamber and the mixed composition is sent to a fuel nozzle where it is atomised here the sample reaches to the flame is only about 5% of the total content.



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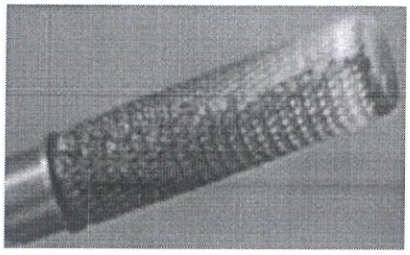
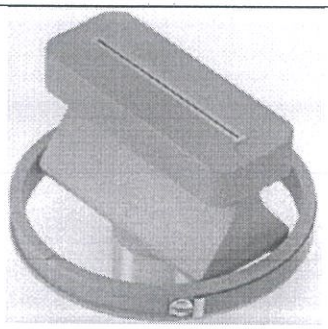
5] Shielded burner: In this burner the flame is shielded from the ambient atmosphere by a stream of inert gas ceiling is required to get better analytical sensitivity during the measurement process following results are obtained with sale did	
6] Nitrous Oxide-Acetylene burner: These flames are superior to other flames for effectively producing free atoms. Metals with very reflective oxides such as aluminium and titanium are analysed by this burner. However, it has a drawback that high temperature reduces its usefulness for the determination of alkali metals as they easily ionised. Also it produces intense background emission which makes measurement of metal emission difficult.	

The flame is main source of energy which is responsible for creates the process of atomization and subsequent measurement. The flame can be divided into different regions or zones called as:

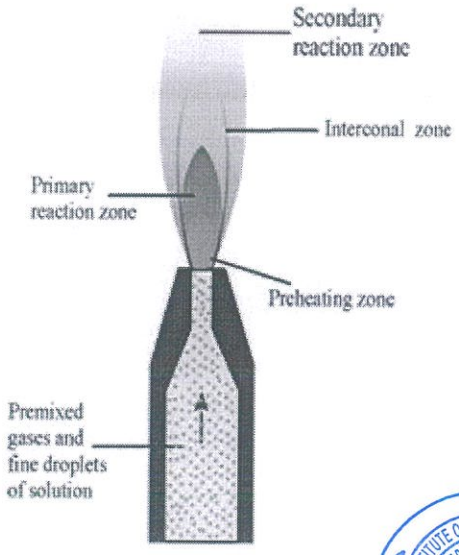


Fig.3. Different zones of a flame

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1] Preheating zone: The combustion mixture is heated here to the ignition temperature by thermal conduction from the primary reaction zone.

2] Primary reaction zone or inner zone: This zone is about 0.1 mm thick at atmospheric pressure and there is no thermodynamic equilibrium in this region. This zone has very high concentration of ions and free radicals. It is not used for measurements in flame photometry

3] Interconal zone: This particular zone can extend upto a considerable height and maximum temperature is achieved just above the tip of this zone. It is also known inner zone and is used in the flame photometric measurements.

4] Secondary reaction zone: The products of combustion process are burnt in this zone to a stable molecule species by help of the surrounding air.

Table 2. Typical list of fuel-oxidant mixture used in flame photometry

Fuel	Oxidant	Maximum Temperature Produced (°C)
Town gas	Air	1700
Propane	Air	1900
Butane	Air	1925
Acetylene	Air	2200
Town gas	Oxygen	2700
Propane	Oxygen	2800
Butane	Oxygen	2900
Acetylene	Nitrous oxide	2955

3] Filters and Monochromators:

In flame photometry the wavelength and intensity of the radiation emitted by the element are monitored. Hence a filter or monochromator is to be used in the instrument. A simple flame photometer contains a filter wheel containing several filters for elements like Calcium, Lithium, Sodium or Potassium and when a particular element has to be analysed a specific filter is chosen.

Similarly, the monochromators convert polychromatic light into monochromatic. Two types of monochromators are generally used for this purpose.

A] Prism: It is made up of quartz material and it is transparent over entire region of measurement

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B] Grating: It employs the grating which is a series of parallel straight lines cut into a plane surface.

4] Detectors

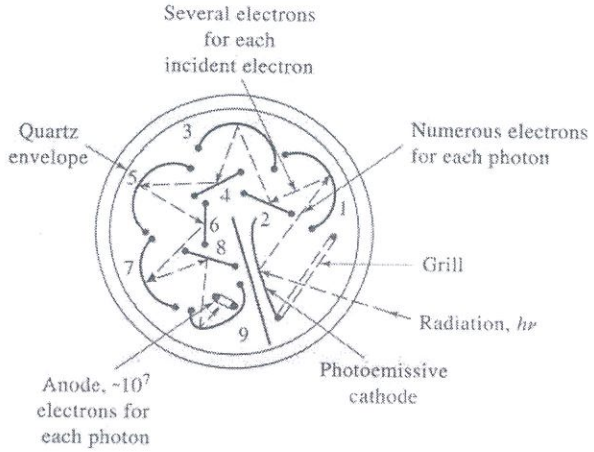

Fig.4. Schematic presentation of PMT

Photomultiplier tube (PMT) detector is most sensitive of all the detectors available and expensive. The principle employed in this detector depends on multiplication of photoelectrons by secondary emission of electrons. This multiplication is achieved by using a photocathode and a series of anodes called is dynodes. The PMT can use upto 10 dynodes. These dynodes are maintained at 75-100V higher than the preceding dynode. After each stage the electron emission is multiplied by a factor of 4-5. The PMT can detect very weak signals.

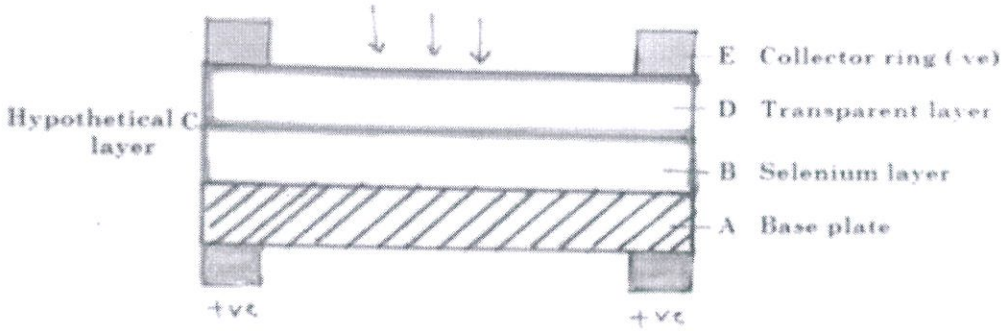

Fig.5. Schematic representation of photovoltaic cell

The photovoltaic cell has a thin metallic layer coated with silver or gold which app says an electrode also has a metal base plate which acts as another electrode. The two layers are separated by semiconductor layer of Selenium. When light radiation falls on selenium layer it creates potential difference between the two electrode and causes flow of current. The flow of

current causes deflection of the galvanometer needle which depends on the wavelength and intensity of radiation. It has a disadvantage that the amplification of the signal is not possible because the resistance of the external circuit has to be low, fatigue effects and lesser response of the detector with light other than blue and red light. It is a very inexpensive instrument.

5] Read out device

The signal from the detector is shown as a response in the digital reader device the readings are displayed as an arbitrary scale i.e. % flame intensity.

Applications

- Alkali and alkaline earth metals can be estimated by flame photometry.
- Many alkali and alkaline metals amount can be detected by the flame photometry by using method of internal standard, method of standard addition, direct comparison method and calibration curve method. Examples of such quantifications include

(a) Determination of concentration of calcium in serum

(b) Determination of concentration of calcium, sodium and potassium in urine

(c)Determination of amount of sodium potassium, calcium and magnesium in intravenous fluid and oral rehydration salts.

(d) Assay of potassium chloride in syrup

(e)Determination of concentration of Lithium in serum for therapeutic drug monitoring

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Unit-2

NMR SPECTROSCOPY

- Nuclearmagnetic resonance isa branch of spectroscopy.
- NMRisa powerful tool for investigating nuclear structure.
- The analyticalfieldinvolvedwiththeinteractionbetweenthenucleiandRFradiation is called NMR.
- Inanalyticalchemistry,NMRisusedforthestudyofshapeandstructureof molecules.
- Mostimportantapplicationisthe studyofhydrogen atomsinorganic molecules.
- Infood science NMR spectra isone dimensional&multidimensional.
- Infoodrelatedapplications1Dand2Dexperimentsarecommonly used.
- Several compounds such asα&β-glucose,fructose,tartaricacidandmalicacidcan be easily determined by their distinct NMR signals.
- Mainpurposeof2D NMRexperimentsistoprovideinformation'sabout neighbouring nuclei.
- CreditforthediscoveryofNMRgoes to Isidor Isaac Rabi, who received the Nobel Prize in Physics in 1944.

Principle

The theory behind the NMRspectroscopy comes from the spinning of a nucleus Generatedby amagnetic field. Without an externalappliedmagneticfield,thenuclearspinarerandom in directions.When external magnetic field is present the nuclei align themselves against the external magnetic field.

Theenergytransferispossibleb/wgroundstatetoexcitedstate.Radiofrequencywaveinduce transitions b/w magnetic energy levels of nuclei in a molecule. When the spin returns to ground state level the absorbed radio frequency energy is emitted. Emitted radio frequency signal give the NMR spectrum. If nuclei is not magnetic,NMR study not possible

Subatomicparticles(electron,proton,neutron)spinontheiraxis

These spins are paired against each other.So nucleusof anatom has no overalls pin.Insome atoms,nuclei possess an overallspin,and it isdenoted by I.

Anucleusofspin1has2I+1orientation. ie, orientation.

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Effectofmagnetic field:

In the absence of magnetic field,these orientations are of equal energy. On application of magnetic field, the energy levels split. Each level given magnetic quantum number **m.** Only those nuclei in the lower energy level can absorb radiation. Thèse nuclei can be excited to higher level. This absorption is called **Resonance.**

Frequency of radiation needed is determined by the difference in energy between theenergy levels (precision frequency). By exciting those nuclei in the lower level, the population of lower and higher energy levels become equal. There will be NO further absorption of radiation

Relaxation process

Theno.ofnucleiinlowerand higher energy level becomes equal. It has to return to lower state.There is two relaxation processes:

1. Longitudinal relaxation :
    - Itoccurswhentheexcitednucleuslosetheenergytothesurroundings
    - Energychangedtoheat
    - Temperatureincreases
    - Noother nuclei isexcited
2. Transverserelaxation
    - Iftheexcitednucleustransferitsenergytounexcitednucleusofsimilar molecules nearby
    - Theunexcitednucleusbecomesexcited
    - Previouslyexcitedbecomes unexcited
    - Inliquidsamples,netrelaxationtimeislong-Narrowband
    - Insolid samples,net relaxation time isvery short-wide band

Thewidth of absorption line iscontrolled by

1. Applied magnetic field:
    - -Should be constant over entire sample
    - If varied,thick absorption lines
2. Relaxation time
    - Net relaxation time very short-wide absorption band
3. Presence of ions,dissolved oxygen cause line broadening

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CHEMICALSHIFT

- Shift in the position of NMR signal with reference to standard
- TetraMethylSilane(TMS)usedasstandardbecause:ItisinertandhavingLow boiling point
- CausesofchemicalshiftareInductiveeffectandAnisotropiceffect

Shieldingand deshielding

The electrons around the protons create a magnetic field that opposes the applied field.This reduces the field experienced at the nucleus,the electrons are said to shield the proton(shielding). Shielded protons require strong applied field for absorption to take place. ie, absorption takes place upfield and Chemical shift decreases. It is also Known as positive shield.

Presence of electronegative groups (e withdrawing group) decreases the electron density around the protonsand it results Less shielding or DESHIELDING. Herethechemicalshift increases andabsorption take place downfield. It is also called Negative shield. This is known as **Inductive effect.**

Anisotropiceffect

Molecules with Π electrons (alkenes,alkynes) interactwiththeappliedfield.Itcauseinduced magnetic field. The nearby protons will experience: Applied field orInducedmagneticfield. As a result nearby protons can become shielded or deshielded and It depends with the orientation of its proton with respect to the Π bond

INSTRUMENTATION

1. Sample holder
2. Permanent magnet
3. Magnetic coils
4. Sweep generator
5. Radio frequency transmitter
6. Radio frequency receiver

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1.Sample holder	• glasstube with8.5 cmlong, 0.3cm in diameter. • sampleshouldbeheldinaholderwhichshouldbe chemically inert, durable and transparent to rf radiation.
2.Permanent magnet	• permanent magnet orelectromagnetcanbeusedinanuclear magnetic resonance instrument. • itprovideahomogenousmagneticfield • conventionalelectromagnetsarelessstable. • electromagnets are interact much less with external magnetic effect as compared to the permanent magnets. • A smallvariablemagneticfieldissuperimposedonthemain field • usingapairofHelmholtzcoilsinthepolefaceofthe permanent magnet. • appearasa single magnetic field to the molecule.
3.Magnetic coils	thesecoilsinducemagneticfieldwhencurrentflowsthrough them.
4Sweep generator	Toproducetheequalamountofmagneticfieldpassthroughthe sample.
5.Radiofrequency transmitter	Aradiotransmittercoilthatproducesashortpowerfulpulseof radio waves.
6.Radiofrequency receiver	Aradioreceivercoilthatdetectsradiofrequenciesemittedas nuclei relax to a lower energy level.
7.Readout system	Acomputerthatanalysesandrecordthedata.

APPLICATION

- → Solution structure.
- → Molecular dynamics.
- → Protein folding.
- → Ionization state.
- → Protein hydration.
- → Typesofatomspresentinthesample.
- → Thespecificenvironmentsofatomswithina molecule.
- → The purity and composition of a sample.
- → Structural information about a molecule.

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ADVANTAGE&DISADVANTAGEOFNMR:

ADVANTAGE:

★Detectmanytypeofmolecules(fat,water,ATPetc).

★Scan subject noninvasively.

★ Good time resolution.

★Absolutequantificationofconcentrationispossible(withappropiatestandard solution).

★Painlessexperimentalsubjects.

★Scan can be localized to specific anatomical region.

Disadvantage:

- Alots of atoms and a lot of extracted data from a system.
- This is good for the more accurate determination of the structure, but not for the availability of higher molecular masses.
- The resolving power of NMR islessthansomeothertypeofexperiments(e.g.:X-ray crystallography) since the information got from the same material is much more complex.
- The highest molecular mass which was examined successfully is just a 64kDa protein-complex.

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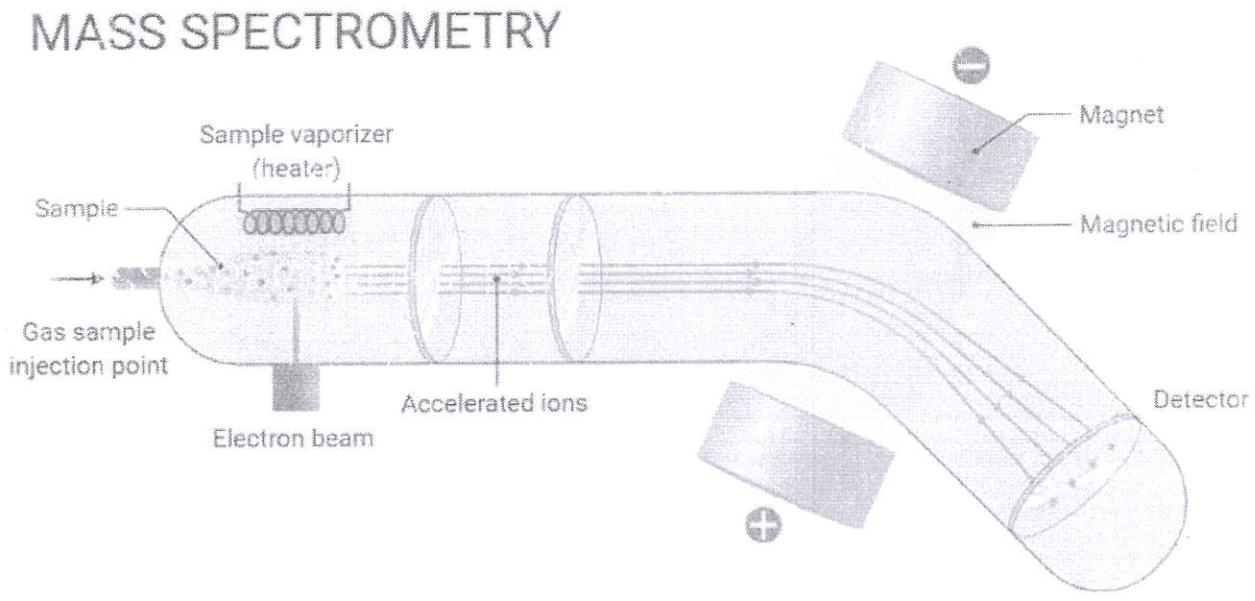
Unit -3

Mass Spectrometry

Mass Spectrometry (MS) is an analytical chemistry technique that helps identify the amount and type of chemicals present in a sample by measuring the mass-to-charge ratio and abundance of gas-phase ions.

- In this instrumental technique, the sample is converted to rapidly moving positive ions by electron bombardment and charged particles are separated according to their masses.
- A mass spectrum is a plot of relative abundance against the ratio of mass/charge (m/e).
- These spectra are used to determine the elemental or isotopic signature of a sample, the masses of particles and of molecules, and to elucidate the chemical structures of molecules and other chemical compounds.

Principle of Mass Spectrometry (MS)



1. In this technique, molecules are bombarded with a beam of energetic electrons.
2. The molecules are ionized and broken up into many fragments, some of which are positive ions. Each kind of ion has a particular ratio of mass to charge, i.e. m/e ratio (value).
3. For most ions, the charge is one, and thus, the m/e ratio is simply the molecular mass of the ion.
4. The ions pass through magnetic and electric fields to reach the detector where they are detected and signals are recorded to give mass spectra.

Watch How Long Duration Solar Flare Spurs Massive Coronal Mass Ejection

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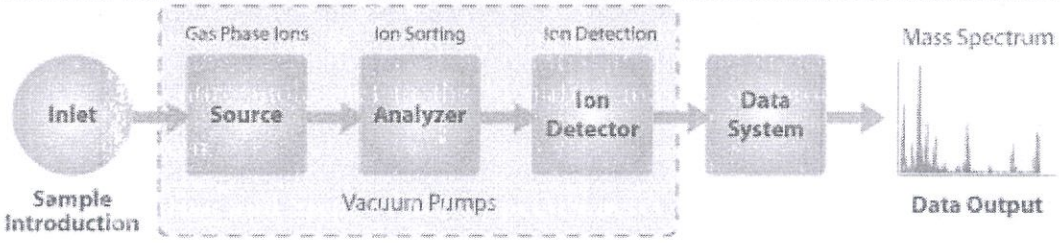
Working of Mass Spectrometry (MS)

- In a typical procedure, a sample, which may be solid, liquid, or gas, is ionized, for example by bombarding it with electrons.
- This may cause some of the sample's molecules to break into charged fragments. These ions are then separated according to their mass-to-charge ratio, typically by accelerating them and subjecting them to an electric or magnetic field:
- Ions of the same mass-to-charge ratio will undergo the same amount of deflection.
- The ions are detected by a mechanism capable of detecting charged particles, such as an electron multiplier. Results are displayed as spectra of the relative abundance of detected ions as a function of the mass-to-charge ratio.
- The atoms or molecules in the sample can be identified by correlating known masses (e.g. an entire molecule) to the identified masses or through a characteristic fragmentation pattern.

Instrumentation and Steps of Mass Spectrometry (MS)



A. Sample Inlet

- A sample stored in the large reservoir from which molecules reach the ionization chamber at low pressure in a steady stream by a pinhole called "Molecular leak".

B. Ionization

- Atoms are ionized by knocking one or more electrons off to give positive ions by bombardment with a stream of electrons. Most of the positive ions formed will carry a charge of +1.
- Ionization can be achieved by :
  - Electron Ionization (EI-MS)
  - Chemical Ionization (CI-MS)
  - Desorption Technique (FAB)

C. Acceleration

- Ions are accelerated so that they all have the same kinetic energy.
- Positive ions pass through 3 slits with voltage in decreasing order.
- Middle slit carries intermediate and final at zero volts.

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D. Deflection

- Ions are deflected by a magnetic field due to differences in their masses.
- The lighter the mass, the more they are deflected.
- It also depends upon the no. of +ve charge an ion is carrying; the more +ve charge, the more it will be deflected.

E. Detection

- The beam of ions passing through the mass analyzer is detected by a detector on the basis of the m/e ratio.
- When an ion hits the metal box, the charge is neutralized by an electron jumping from the metal onto the ion.
- Types of analyzers:
  - Magnetic sector mass analyzers
  - Double focussing analyzers
  - Quadrupole mass analysers
  - Time of Flight analyzers (TOF)
  - Ion trap analyzer
  - Ion cyclotron analyser

Applications of Mass Spectrometry (MS)

- Environmental monitoring and analysis (soil, water, and air pollutants, water quality, etc.)
- Geochemistry – age determination, soil, and rock composition, oil and gas surveying
- Chemical and Petrochemical industry – Quality control
- Identify structures of biomolecules, such as carbohydrates, nucleic acids
- Sequence biopolymers such as proteins and oligosaccharides
- Determination of the molecular mass of peptides, proteins, and oligonucleotides.
- Monitoring gases in patients' breath during surgery.
- Identification of drug abuse and metabolites of drugs of abuse in blood, urine, and saliva.
- Analyses of aerosol particles.
- Determination of pesticides residues in food.

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UNIT-4

A. Chromatography

Chromatography was invented by the Russian botanist Mikhail Tswet in the year 1903. He employed the technique to separate various plant pigments (i.e. Chlorophylls and Xanthophylls) by passing solutions of these substances (in petroleum-ether extract) through a glass column packed with finely powdered $CaCO_3$. The separated species appeared as separate bands having colored bands; the various pigments migrating through the column at different rates (because of differences in their distribution ratios). The separated species appearedasseparate bands having colored bands: the various pigments migrating through the column at different rates (because of differences in their distribution of ratios). The various solutes were isolated by cutting and sectioning of the chalk packing. Twswett choose to designate the name of such a process of separation as chromatography (Chroma-color, graphein-writing). Tswett's original experiments remained unnoticed in the literature for several decades. It was not until 1931 when kuhan and Lederer investigated polyene pigments that interest in such a technique was renewed.

But later on a diversify group of techniques which allow the separation of closely related components of the complex mixtures. In this technique, the sample is moved in a mobile phase, may be a gas, a liquid or a supercritical fluid. Such a mobile phase is then allowed to flow through an immiscible stationary phase.

Chromatography is a physical method of separation in which the components to be separated or distributed between two phases, one of which is stationary (stationary phase), while the other, the mobile phase moves in a definite direction.

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Classification of Chromatographic methods:

General Classification	Type of method	Stationary Phase	Mobile Phase	Type of equilibration Process	Name of the Technique
Liquid Chromatography (LC)	Liquid-Liquid Or Partition	Liquid Supported on a solid surface	Liquid	Partition between the immiscible liquids	Paper Chromatography (PC) Thin layer Chromatography (TLC) High Performance thin layer Chromatography (HPTLC)
	Liquid-Solid, Or adsorption	Solid	Liquid	Adsorption	Adsorption Column Chromatography (ACC)
	Liquid-Solid Or adsorption	Very finely divided solid packed in a column	Liquid	Adsorption (using very much higher pressures for the flow of mobile phase)	HighPerformance liquid Chromatography (HPLC)

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General Classification	Types of method	Stationary Phase	Mobile Phase	Type of equilibration Process	Name of the Technique
	Ion-Exchange	Solid (ion-exchange resign)	Liquid	Partition/Sieving	Ion-exchange chromatography (IEC)
	Affinity usually uses enzymes Or Antigen-Antibody highly specific interactions	Group – Specific liquid bonded to a solid surface (an antibody , immobilized on a stationary phase by covalently binding to it – an affinity ligand)	Liquid	Partition between surface liquid (immobilized) and mobile phase	Affinity chromatography.
Gas Chromatography	Gas – Solid (or adsorption) Gas – liquid (or Partition)	Solid Liquid adsorbed on a solid	Gas Gas	Adsorption Partition between Gas and liquid	Gas-solid chromatography (GSC) Gas-Liquid Chromatography (GLC)
Supercritical fluid chromatography (SFC)	Bio specific adsorption or bio affinity	Organic Species bonded to a solid surface	Supercritical fluid	Partition between Super-critical fluid and bonded species	Super-critical fluid chromatography (SFC) or Bioaffinity chromatography (BC)

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Column Chromatography

When a column of stationary phase is used, the technique is called as column chromatography. Based on the nature of the stationary phase i.e. whether it is solid or liquid, it is called as column adsorption chromatography or. Column partition chromatography is not widely used.

Principle:

1. This technique is based on the principle of differential adsorption where different molecules in a mixture have different affinities with the adsorbent present in the stationary phase.
2. The molecules having higher affinity remain adsorbed for a longer time decreasing their speed of movement through the column.
3. However, the molecules with lower affinity move with a faster movement, thus allowing the molecules to be separated in different fractions.
4. Here, the stationary phase in the column chromatography also termed the adsorbent is a solid (mostly silica) and the mobile phase is a liquid that allows the molecules to move through the column smoothly. The type of interaction between the stationary phase (adsorbent) & the solute is reversible in nature.

The rate of movement of a component (R) is given as follows

$$R = \frac{Rate\ of\ movement\ of\ component}{Rate\ of\ movement\ of\ mobile\ p\square ase}$$

The equation can be simplified as follows:

$$\mathbf{R = \frac{Distance\ moved\ by\ the\ solute}{Distance\ moved\ by\ the\ solvent}}$$

When a liquid mobile phase is used, the equation is written as

$$\mathbf{R = \frac{Am}{Am + a\ As}}$$

Where α is the Partition coefficient $= \frac{Conc.in\ stationary\ p\square ase}{Conc.in\ mobile\ p\square ase}$

Am is the average cross section of mobile phase

As is the average cross section of stationary phase

Practical Requirement

1. Stationary Phase
2. Mobile Phase
3. Column characteristics
4. Preparation of the column

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Stationary Phase

Adsorbents are used in this technique may be organic and inorganic classes of compounds. The ideal requirements of adsorbent are:

i. It should produce only adsorption of the analyte over it
ii. The particles should have uniform size distribution and have spherical shape. Particle size: 60-200μ.
iii. It should have high mechanical stability
iv. It should be inert & should not react with the solute or other components.
v. Insoluble in the solvents or mobile phases used.
vi. It should be colorless to facilitate observations of zones and recovery of components.

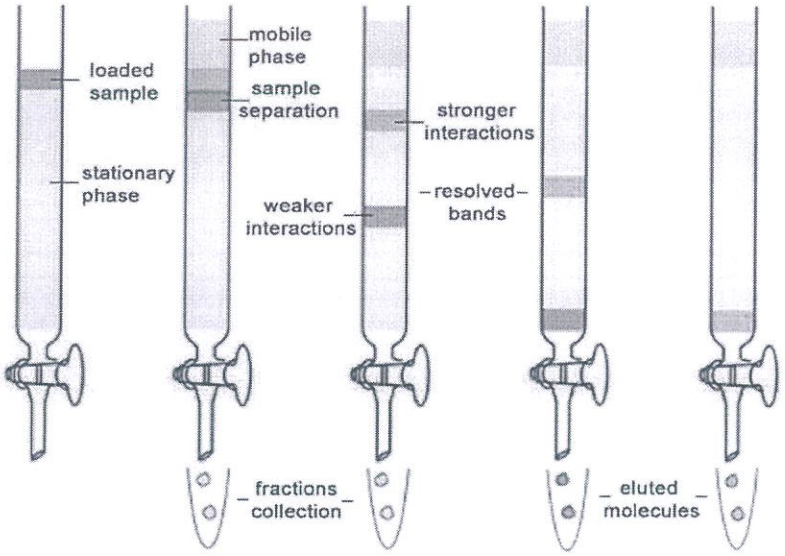

Figure: 1 Column chromatography.

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Medium	Calcium carbonate	Acetone
	Calcium phosphate	Benzene
	Magnesium carbonate	Toluene
	Magnesium oxide	Esters
	Calcium hydroxide	Chloroform
	Activated magnesium silicate	Acetonitrile
Strong	Activated alumina	Alcohols
	Activated charcoal	Water
	Activated magnesia	Pyridine
	Activated silica	Organic acids
	Fuller's earth	Mixtures of acids or bases with ethanol or pyridine

The most commonly used adsorbent is Silica gel of 80-100 mesh or 100 – 200 mesh size which has a particle size of 60-200μ.

Selection of Stationary Phase

The selection of stationary phase in column chromatography depends on the following:

1. Removal of impurities: When a small quantity of impurity is present and there is difference in affinity when compared to the major component, a weak adsorbent is sufficient.
2. No. of components to be separated: When few components are to be separated, weak adsorbent is used. When more components are to be separated, a strong adsorbent is used.
3. Affinity differences between different components: When components have similar affinities, a strong adsorbent will be effective. When there is more differences in affinities, a weak adsorbent is selected.
4. Length of the column used: When a shorter column is used, strong adsorbent has to be used. When a longer column is used, a weak adsorbent can be used.
5. Quantity of adsorbent used: 20 or 30 times the weight of the adsorbent is used for effective separation.
   Adsorbate: Adsorbent = 1: 20 or 1: 30.

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Mobile Phase: Mobile Phase is the very important and they are several functions. Mobile is acting as solvent, developer, and as eluent. The functions of a mobile phase are:

Different mobile phases used: It is used in increasing order of polarity or elution strength. The solvents are given in the above Table 1. These solvents can be used in either pure form or as a mixture of solvents of varying compositions

ColumnCharacteristics

Column is mostly best quality of neutral glass since it should not be affected by solvents, acids or alkalies. An ordinary burette can be used as column for separation.

Length/diameter ratio is 10-15:1.

For more efficiency, the length/diameter ratio is 100:1.

Column length

a. Multi-component system long column
b. Components with similar affinities for adsorbent long column
c. Components with different affinities for adsorbent short column

Preparation of the Column

- The column mostly consists of a glass tube packed with a suitable stationary phase.
- Glass wool/cotton wool or an asbestos pad is placed at the botton of the column before packing the stationary phase.
- After packing, a paper disc kept on the top, so that the stationary layer is not disturbed during the introduction of sample or mobile phase.

There are two types of preparing the column, they are:

1. Dry packing / dry filling

In this the required quantity of adsorbent is poured as fine dry powder in the column and the solvent is allowed to flow through the column till equilibrium is reached.

2. Wet packing / wet filling

In this, the slurry of adsorbent with the mobile phase is prepared and is poured into the column. It is considered as the ideal technique for packing.

- Before using column, it should be washed properly and dried.

Introduction of the Sample

- The sample which is usually a mixture of components is dissolved in minimum quantity of the mobile phase or a solvent of minimum polarity
- The entire sample is introduced into the column at once and gets adsorbed on the top portion of the column.
- From this zone, individual sample can be separated by a process of elution.

C. Elution (Development technique)

- By elution technique, the individual components are separated out from the column.

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- It can be achieved by two techniques:

Eg. Use of chloroform alone or Pet.ether: Benzene = 1:1 only, etc.

- **Gradient elution technique:** Solvents of gradually ↑ (increasing) polarity or ↑ (increasing) elution strength are used during the process of separation.

E.g. initially benzene, then chloroform, then ethyl acetate then chloroform

Other techniques like Frontal analysis and Displacement analysis where a graph of concentration of eluate Vs. volume of eluate will give an idea of how compounds are eluted out from the column.

D. Detection of Components

1. If the compounds separated in a column chromatography procedure are colored, the progress of the separation can simply be monitored visually.
2. If the compounds to be isolated from column chromatography are colorless. Then the technique depends upon the properties of the components. Different properties which can be used are
3. Absorption of light (UV/Vis) – Using UV-Visible Spectropotometer
4. Flourescence or light emission characteristics – Using fluorescence detector
5. By using flame ionization flame detector
6. Refractive index detector- based on the refractive index difference between the mobile phase and mobile phase + component
7. Evaporation of the solvent and weighing the residue
8. Small fractions of the eluent are collected sequentially in labeled tubes and the composition of each fraction is analyzed by TLC (thin layer chromatography).

Recovery of components: Earlier, recoveries of the components were done by cutting the column into several distinct zones. Later, extrusions of the column into zones were done by using plunger. The best technique is to recover the components by a process called as***elution.*** The components are called as **eluate,** the solvent called as **eluent** and the process of removing the components from the column is called as **elution.** The different elution techniques like isocratic elution technique and gradient elution technique.Recovery is done by collecting different fractions of mobile phase of equal volume like 10ml, 20ml etc or unequal volume. They can also be collected time wise i.e. a fraction every 10 or 20 minutes etc. The recovered fractions are detected by using the techniques discussed earlier. Similar fractions are mixed so that the bulk of the compound of each type is obtained in a pure form. If a fraction still contains several components, it can be resolved by using another column.

Applications:

1. Separation of mixture of compounds: Separation of glycosides, amino acids, plant extracts
2. Removal of impurities Isolation of the active constituents from the plant extract or from

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i. Separation of diastereomers.
ii. Separation of tautomers and racemates

Factor affecting Column efficiency

1. Dimensions of the column
2. Particle size of the adsorbent
3. Nature of the solvent
4. Temperature of the column
5. Pressure

Advantages:

1. Any type of mixture can be separated by column chromatography.
2. Any quantity of the mixture can also be separated (µg to mg of substance).
3. Wider choice of mobile phase.
4. In preparative type, the sample can be separated and reused.
5. Automation is possible.

Limitation or Disadvantages of Column chromatography

1. Time consuming method.
2. More amounts of solvents are required which may be expensive.
3. Automation makes the technique more complicated and costly.

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Thin layer Chromatography (TLC)

Introduction: The history of thin layer chromatography dates back to 1938 when Izmailov and Shraiber separated plant extracts using 2mm thick and firm layer of alumina set on glass plate. In 1944, Consden, Goden and Martin used filter papers for separating amino acids. In 1950, Kirchner identified terpens on filter paper and later glass fibre paper coated with alumina. Only in 1958, Stahl developed standard equipment for analyzing by Thin layer chromatography.

Principle:

Thin Layer Chromatography can be defined as a method of separation or identification of a mixture of components into individual components by using finely divided adsorbent coated or spread over a chromatographic plate. The mobile phase solvent flows through because of capillary action (against gravitational force). The components move according to their affinities towards the adsorbent. The component with more affinity towards the stationary phase travels slower. The component with lesser affinity towards the stationary phase travels faster. Thus the components are separated on a thin layer chromatographic plate based on the affinity of the components towards the stationary phase.

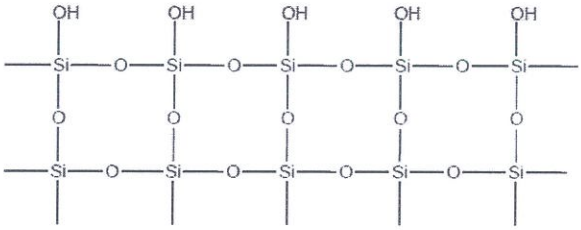
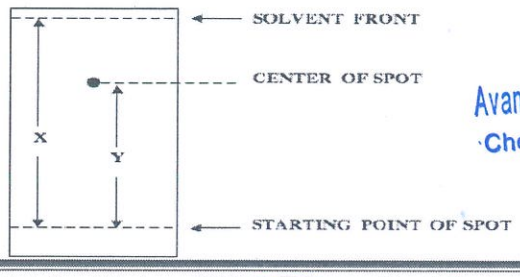


Fig 2: Silica extended structure and surface.

Silica (SiO_2) is a solid with an extended structure of tetrahedral silica atoms bridged together by bent oxygen atoms. On the surface of the silica particles, the solid terminates in very polar silanol (Si-O-H) groups. The silica is the stationary phase because it remains adhered to the glass plate and does not move during the chromatography process.

The Silica extended structure and surface is shown in the Fig 2. The developed TLC plate is shown in the Fig 3.



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Advantages of TLC

1. It is a simple process with a short development time.
2. It helps with the visualization of separated compound spots easily.
3. It helps in isolating of most of the compounds.
4. The separation process is faster and the selectivity for compounds is higher (even small differences in chemistry is enough for clear separation).
5. The purity standards of the given sample can be assessed easily.
6. It is a cheaper chromatographic technique.
7. TLC offers a faster and more efficient separation than paper chromatography and the majority of paper chromatographic separations have now been superseded by the TLC Procedures.

Practical Requirement:

1. **Stationary Phase:** There a several adsorbents which can be used as stationary phases. Some of the stationary phases, their composition and the ratio in which they have to be mixed with water or other solvents to form a slurry for preparing thin layer chromatographic plates are given in the below Table 2:

Name	Composition	Adsorbent: Water ratio
Silicagel H	Silicagel without binder	1:1.5
Silicagel GF	Silicagel + Binder + Fluorescent indicator	1:2
Silicagel G	Silicagel + $CaSO_4$(gypsum)	1:2
Alumina Neutral Basic Acidic	Al_2O_3 without binder	1:1.1
Al_2O_3 G	Al_2O_3 + binder	1:2
Cellulose powder	Cellulose without binder	1:5
Cellulose powder	Cellulose with binder	1:6
Kieselguhr G	Diatomaceous earth + binder	1:2
Polyamide powder	Polyamide	1:9 (CHCl3 : CH3OH= 2:3)

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Fluoroscent indicator Zinc silicate

Silica gel and alumina are available with different specific surface areas and these grades are identified by a number, e.g., silica gel 60 (or 40 or 150) which indicates the mean pore size in Angstroms (10^{-10}m).The particle size of silica gel for TLC is 10-40 µm (average 15 µm).

2. **Preparation of the Glass Plates:** The sizes of the glass plates for use with commercially available spreaders are usually 20 X 20, 20 X 10 or 20 X 5 cm.
   Microscopic slides can also be used for some applications like monitoring the progress of chemical reaction.
   In general, the glass plates should be of good quality and should be withstand temperatures used for drying the plates.
   General method:
   Mix 30gm of the adsorbent in a mortar to a smooth consistence with the requisite amount of water or solvent specified in the manufacturer's instruction and transfer the slurry quickly to the spreader. Spread the mixture over 4 to 5 plates (20 X 20cm) or a proportionately larger number of smaller plates and allow the thin layers to set (about 4minutes when CaSO4 is present). Transfer the plates carefully to a suitable holder and after a further 30minutes, dry at 100-120 ^{0}C for 1 hour to activate the adsorbent. Cool and store the plates in a desiccator over silica gel. The thickness of the moist thin layer should be about **0.25 mm**.
   Special methods:
   a. Preparative thin layer. The layers are 0.5 – 2mm thick, prepared as described under the general method, but using a smaller quantity of water and allowing a longer time for the initial drying of the plate.
   b. Microscopic slides are conveniently coated by a dipping technique in the following way: prepare slurry of the adsorbent by shaking withchloroform or chloroform-methanol (2:1) and insert two microscope slides (back to back) into the slurry. Withdraw the slides; allow draining, separating the slides and drying.
   c. The slurry, prepared in the normal way, is sprayed onto the surface of glass plates, using a laboratory spray gun.
   d. Theadsorbent, mixed with an organic solvent, e.g., chloroform or ethyl acetate, is distributed evenly over a glass plate by careful tilting, and, after evaporation of solvent, is dried in the normal way.
   In all the methods the plates should be tidied before use by cleaning the edges and backs (microscope slides).
3. **Application of Sample:** In order to get good spots, the concentration of the sample or standard solution can be 2-5µl of a %1 solution of either standard or test sample is spotting using a capillary tube or micropipette. The spots can be placed at random or equidistant

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from each other by using a template, with markings. The spot should be kept at least 2cm

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4. **Development Tank:** For the purpose of development, a developing tank or chamber of different sizes to hold TLC plates of standard dimensions are used. These require more solvents for developing the chromatogram. When a new method is developed, it is better to develop in glass beakers or specimen jars, etc, to avoid more wastage of solvents. When developed method or standard method is used, it is better to use development tank. In the new type of development tanks have **hump** in the middle, which require less solvent. The development chamber or tank should be lined inside with filter paper moistened with the mobile phase so as to saturate the atmosphere. If this kind of saturation of the atmosphere is not done, "edge effect" occurs where the solvent front in the middle of the TLC plate moves faster than that of the edge. The development tank examples are shown in the below Fig 3.

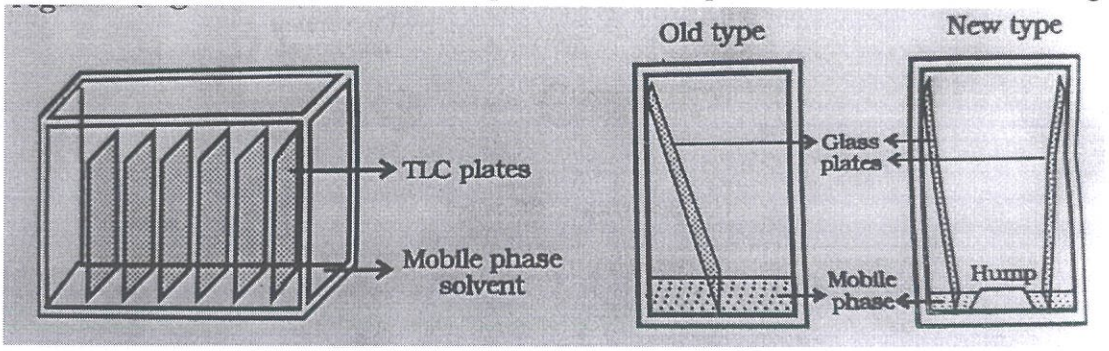

Fig 3: Development tank

5. **Mobile Phase:** Selection of the mobile phase depends upon the below factors
   i. Nature of the substances to be separated
   ii. Nature of the stationary phase used
   iii. Mode of chromatography (Normal phase or reverse phase)
   iv. Separation to be achieved – Analytical or preparative

   Pure solvents or mixture of solvents are used. The following gives a list of solvents (of increasing polarity).

Petroleum ether, Carbon tetrachloride, Cyclohexane, Carbon di-sulphide, Ether, Acetone, Benzene, Toluene, Ethyl acetate, Chloroform, Alcohols like methanol or ethanol, Water, pyridine. The solvent composition is done by trial and error method only but with a review of literature and other logical considerations like solubility of the substance, polar or non-polar character of the samples, etc.

6. **Development technique:** Different development techniques are used for efficient separations. They are
   i. Vertical development (One dimensional)
   ii. Two dimensional development

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i. Vertical development (One dimensional): In this technique, the plates are kept vertical and the solvent flows against gravity, because of capillary action.

ii. Two dimensional techniques: For complex mixtures this technique is used. First, the plates are developed in one axis and the plates after drying are developed in the other axis. When large number compounds cannot be separated by using one dimensional technique.

7. Detecting or Visualizing Agents

After the development of TLC plates, the spots should be visualized. Detecting colored spots can be done visually. But for detecting colorless spots, any one of the following techniques can be used.

a. Specific methods: In this method particular detecting agents are used to find out the nature of compounds or for identification purposes. Examples are
   i. Ferric chloride- for phenolic compounds and tannins.
   ii. Ninhydrin in acetone- for amino acids
   iii. Dragendroff's reagent – for alkaloids
   iv. 2,4 – Dinitrophenyl hydrazine – for aldehydes and ketones

b. Nonspecific methods: Where the number of spots can be detected, but not the exact nature or type of compound.
   Examples
   i. Iodine chamber method: Where brown or amber spots are observed when the TLC plates are kept in a tank with few iodine crystals at the bottom.
   ii. Sulphuric acid spray reagent: 70-80% v/v of sulphuric acid with few mg of either potassium dichromate or potassium permanganate or few ml of nitric acid as oxidizing agent is used. This reagent after spraying on TLC plates is heated in an oven . Black spots are seen due to charring of compounds.
   iii. Using fluorescent stationary phase: When the compound s are not flourscent, a fluorescent stationary phase is used. When the plates are viewed under UV chamber, dark spots are seen on a fluorescent background. Examples of such stationary phase is Silica gel GF

The detecting techniques can be categorized as

i. **Destructive technique:** Specific spray reagents, Sulphuric acid spray reagent, etc where the samples are destroyed for detection.

ii. **Non-Destructive technique:** like UV chamber method, Iodine chamber method, densitometric method, etc where the sample is not destroyed even after detection. These detecting techniques are used in TLC method development and in preparative TLC.

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8. Qualitative analysis

The Rf value is calculated for identifying the spots in qualitative analysis. Rf value is the ratio of distance travelled by the solute to the distance travelled by the solvent front.

$$\mathbf{Rf} = \frac{Distance\ travelled\ by\ solute}{Distance\ travelled\ by\ the\ solvent\ front}$$

The Rf value ranges from 0 to 1. The ideal value is 0.3 to 0.8.

The Rf value is constant for every compound in a particular combination of stationary and mobile phase. When the Rf value of a sample and reference compound is same, the compound is identified by its standard. When the Rf value differs, the compound may be different from its reference standard.

Rx value is the ratio of distance travelled by the sample and the distance travelled by the standard. Rx value is always closer to 1.

Rm value is used to find out whether the compounds belong to a homologous series. If they belong to a homologous series, the ΔRm values are constant. The ΔRm values for a pair of adjacent member of a homologous series are determined by using the formula:

$$Rm = log\ (\frac{1}{Rf} - 1)$$

9. Quantitative Analysis

Indirect method: Quantitative analysis can be done after eluting the individual spotswith solvent and filtering off the stationary phase. The solution can be concentrated and the exact quantities of the compound determined by the methods like UV-Visible spectrophotometry, fluorescence method, flame photometric method, electrochemical methods of analysis.

Direct method: It can be done after eluting the individual spots with solvent and filtering off the stationary phase. The solution can be the concentrated and the exact amount of the compound deterimined by the various methods like UV-visible spectrophotometry, flourscence method, flame photometric method, electrochemical methods of analysis etc.

10. Application of TLC

i. Separation of mixtures of drugs of chemicals or biological origin, plant extracts etc
ii. Separation of carbohydrate, vitamins, antibiotics, proteins, alkaloids, glycosides etc
iii. Identification of drugs

Drug	Stationary Phase	Mobile Phase	Detecting agent

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Amoxycillin trihydrate	Silica Gel G.F-254	Buffer pH 6: acetone (4:1)	NaOH+ Starch+glacial acetic acid+Iodinein potassium iodide

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Test for impurities, decomposition & related substances in pharmaceutical products (as per British Pharmacopoeia substances and preparations)

Substance	Tested for	Mobile Phase	Detection
Chlorpropamide	p-Chlorobenzene sulphonamide and NN'-diropylurea (0.33%)	Chloroform : methanol:cyclohexane:13.5M ammonia (100:50:30:11.5)	Sodium hypochlorite followed by potassium iodide in starch mucilage
Nitrazepam Tablets	Decomposition and related substances 0.5%	Nitromethane : ethyl acetate(85:15)	254nm radiation
Desipramine Hydrochloride	Iminodibenzyl (0.2%)	Toluene: ethyl acetate: ethanol: diethylamine (20:20:4:1)	Potassium dichromate (0.5%) in sulphuric acid:water(4:4)

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Paper Chromatography

Paper chromatography (PC) is a type of a planar chromatography whereby chromatography procedures are run on a specialized paper.It is considered to be the simplest and most widely used of the chromatographic techniques because of its applicability to isolation, identification and quantitative determination of organic and inorganic compounds.It was first introduced by German scientist Christian Friedrich Schonbein (1865).

Types of Paper chromatography:

(i) Paper Adsorption Chromatography: Paper impregnated with silica or alumina acts as adsorbent (stationary phase) and solvent as mobile phase.

(ii) Paper Partition Chromatography : Moisture / Water present in the pores of cellulose fibers present in filter paper acts as stationary phase & another mobile phase is used as solvent In general paper chromatography mostly refers to paper partition chromatography.

Principle of Separation

The principle of separation is mainly partition rather than adsorption. Substances are distributed between a stationary phase and mobile phase. Cellulose layers in filter paper contain moisture which acts as stationary phase. Organic solvents/buffers are used as mobile phase. The developing solution travels up the stationary phase carrying the sample with it. Components of the sample will separate readily according to how strongly they adsorb onto the stationary phase versus how readily they dissolve in the mobile phase.

Instrumentation of Paper chromatography

2. Stationary phase & papers used
3. Mobile phase
4. Application of sample
5. Developing Chamber
6. Detecting or Visualizing agents

1. STATIONARY PHASE AND PAPERS: Whatmann filter papers of different grades like No.1, No.2, No.3, No.4, No.17, No.20 etc are used.

In general the paper contains 98-99% of α-cellulose, 0.3 – 1% β -cellulose. These papers differ in sizes, shapes, porosities and thickness.

Other modified papers like Acid or base washed filter paper, glass fiber type paper.

Hydrophilic Papers – Papers modified with methanol, formamide, glycol, glycerol etc.

Hydrophobic papers – acetylation of OH groups leads to hydrophobic nature, hence can be used for reverse phase chromatography. Silicon pretreatment and organic non-polar polymers can also be impregnated to give reverse phase chromatographic mode.

Impregnation of silica, alumna, or ion exchange resins can also be made.

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2. **Application of sample:** The sample to be applied is dissolved in the mobile phase and applied using capillary tube or using micropipette. Very low concentration is used to avoid larger zone

3. PAPER CHROMATOGRAPHY MOBILE PHASE

Pure solvents, buffer solutions or mixture of solvents can be used. Some of the Examples of

Hydrophilic mobile phases

Isopropanol: ammonia:water 9:1:2

Methanol: water 4:1 or 3:1

n-Butanol: glacial acetic acid: water 4:1:5

Hydrophobic mobile phases

kerosene: 70% isopropanol

Dimethyl ether: cyclohexane

The commonly employed solvents are the polar solvents, but the choice depends on the nature of the substance to be separated.

If pure solvents do not give satisfactory separation, a mixture of solvents of suitable polarity may be applied.

4. **CHROMATOGRAPHIC CHAMBER:** The chromatographic chambers are made up of many materials like glass, plastic or stainless steel. Glass tanks are preferred most. They are available in various dimensional sizes depending upon paper length and development type. The chamber atmosphere should be saturated with solvent vapor.

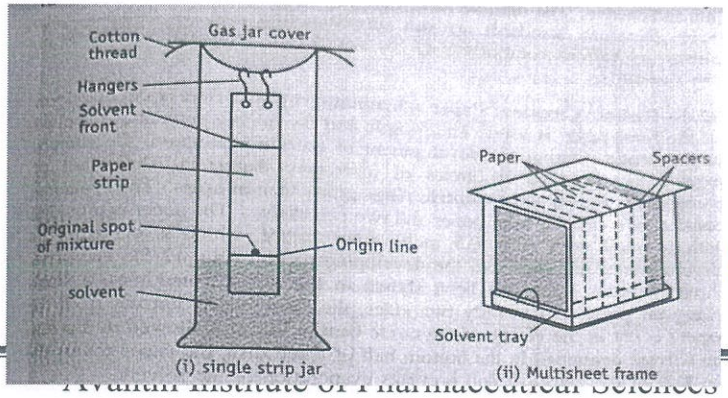
Development technique:

Sample loaded filter paper is dipped carefully into the solvent not more than a height of 1 cm and waited until the solvent front reaches near the edge of the paper.

Different types of development techniques can be used:

a. ASCENDING DEVELOPMENT

Like conventional type, the solvent flows against gravity. The spots are kept at the bottom portion of paper and kept in a chamber with mobile phase solvent at the bottom. (Same as in TLC) (Fig 4)



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b. **DESCENDING TYPE:** This is carried out in a special chamber where the solvent holder is at the top.The spot is kept at the top and the solvent flows down the paper.In this method solvent moves from top to bottom so it is called descending chromatography (Fig: 5).

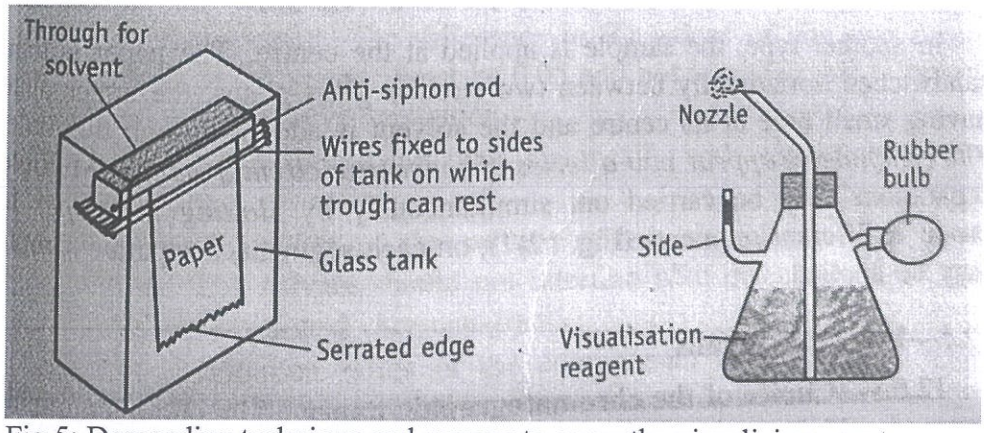

Fig 5: Descending technique and sprayer to spray the visualizing agent

c. **ASCENDING – DESCENDING DEVELOPMENT:** A hybrid of above two techniques is called ascending-descending chromatography.Only length of separation increased, first ascending takes place followed by descending.

d. **CIRCULAR / RADIAL DEVELOPMENT**

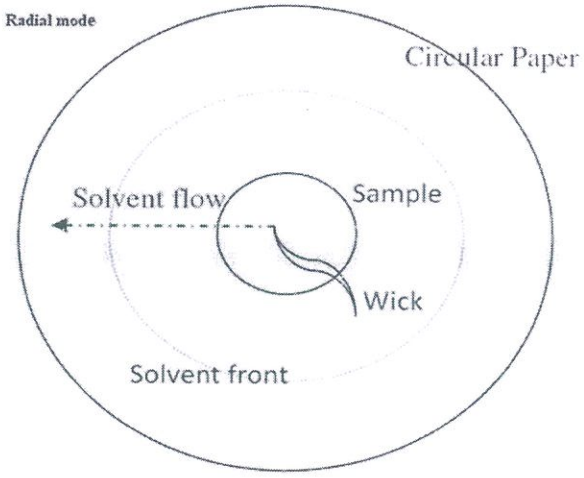

Fig 6: Circular/Development technique

Spot is kept at the centre of a circular paper.The solvent flows through a wick at the centre & spreads in all directions uniformly. Hence the individual spots after development look like concentric circles. By making perforations radially, number of quadrants can be created allowing more number of samples to be spotted (Fig 6).

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allowed for first development. Then the paper is again immersed in the mobile phase at a right angle to the previous development for the second chromatogram. In the second direction, either the same solvent system or different solvent system can be used for development.

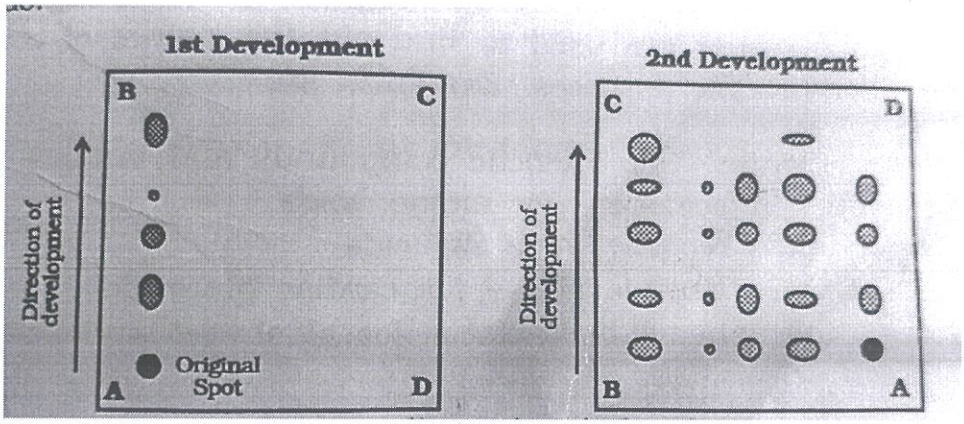

Fig 7: Two dimensional techniques

e. **Drying of Chromatogram:** After the development, the solvent front is marked and the left to dry in a dry cabinet or oven.

f. **Detection:** After the development of chromatogram, the spots should be visualized. Detecting colored spots can be done visually. But for detecting colorless spots, any one of the following technique can be used.

a. Nonspecific methods: where brown or amber of spots can be detected, but not the exact nature or type of the compound.

Examples

(i) Iodine chamber method where brown or amber spots are observed when the developed papers are kept in atank with few iodine crystals at the bottom.

(ii) UV chamber for fluorescent compounds: When compounds are viewed under UV chamber, at 254nm (short λ) or at 365nm (long λ), fluorescent compounds can be detected. Bright spots can are seen against a dark background.

b. Specific methods: Specific spray reagents or detecting or visualizing agents are used to find out the nature of compounds or identification purposes.

a. Ferric chloride- For phenolic compounds and tannins
b. Ninhydrin in acetone- for amino acids
c. Dragendroff's reagent- for alkaloids

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The detecting techniques can also be categorized as

a. **Destructive technique:** Specific spray reagents etc where the samples are destroyed before detection e.g. Ninhydrin reagent.
b. **Non-destructive technique:** UV chamber method, Iodine chamber method, densitometric method, e.t.c, where the sample is not destroyed even after detection.

   For radioactive materials, detection is by using autoradiographyor Geiger muller counter.

   For antibiotics, the chromatogram is layed on nutrient agar inoculated with appropriate strain and the zone of inhibition is compared.

Quantitative Analysis

Direct technique: Densitometer is an instrument whichmeasures quantitatively the density of the spots. When the optical densities of the spots for the standard and test solution are determined, the quantity of the substance can be calculated. The papers are neither destroyed nor eluted with solvents to get the compounds. The method is also known as in-situ method.

Indirect techniques: In this technique, the spots are cut into portions and eluted with solvents. The solution can be analyzedby any conventional techniques of analysis like spectrophotometry, electrochemical methods, etc.

Qualitative Analysis: a. Rf value

$$Rf = \frac{Distance\ travelled\ by\ solute}{Distance\ traveled\ by\ solvent\ front}$$

The Rf value ranges from 0 to 1. But the ideal values are from 0.3 to 0.8.

b. Rx value: It is always closure to 1.

$$Rx = \frac{Distance\ travelled\ by\ solute}{Distance\ traveled\ by\ standard}$$

c. Rm value: It is mainly used to find out whether the compounds belong to a homologous series. If they belong to a homologous series, the **Δ**Rm values are constant. The **Δ**Rm values for a pair of adjacent member of a homologous series are determined by using the below formula:

$$Rm = \log\left(\frac{1}{Rf} - 1\right)$$

Application:

(i) To check the control of purity of pharmaceuticals,
(ii) For detection of impurities

Drug	Mobile phase	Detecting agent

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Hydroxocobalamin	Butyl alcohol: acetic acid:potassium cyanide	Elution and measurement of absorbance at 361nm.

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(iii) Detect the contaminants in foods and drinks,

(iv) For the detection of drugs

Drug	Mobile phase	Detecting agent
Gentamycin	Chloroform : Methanol : Ammonia : Water (10:5:3:2)	Ninhydrin in pyridine-acetone mixture
Vancomycin	t-Amyl alcohol : Acetone: water (2:1:2)	Nutrient agar containing Bacilus subtilis

(v) In analysis of cosmetics
(vi) Analysis of the reaction mixtures in biochemical labs.
(vii) Identification of decomposition products
(viii) Analysis of metabolites of drugs in blood, urine etc.
(ix) In the study of ripening and fermentation

Advantages of Paper Chromatography:

1. Simple and Rapid
2. Paper Chromatography requires very less quantitative material.
3. Paper Chromatography is cheaper compared to other chromatography methods.
4. Both unknown inorganic as well as organic compounds can be identified by paper chromatography method.
5. Paper chromatography does not occupy much space compared to other analytical methods or equipment's.

Limitations of Paper Chromatography

1. Large quantity of sample cannot be applied on paper chromatography.
2. In quantitative analysis paper chromatography is not effective.
3. Complex mixture cannot be separated by paper chromatography.
4. Less Accurate compared to HPLC or HPTLC

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UNIT-4
GAS CHROMATOGRAPHY

Gas chromatography is a term used to describe the group of analytical separation techniques used to analyze volatile substances in the gas phase. In gas chromatography, the components of asample are dissolved ina solvent and vaporizedin orderto separate the analytes by distributing the sample between two phases: a stationary phase and a mobile phase. The mobile phase is a chemically inert gas that serves to carry the molecules of the analyte through the heated column. Gas chromatography is one of the sole forms of chromatography that does not utilize the mobile phaseforinteractingwiththeanalyte.Thestationaryphaseiseitherasolidadsorbant,termed gas-solid chromatography (GSC), or a liquid on an inert support, termed gas-liquid chromatography (GLC).

1. Introduction

In early 1900s, Gas chromatography (GC) was discovered by Mikhail Semenovich Tsvett as a separation technique to separate compounds. In organic chemistry, liquid-solid column chromatography is oftenusedto separateorganiccompounds in solution. Among thevarious types of gas chromatography, gas-liquid chromatography is the method most commonly used to separate organic compounds. The combination ofgas chromatography and mass spectrometry isan invaluable tool in the identification of molecules. A typical gas chromatograph consists of an injection port, a column, carrier gas flow control equipment, ovens and heaters for maintaining temperatures of the injection port and the column, an integrator chart recorder and a detector.

Toseparatethecompoundsingas-liquidchromatography,asolutionsamplethatcontains organic compounds of interest is injected into the sample port where it will be vaporized. The vaporizedsamplesthatareinjectedarethencarriedbyaninertgas,whichisoftenusedby helium or nitrogen. This inert gas goes through a glass column packed with silica that is coated with a liquid. Materials that are less soluble in the liquid will increase the result faster than the materialwithgreatersolubility.The purposeofthismodule istoprovideabetter understanding on its separation and measurement techniques and its application.

In GLC, the liquid stationary phase is adsorbed onto a solid inert packing or immobilized on the capillary tubing walls. The column is considered packed if the glass or metal column tubing is packed with small spherical inert supports. The liquid phase adsorbs onto the surface of these beads ina thinlayer.Ina capillary column, the tubing walls are coated with the stationary phase or an adsorbant layer, which is capable of supporting the liquid phase. However, the method of GSC,haslimitedapplicationinthelaboratory andisrarely used due to severe peak tailing and the semi-permanent retention of polar compounds within the column. Therefore, the method of gas-

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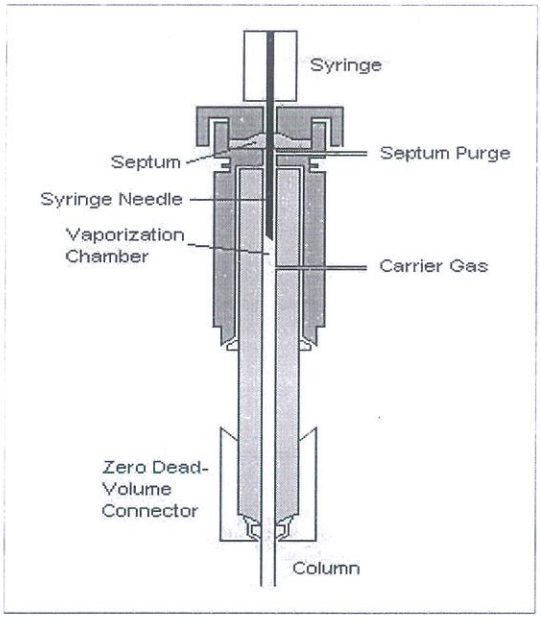
such here. The purpose of this module is to provide a better understanding on its separation and measurement techniques and its application.

2. Instrumentation

SampleInjection

Asampleportisnecessaryforintroducingthesampleattheheadofthecolumn.Modern injectiontechniquesoftenemploy theuseofheatedsampleportsthroughwhichthesamplecan be injected and vaporized in a near simultaneous fashion. A calibrated microsyringe is used to deliver a sample volume in the range of a few microliters through a rubber septum and into the vaporization chamber. Most separations require only a small fraction of the initial sample volume and a sample splitter is used to direct excess sample to waste. Commercial gas chromatographs often allow for both split and split less injections when alternating between packed columns and capillary columns. The vaporization chamber is typically heated 50 °C above the lowest boiling point of the sample and subsequently mixed with the carrier gas to transport the sample into the column.

Figure1:Across-sectionalviewofamicroflashvaporizerdirectinjector.



CarrierGas

Thecarriergasplaysanimportantrole,andvariesintheGCused.Carriergasmustbedry,free of oxygen and chemically inert mobile-phase employed in gas chromatography. Helium is most commonly used because it is safer than, but comprable to hydrogen in efficiency, has a largerrangeofflowratesandiscompatiblewithmanydetectors.Nitrogen,argon,andhydrogenare also used depending upon the desired performance and the detector being used. Bothhydrogenand helium, which are commonly used on most traditional detectors such as

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analysis time and lower elution temperatures of the sample due to higher flow rates and low molecularweight.Forinstance,hydrogenorheliumasthecarriergasgivesthehighest sensitivity with TCD because the difference in thermal conductivity between the organic vaporand hydrogen/helium is greater than other carrier gas. Other detectors such as mass spectroscopy, uses nitrogen or argon which has a much better advantage than hydrogen or helium due to their higher molecular weights, in which improve vacuum pump efficiency.

Allcarriergasses are availableinpressurized tanksandpressureregulators,gagesandflow metersareused tometiculously controlthe flowrateof thegas.Mostgassuppliesusedshould fall between 99.995% -99.9995% purity range and contain a low levels (< 0.5 ppm) of oxygenand total hydrocarbons in the tank. The carrier gas system contains a molecular sieve to remove water and other impurities. Traps are another option to keep the system pure and optimumsensitive and removal traces of water and other contaminants. A two stage pressure regulation is required tousetominimizethe pressure surgesandto monitor theflowrateofthegas.To monitor the flow rate of the gas a flow or pressure regulator was also require onto both tank and chromatograph gas inlet. This applies different gas type will use different type of regulator. The carriergasispreheatedandfilteredwithamolecularsievetoremoveimpuritiesandwaterprior to being introduced to the vaporization chamber. A carrier gas is typically required in GC systemto flow through the injector and push the gaseous components of the sample onto the GC column, which leads to the detector.

Gas Recommendations for Capillary Columns

Detector	Carrier gas	Preferred makeup gas	Second choice	Detector, anode purge, or reference gas
Electron Capture	Hydrogen	Argon/Methane	Nitrogen	Anode purge must be same as makeup
	Helium	Argon/Methane	Nitrogen	
	Nitrogen	Nitrogen	Argon/Methane	
	Argon/Methane	Argon/Methane	Nitrogen	
Flame Ionization	Hydrogen	Nitrogen	Helium	Hydrogen and air for detector
	Helium	Nitrogen	Helium	
	Nitrogen	Nitrogen	Helium	
Flame Photometric	Hydrogen	Nitrogen		Hydrogen and air for detector
	Helium	Nitrogen		
	Nitrogen	Nitrogen		
	Argon	Nitrogen		
Nitrogen-Phosphorus	Helium	Nitrogen	Helium**	Hydrogen and air for detector
	Nitrogen	Nitrogen	Helium**	
Thermal Conductivity	Hydrogen*	Must be same as carrier and reference gas	Must be same as carrier and reference gas	Reference must be same as carrier and makeup
	Helium			
	Nitrogen			

* When using hydrogen with a thermal conductivity detector, vent the detector exhaust to a fume hood or a dedicated exhaust to avoid buildup of hydrogen gas.

** Helium is not recommended as a makeup gas at flow rates > 5 mL/min. Flow rates above 5 mL/min shorten detector life.

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Figure2.GasRecommendationsforCapillaryColumns

Gas Recommendations for Packed Columns

Detector	Carrier gas	Comments	Detector, anode purge, or reference gas
Electron Capture	Nitrogen	Maximum sensitivity	Nitrogen
	Argon/Methane	Maximum dynamic range	Argon/Methane
Flame Ionization	Nitrogen	Maximum sensitivity	Hydrogen and air for detector
	Helium	Acceptable alternative	
Flame Photometric	Hydrogen		Hydrogen and air for detector
	Helium		
	Nitrogen		
	Argon		
Nitrogen-Phosphorus	Helium	Optimum performance	Hydrogen and air for detector
	Nitrogen	Acceptable alternative	
Thermal Conductivity	Helium	General use	Reference must be same as carrier
	Hydrogen	Maximum sensitivity (Note A)	
	Nitrogen	Hydrogen detection (Note B)	
	Argon	Maximum hydrogen sensitivity (Note B)	

Note A: Slightly greater sensitivity than helium. Incompatible with some compounds.
Note B: For analysis of hydrogen or helium. Greatly reduces sensitivity for other compounds.

Figure3.GasRecommendationsforPackedColumns

ColumnOven

The thermostatted oven serves to control the temperature of the column within a few tenths of a degree to conduct precise work. The oven can be operated in two manners: isothermal programming or temperature programming. In isothermal programming, the temperature of the column is held constant throughout the entire separation. The optimum column temperature for isothermal operation is about the middle point of the boiling range of the sample. However, isothermal programming works best only if the boiling point range of the sample is narrow. If a low isothermal column temperature is used with a wide boiling point range, the low boiling fractions are well resolved but the high boiling fractions are slow to elute with extensive band broadening. If the temperature is increased closer to the boiling points of the higher boiling components,thehigherboilingcomponentseluteassharppeaksbutthelower boiling components elute so quickly there is no separation.

Inthetemperatureprogrammingmethod,thecolumntemperatureiseitherincreased continuously or in steps as the separation progresses. This method is well suited to separating a mixture with a broad boiling point range. The analysis begins at a low temperature to resolve the

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boiling components of the sample. Rates of 5-7 °C/minute are typical for temperatureprogramming separations.

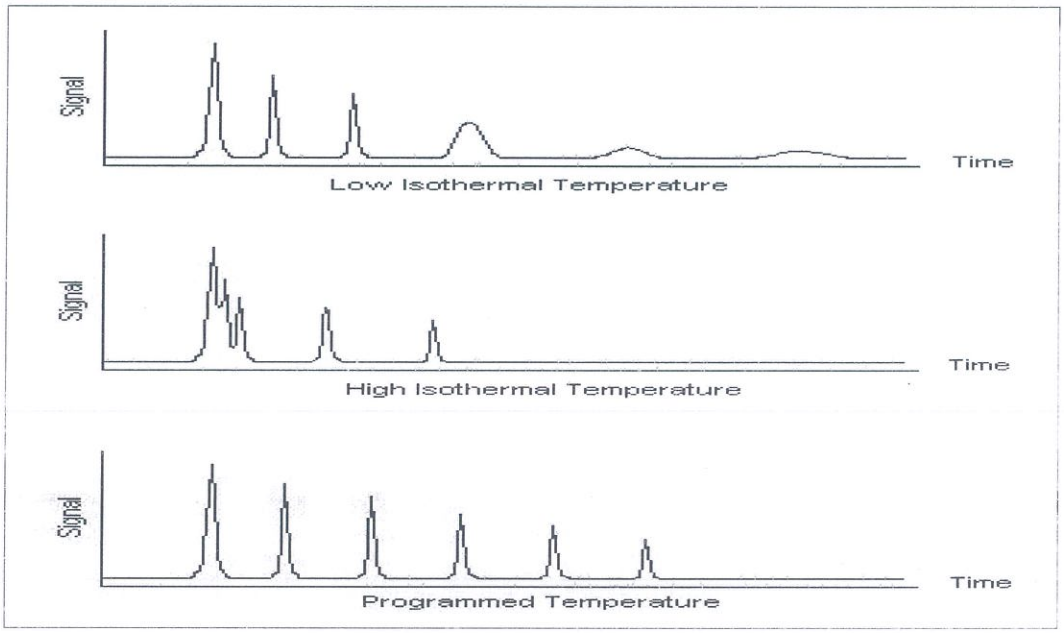

Figure4. Theeffectofcolumntemperatureontheshapeofthepeaks.

OpenTubularColumnsandPackedColumns

Open tubular columns, which are also known as capillary columns, come in two basic forms. The first is a wall-coated open tubular (WCOT) column and the second type is a support-coated open tubular (SCOT) column. WCOT columns arecapillary tubes that have a thin layer of thestationary phase coated along the column walls. In SCOT columns, the column walls are first coated with a thin layer (about 30 micrometers thick) of adsorbent solid, such as diatomaceous earth, a material which consists of single-celled, sea-plant skeletons. The adsorbent solid is then treated with the liquid stationary phase. While SCOT columns are capable of holding a greater volume of stationary phase than a WCOT column due to its greater sample capacity, WCOT columns still have greater column efficiencies.

Most modern WCOT columns are made of glass, but T316 stainless steel, aluminum, copper and plastics have also been used. Each material has its own relative merits depending upon the application. Glass WCOT columns have the distinct advantage of chemical etching, which is usually achieved by gaseous or concentrated hydrochloric acid treatment. The etching process gives the glass a rough surface and allows the bonded stationary phase to adhere more tightly tothe column surface.

One of the most popular types of capillary columns is a special WCOT column called the fused-silica wall-coated (FSWC) open tubular column. The walls of the fused-silica columns are drawn

column, a polyimide coating is applied to the outside of the tubing and bent into coils to fit inside the thermostatted oven of the gas chromatography unit. The FSWC columns are commercially available and currently replacing older columns due to increased chemical inertness, greater column efficiency and smaller sampling size requirements. It is possible to achieve up to 400,000 theoretical plates with a 100 m WCOT column, yet the world record for the largest number of theoretical plates is over 2 million plates for 1.3 km section of column.

Packed columns are made of a glass or metal tubing which is densely packed with a solid support like diatomaceous earth. Due to the difficulty of packing the tubing uniformly, these types of columns have a larger diameter than open tubular columns and have a limited range of length. Asa result, packed columns can only achieve about 50% of the efficiency of a comparable WCOT column. Furthermore, the diatomaceous earth packing is deactivated over time due to the semi-permanent adsorption of impurities within the column. In contrast, FSWC open tubular columns are manufactured to be virtually free of these adsorption problems.

	Type of Column			
	FSWC	WCOT	SCOT	Packed
Length	10 to 1000 m	10 to 1000 m	10 to 100 m	1 to 6 m
Inner Diameter	0.1 to 0.3 mm	0.25 to 0.75 mm	0.5 mm	2 to 4 mm
Efficiency (plates/m)	2000 to 4000	1000 to 4000	600 to 1200	500 to 1000
Sample Size	10 to 75 ng	10 to 1000 ng	10 to 1000 ng	10 to 10^6 ng
Pressure	Low	Low	Low	High
Speed	Fast	Fast	Fast	Slow
Inertness	Best	Good	Fair	Poor

Figure5.PropertiesofGaschromatographycolumns.

Different types of columns can be applied for different fields. Depending on the type of sample, some GC columns are better than the others. For example, the FSWC column is designed especially for blood alcohol analysis. It produces fast run times with baseline resolution of key components in less than 3 minutes. Moreover, it displays enhanced resolutions of ethanol and acetone peaks, which helps with determining the BAC levels. This particular column is known as Zebron-BAC and it made with polyimide coating on the outside and the inner layer is made of fused silica and the inner diameter ranges from .18 mm to .25 mm. There are also many other Zebron brand columns designed for other purposes.

AnotherexampleofaZebronGCcolumnisknownasthe Zebron-inferno.Itsouterlayeris coated with a

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provide true boiling point separation of hydrocarbons distillation methods. Moreover, it is alsoused for acidic and basic samples.

DetectionSystems

The detector is the device located at the end of the column which provides a quantitative measurement of the components of the mixture as they elute in combination with the carrier gas.In theory,any property of the gaseous mixture that is different from the carrier gas can be used asa detection method. These detection properties fall into two categories: bulk properties andspecificproperties.Bulk properties, which are also known asgeneral properties,are properties that both the carrier gas and analyte possess but to different degrees. Specific properties, such as detectors that measure nitrogen-phosphorous content, have limited applications but compensatefor this by their increased sensitivity.

Each detector has two main parts that when used together they serve as transducers to convertthedetectedpropertychangesintoanelectricalsignalthatisrecordedasa chromatogram. The first part of the detector is the sensor which is placed as close to the column exit as possible in order to optimize detection. The second is the electronic equipment used to digitizetheanalogsignalsothatacomputermayanalyzetheacquiredchromatogram.The sooner the analog signal is converted into a digital signal, the greater the signal-to-noise ratio becomes, as analog signal are easily susceptible to many types of interferences.

An ideal GC detector is distinguished by several characteristics. The first requirement is adequate sensitivity to provide a high resolution signal for all components in the mixture. This is clearly an idealized statement as such a sample would approach zero volume and the detector would need infinite sensitivity to detect it. In modern instruments, the sensitivities of the detectors are in the range of 10^{-8} to 10^{-15} g of solute per second. Furthermore, the quantity of sample must be reproducible and many columns will distort peaks if enough samples are not injected. An ideal column will also be chemically inert and should not alter the sample in any way. Optimized columns will be able to withstand temperatures in the range of -200 °C to at least 400 °C. In addition, such a column would have a short linear response time that is independent of flow rate andextendsfor severalordersofmagnitude.Moreover,thedetector shouldbe reliable, predictable and easy to operate.

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Table2:Typicalgaschromatographydetectorsandtheirdetectionlimits.		
TypeofDetector	**ApplicableSamples**	**DetectionLimit**

Table2:Typicalgaschromatographydetectorsandtheirdetectionlimits.

TypeofDetector	ApplicableSamples	DetectionLimit
MassSpectrometer(MS)	Tunableforanysample	0.25to100pg
FlameIonization(FID)	Hydrocarbons	1pg/s
ThermalConductivity(TCD)	Universal	500pg/ml
Electron-Capture(ECD)	Halogenatedhydrocarbons	5fg/s
AtomicEmission(AED)	Element-selective	1pg
Chemiluminescence(CS)	Oxidizingreagent	Dark currentofPMT
Photoionization(PID)	VaporandgaseousCompounds	0.002to0.02µg/L

Understandably, it is not possible for a detector meet all of these requirements. The next subsectionswilldiscusssomeofthemorecommontypesofgaschromatography detectorsand the relative advantages and/or disadvantages of each.

MassSpectrometryDetectors

Mass Spectrometer (MS) detectors are most powerful of all gas chromatography detectors. In a GC/MS system, the mass spectrometer scans the masses continuously throughout the separation. When the sample exits the chromatography column, it is passed through a transfer line into theinlet of the mass spectrometer. The sample is then ionized and fragmented, typically by an electron-impact ion source. During this process, the sample is bombarded by energetic electrons which ionize the molecule by causing them to lose an electron due to electrostatic repulsion. Further bombardment causes the ions to fragment. The ions are then passed into a mass analyzer wheretheionsaresortedaccordingtotheirm/zvalue,ormass-to-chargeratio.Mostionsare only singly charged.

TheChromatogramwillpointoutthereteniontimesandthemassspectrometerwillusethe peaks to determine what kind of molecules are exist in the mixture. The figure below represents a typical

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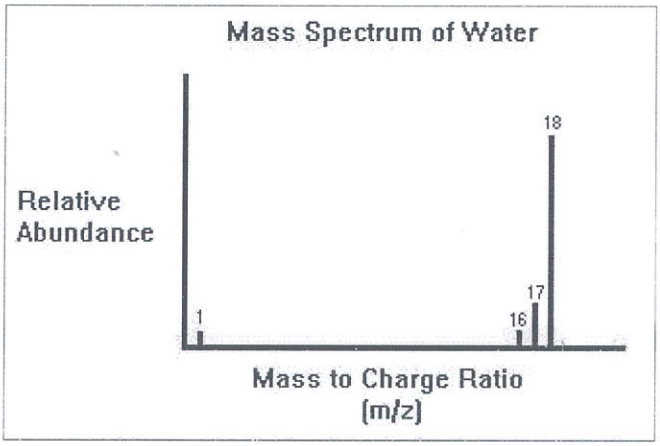

Figure6.MassSpectrumofWater

Instrumentation

One of the most common types of mass analyzer in GC/MS is the quadrupole ion-trap analyzer, which allows gaseous anions or cations to be held for long periods of time by electric andmagnetic fields. A simple quadrupole ion-trap consists of a hollow ring electrode with two grounded end-cap electrodes as seen in figure #. Ions are allowed into the cavity through a grid in the upper end cap. A variable radio-frequency is applied to the ring electrode and ions with an appropriatem/zvalueorbitaroundthecavity.Astheradio-frequency isincreasedlinearly,ions of a stable m/z value are ejected by mass-selective ejection in order of mass. Ions that are tooheavy or too light are destabilized and their charge is neutralized upon collision with the ring electrode wall. Emitted ions then strike an electron multiplier which converts the detected ionsinto an electrical signal. This electrical signal is then picked up by the computer through various programs. As an end result, a chromatogram is produced representing the m/z ratio versus the abundance of the sample.

GC/MSunitsareadvantageousbecausetheyallowfortheimmediatedeterminationof themass of the analyte and can be used to identify the components of incomplete separations. They are rugged, easy to useand can analyze the sample almost as quickly as itiseluted. The disadvantages of mass spectrometry detectors are the tendency for samples to thermally degrade before detection and the end result of obliterating the entire sample by fragmentation.

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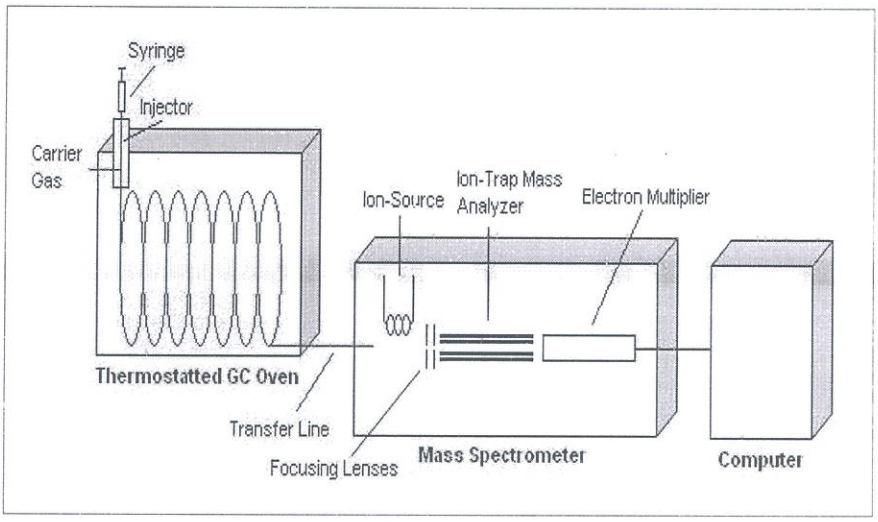

Figure7.SchematicoftheGC/MSsystem.

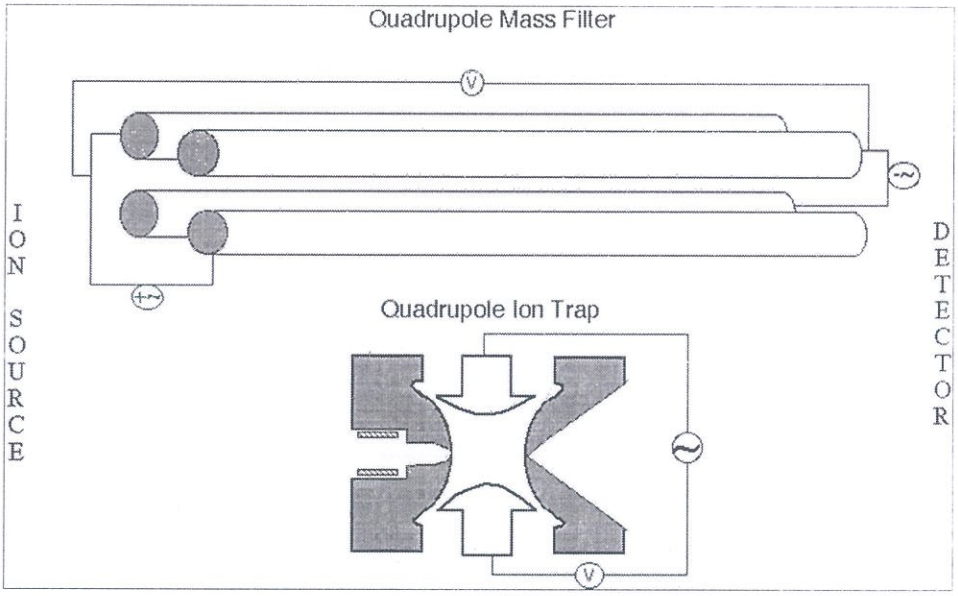

Figure8.ArrangementofthepolesinQuadrupoleandIonTrapMassspectrometers

FlameIonizationDetectors

Flame ionization detectors (FID) are the most generally applicable and most widely useddetectors.Ina FID, the sample is directedat an air-hydrogen flame after exiting the column. Atthe high temperature of the air-hydrogen flame, the sample undergoes pyrolysis, or chemical decomposition through intense heating. Pyrolized hydrocarbons release ions and electrons that carry current. A high-impedance picoammeter measures this current to monitor the sample's elution.

It is advantageous to use FID because the detector is unaffected by flow rate, noncombustiblegases and water. These properties allow FID high sensitivity and low noise. The unit is both reliable and relatively easy to use. However, this technique does require flammable gas and also destroys the sample.

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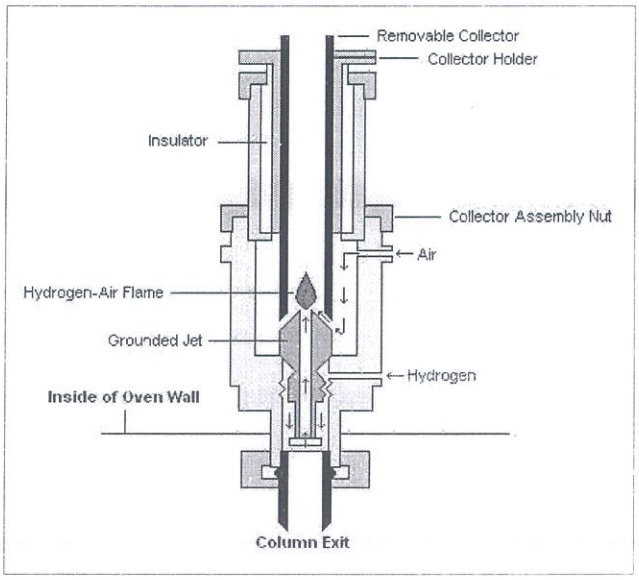

Figure9.Schematicofatypicalflameionizationdetector.

ThermalConductivityDetectors

Thermal conductivity detectors (TCD) were one the earliest detectors developed for use with gas chromatography. The TCD works by measuring the change in carrier gas thermal conductivity caused by the presence of the sample, which has a different thermal conductivity from that of the carrier gas. Their design is relatively simple, and consists of an electrically heated source that is maintained at constant power. The temperature of the source depends upon the thermal conductivities of the surrounding gases. The source is usually a thin wire made of platinum, gold. The resistance within the wire depends upon temperature, which is dependent upon the thermal conductivity of the gas.

TCDs usually employ two detectors, one of which is used as the reference for the carrier gas and the other which monitors the thermal conductivity of the carrier gas and sample mixture. Carrier gases such as helium and hydrogen has very high thermal conductivities so the addition of even a small amount of sample is readily detected.

The advantages of TCDs are the ease and simplicity of use, the devices' broad application to inorganic and organic compounds, and the ability of the analyze to be collected after separationand detection. Thegreatest drawback of the TCD is the low sensitivity of the instrument inrelation to other detection methods, in addition to flow rate and concentration dependency.

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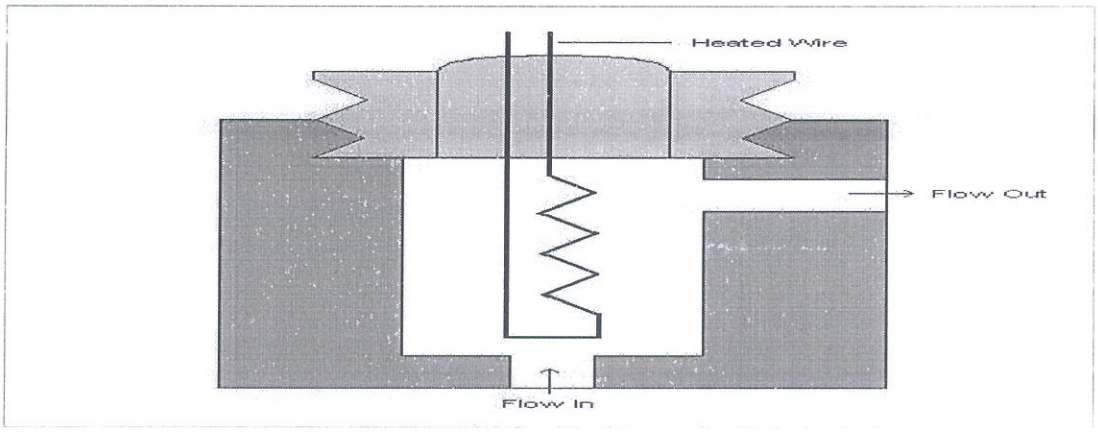

Figure10.Schematicofthermalconductivitydetectioncell.

Electron-captureDetectors

Electron-capture detectors (ECD) are highly selective detectors commonly used for detecting environmentalsamplesasthedeviceselectivelydetectsorganiccompoundswithmoietiessuch as halogens, peroxides, quinones and nitro groups and gives little to no response for all other compounds. Therefore, this method is best suited in applications where traces quantities of chemicalssuchaspesticidesaretobedetectedandotherchromatographicmethodsare unfeasible.

The simplest form of ECD involves gaseous electrons from a radioactive emitter in an electric field.AstheanalyteleavestheGCcolumn,itispassedoverthisemitter,whichtypically consistsofnickle-63ortritium.Theelectronsfromtheemitterionizethenitrogencarriergas and cause it to release a burst of electrons. In the absence of organic compounds, a constant standing current is maintained between two electrodes. With the addition of organic compounds withelectronegativefunctionalgroups,thecurrentdecreasessignificantlyasthefunctional groups capture the electrons.

The advantages of ECDs are the high selectivity and sensitivity towards certain organic species with electronegative functional groups. However, the detector has a limited signal range and is potentially dangerous owing to its radioactivity. In addition, the signal-to-noise ratio is limited by radioactive decay and the presence of O2 within the detector.

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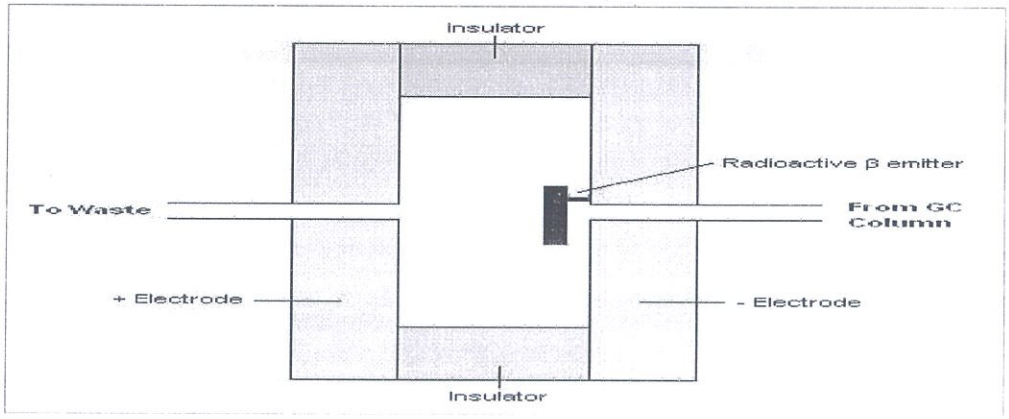

Figure11.Schematicofanelectron-capturedetector.

AtomicEmissionDetectors

Atomic emission detectors (AED), one of the newest additions to the gas chromatographer's arsenal, are element-selective detectors that utilize plasma, which is a partially ionized gas, to atomize all of the elements of a sample and excite their characteristic atomic emission spectra. AED is an extremely powerful alternative that has a wider applicability due to its based on the detection of atomic emissions. There are three ways of generating plasma: microwave-induced plasma (MIP), inductively coupled plasma (ICP) or direct current plasma (DCP). MIP is the most commonly employed form and is used with a position able diode array to simultaneously monitor the atomic emission spectra of several elements.

Instrumentation

The components of the Atomic emission detectors include 1) an interface for the incoming capillary GCcolumnto induce plasma chamber,2) a microwave chamber,3) a cooling system, 4)a diffractiongrating that associated optics, and 5) a position adjustable photodiode arrayinterfaced to a computer.

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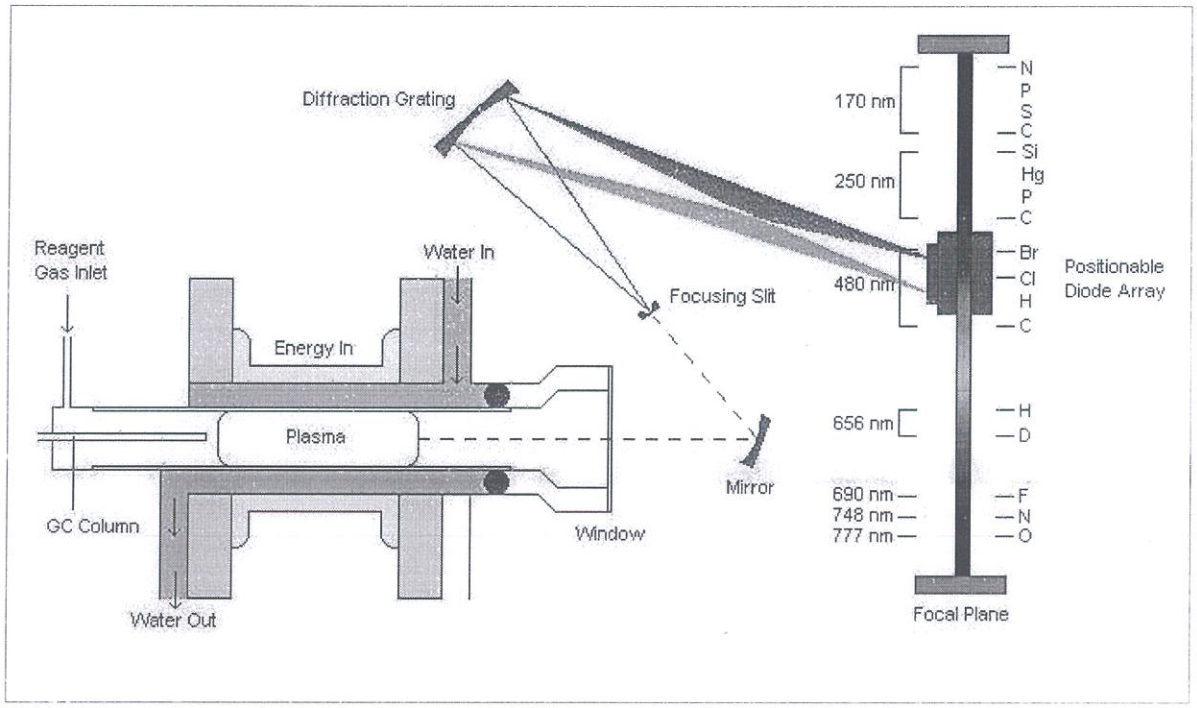

Figure12.Schematicofatomicemissiondetector.

GCChemiluminescenceDetectors

Chemiluminescence spectroscopy (CS) is a process in which both qualitative and quantitative properties can be be determined using the optical emission from excited chemical species. It isvery similar to AES, but the difference is that it utilizes the light emitted from the energized molecules rather than just excited molecules. Moreover, chemiluminescence can occur in eitherthe solution or gas phase whereas AES is designed for gaseous phases. The light source for chemiluminescence comes from the reactions of the chemicals such that it produces light energyas a product. This light band is used instead of a separate source of light such as a light beam.

Like other methods, CS also has its limitations and the major limitation to the detection limits of CS concerns with the use of a photomultiplier tube (PMT). A PMT requires a dark current in it to detect the light emitted from the analyte.

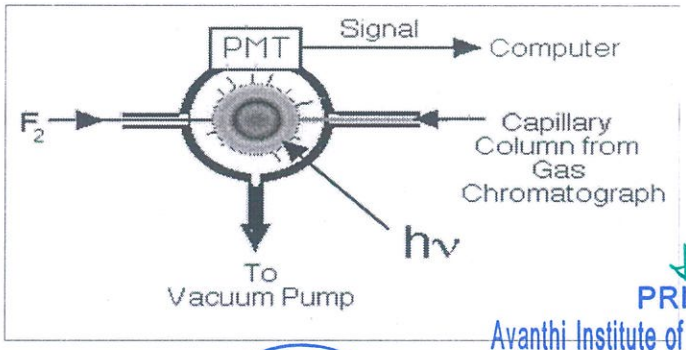

Figure13.SchematicofaGCChemiluminescenceDetector

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vapor and gas detector that has selective determination of aromatic hydrocarbons, organo-heteroatom, inorganic species and other organic compounds. PID comprise of an ultrvioletlampto emit photons that are absorbed by the compounds in an ionization chamber exiting from a GC column. Small fraction of the analyte molecules are actually ionized, nondestructive, allowing confirmation analytical results through other detectors. In addition, PIDs are available in portable hand-held models and in a number of lamp configurations. Results are almost immediate. PID is used commonly to detect VOCs in soil, sediment, air and water, which is often used to detect contaminants in ambient air and soil. The disadvantage of PID is unable to detect certain hydrocarbon that has low molecular weight, such as methane and ethane.

Instrumentation

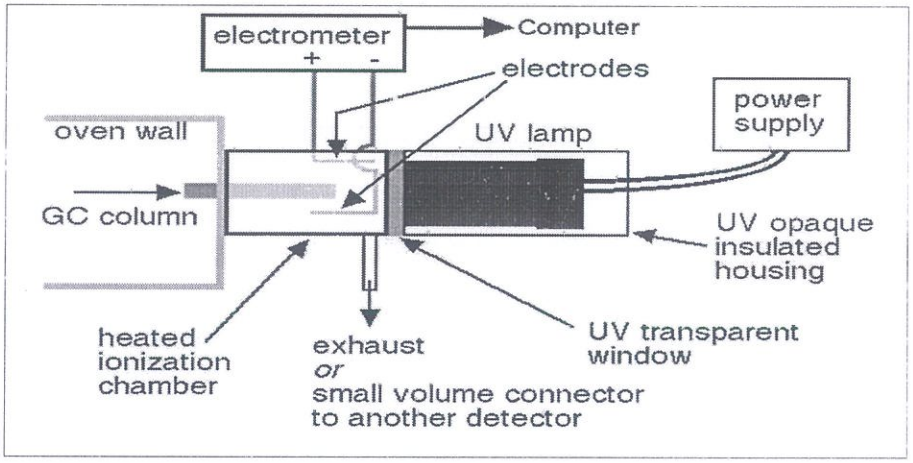

Figure14.Schematicofaphotoionizationdetector

3. Derivatization

Derivatizationistheprocessbywhichacompoundischemicallychanged,producinganew compound thathaspropertiesmore amenableto a particular analyticalmethod. Some samples analyzed by GC require derivatization in order to make them suitable for analysis. Compounds thathave poor volatility, poor thermal stability, or that can be adsorbed in the injector will exhibit no reproducible peak areas, heights, and shapes. Other compounds that respond poorly on a specific detector may need to be "tagged" with a different functional group to improve detection. For example, tagging with chlorine can improve response on an ECD (electron capture detector). In addition to improving suitability and response, derivatization can improve resolution between co-eluting compounds and overlapping peaks.

SelectionofDerivatizationreagent

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a new compound which has properties that are suitable for analysis in GC or LC. The following criteria must be used as guidelines in choosing a suitable derivatization reagent for GC analysis.

i. Thereagentshouldproducemorethan95%complete derivatives.
ii. It should not cause any rearrangements or structural alterations of compounds during formation of the derivative.
iii. Itshouldnotcontributetolossofthesampleduringthereaction.
iv. Itshouldproduceaderivativethatwillnotinteractwiththe GC column.
v. Itshouldproduceaderivativethatisstablewithrespecttotime.

Objectivesforderivatization

i. Improvement of resolution and reduce tailing of polar compounds which may contain – OH, –COOH, =NH, $–NH_2$, –SH, and other functional groups.
ii. Analysisofrelativelynonvolatilecompounds.
iii. ReductionofvolatilityofcompoundspriortoGCanalysis.
iv. Improvementofanalyticalefficiencyandhenceincreasedetectability.
v. StabilizationofcompoundsforGCanalysis.

Typesofderivatizationreactions

Derivatization reactions used for gas chromatography (GC) fall into three general reaction types namely; Alkylation of which the general process is esterification, Acylation and Silylation. Through these three processes, highly polar materials such as organic acids, amides, poly-hydroxy compounds, amino acids are rendered suitable for GC analysis by making them sufficiently volatile. These general processes are discussed below.

Alkylation

Alkylation is mostly used as the first step for further derivatizations or as a method of protection of certain active hydrogens in a sample molecule. It represents the replacement of activehydrogen by an aliphatic or aliphatic-aromatic (e.g., benzyl) group in process referred to as esterification. Equation 1 below shows the general reaction equation representing theesterification process.

$$RCOOH+PhCH_2X \rightarrow RCOOCH_2Ph+HX$$

Equation1:Generalreactionforesterificationprocess

The principal chromatographic use of this reaction is the conversion of organic acids into esters, especially methyl esters that produce better chromatograms than the free acids. Alkylation

and sulphonamides.In general, theproductsof alkylation areless polar than thestarting materials because active hydrogen has been replaced by an alkyl group. The alkyl esters formed offer excellent stability and can be isolated and stored for extended periods if necessary. In esterificationanacidreactswith analcoholtoformanester.Inthereaction,acatalystmore often an inorganic acid such as hydrochloric acid or thionyl chloride.

Derivatizationreagentsusedinalkylation

Common derivatization reagents for the Alkylation type of reactions are Dialkylacetals, Diazoalkales, Pentafluorobenzyl bromide (PFBBr), Benzylbromide, Boron trifluoride (BF_3) in methanol or butanol and Tetrabutylammonium hydroxide (TBH) among others. Alkylation reagents can be used alone to form esters, ethers and amides or they can be used in conjunction with acylation or silylation reagents. The reaction conditions can vary from strongly acidic to strongly basic with both generating stable derivatives.

Examples

- **Dialkylacetals**

Dimethylformamide (DMF) is an example of dialkylacetals with a general formula $CH_3CH_3NCHORO R$ are used to esterify acids to their methyl esters. Dialkylacetals have a wider applicability for the derivatization of a number of functional groups containing reactive hydrogens. Because the principal reaction product is dialkylacetals (DMF), the isolation of the derivative is not required and the reaction mixture can be injected directly into the gas chromatograph. This reagent is an excellent first choice for derivatization of a compound for which there is no published method available. The reaction between N, N-dimethylformamide dimethylacetal and Carboxylic acid is as follows (Equation 2).

$$CH_3CH_3NCHORO R+R`COOH \rightarrow R`COOR+ROH+CH_3CH_3NCHO$$

Equation 2: The reaction between N, N-dimethylformamide dimethylacetal and Carboxylic acid.

Although carboxylic acids, phenols, and thiols react quickly with DMF, to give the corresponding alkyl derivatives, hydroxyl groups are not readily methylated. During derivatizationprocedure,care shouldbetaken because *N*,*N*-dimethylformamide dimethylacetals are moisture sensitive.

- **Tetrabutylammoniumhydroxide(TBH)**

Derivatization of a carboxylic acid with tetrabutylammonium hydroxide (TBH) forms butyl

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weightamines.Equation3representsthederivatizationreactionfortheconversionof carboxylic acid to alkyl esters using TBH.

$$[N(CH_3)_4]^+[OH]^- + RCOOH \rightarrow RCOOC_4H_9$$

Equation3:ConversionofcarboxylicacidtoalkylestersusingTBH.

Thefollowingderivatizationprocedurecanbeusedforflashalkylationwhichissuitablefor biological fluids and thermally stable fatty acids analysis

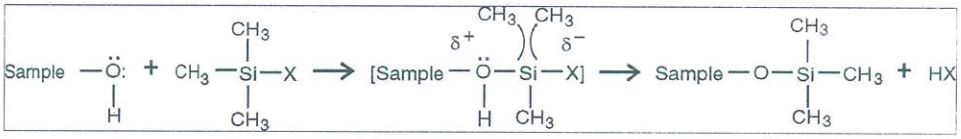
Silylation

Silylation is themost prevalent derivatization method as it readily volatizes the sample andtherefore very suitable for non-volatile samples for GC analysis. Silylation is the introduction of a silyl group into a molecule, usually in substitution for active hydrogen such as dimethylsilyl [$SiH(CH_3)_2$], t-butyldimethylsilyl [$Si(CH_3)_2C(CH_3)_3$] and chloromethyldimethylsilyl [$SiCH_2Cl(CH_3)_2$]. Replacement of active hydrogen by a silyl group reduces the polarity of the compound and reduces hydrogen bonding. Many hydroxyl and amino compounds regarded as nonvolatile or unstable at 200 – 300 °C have been successfully analyzed in GC after silylation. The silylated derivatives are more volatile and more stable and thus yielding narrow and symmetrical peaks.

Silylationreactionandmechanism

The silylation reaction is driven by a good leaving group, which means a leaving group with a low basicity, ability to stabilize a negative charge in the transitional state, and little or no back bonding between the leaving group and silicon atom (Knapp, 1979). The mechanism involves the replacement of the active hydrogens (in -OH, -COOH, -NH, $-NH_2$, and -SH groups) with a trimethylsilyl group.

Silylationthen occursthroughnucleophilicattack (SN_2), wherethe betterthe leavinggroup, the better the siliylation. This results to the production of a bimolecular transition state in the intermediate step of reaction mechanism. The general reaction for the formation of trialkylsilyl derivativesisshownbyequation4.Theleavinggroupinthecaseoftrimethylchlorosilane



(TMCS) istheClatom.

Equation 4: Reaction mechanism for the formation of trialkylsilyl derivatives for

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In silylation derivatisation, care must be taken to ensure that both sample and solvents are dry. Silyl reagents generally are moisture sensitive, and should be stored in tightly sealed containers and therefore the solvents used should be as pure and as little as possible.

DerivatizationreagentsusedinSilylation

Reagentsusedforthesilylationderivatizationprocessinclude Hexamethyldisilzane(HMDS), Trimethylchlorosilane(TMCS),Trimethylsilylimidazole(TMSI),Bistrimethylsilylacetamide (BSA), Bistrimethylsilyltrifluoroacetamide (BSTFA), N-methyl- trimethylsilyltrifluoroacetamide (MSTFA), Trimethylsilyldiethylamine (TMS-DEA), N- methyl-N-t-butyldimethylsilyltrifluoroacetamide (MTBSTFA), and Halo-methylsilyl derivatization reagents.

Examples

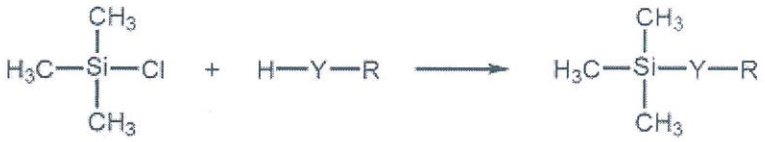
- **Trimethylsilylimidazole(TMSI)**

Trimethylsilylimidazole (TMSI) is not a weak donor, but it is selective as it reacts withalcohols and phenols but not amines or amides (nitrogen groups). Since it is selective, it will target the hydroxyls in wet sugars and also derivatize the acid sites of amino acids.It willleavetheaminogroupfreeforfluorinatedderivatization.Anexampleofreactionequation

usingTMSIisshownbelow(Equation5).

Equation 5: Silylation reaction using Trimethylsilylimidazole (TMSI): TMS = R, R` = Alk, Ar.

The derivatives produced are suitable for ECD analysis. Trimethylchlorosilane (TMCS) is alsoa weak donor. In addition, it produces hydrochloric acid as a byproduct with is acidic. It is therefore not commonly used. However, it is often found as a catalyst to increase TMS donor potential.AnexampleofderivatizationreactionusingTrimethylchlorosilane(TMCS)is shown in equation 6.



Equation 6: Silylation reaction using Trimethylchlorosilane (TMCS), Y = O, S.

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Derivatizationbyacylationisatypeofreactioninwhichanacylgroupisintroduced to an organic compound. In the case of a carboxylic acid, the reaction involves the introduction of the acyl group and the loss of the hydroxyl group. Compounds that contain active hydrogens (e.g., -OH, -SH and -NH) can be converted into esters, thioesters and amides, respectively, through acylation. Acylation is also a popular reactionfortheproductionofvolatilederivativesofhighlypolarandinvolatile organic materials. Acylation also improves the stability of those compounds that are thermally labile by inserting protecting groups into the molecule. Acylation can render extremely polar materials such as sugars amenable to separation by GC and, consequently, are a useful alternative or complimentary to the silylation. Equation. 7 shows an example of an acylation is the reaction between acetic anhydride and an alcohol.

$$CH_3OCOCOCH_3 + HOR \xrightarrow{H^+} CH_3OCOR' + HOCOCH_3$$

Equation7:AcylationReaction

- BenefitsofacylationinGCanalysis.

i. Itimprovesanalytestabilitybyprotectingunstablegroups.
ii. It can provide volatility on substances such as carbohydrates or amino acids, which have many polar groups that they are nonvolatile and normally decompose onheating.
iii. It assists in chromatographic separations which might not be possible with compounds that are not suitable for GC analysis.
iv. Compoundsaredetectableatverylowlevelswithanelectroncapturedetector(ECD).

3.3.3.1Derivatizationreagentsusedinacylation

CommonreagentsfortheAlkylationprocessareFluoracylimidazoles,FluorinatedAnhydrides, N-Methyl-bis(trifluoroacetamide) (MBTFA), Pentafluorobenzoyl Chloride (PFBCI) and Pentafluoropropanol (PFPOH). Acylating reagents readily target highly polar, multi-functional compounds, such as carbohydrates and amino acids. In addition, acylating reagents offer the distinct advantage of introducing electron-capturing groups and therefore enhancing detectability during analysis.

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Examples

- **N-Methyl-bis(trifluoroacetamide)(MBTFA)**

N-Methyl-bis(trifluoroacetamide) (MBTFA) reagent reacts rapidly with primary and secondary amines, and also slowly with hydroxyl groups and thiols. Reaction conditions are mild with relatively inert and non acidic by-products and therefore do not damage the GC column. The general reaction is presented in equation 8;

$$F_3COCN(CH_3)OCCF_3+H\text{-}Y\text{-}R \rightarrow F_3OC\text{-}Y\text{-}R + CH_3NHOCCF_3$$

Equation 8: Representative reaction of the derivatization of amines, hydroxyl groups and thiols using N-Methyl-bis(trifluoroacetamide) (MBTFA) reagent: Y = O, S, NH, NR´, R, R´ = Alk, Ar.

N-Methyl-N-bis(trifluoroacetamideis recommended for theanalysis ofsugars andas an acylation reaction isoften used for aminedrugs, such as stimulants,aminoacids, and alcohols.

- **PentafluorobenzoylChloride(PFBCI)**

Pentafluorobenzoyl chloride (PFBCI) is used in making derivatives of alcohols andsecondary amines of which secondary amines are the most highly reactive, forming the most sensitive ECD derivatives of amine and phenol. Phenols are the most receptive site for this reagent. Pentafluorobenzoyl chloride (PFBCI) is suitable for functional groups that are sterically hindered.AbasesuchasNaOHisoftenusedtoremovetheHClthatisproduced as byproduct. This derivatization procedure which is presented by the reaction below (equation9)basicallyusesapentafluorobenzoylchloride(PFBCl)toproviderapid formation of the derivatives of amines and phenols.

$$C_6F_5\text{-}OCCl+C_6H_5\text{-}OH \rightarrow C_6F_5\text{-}OCO\text{-}C_6H_5+HCl$$

Equation 9: Formation of derivatives of amines and phenols using Pentafluorobenzoyl chloride (PFBCI).

3.3.4ChiralDerivatization

Chiral derivatization involves reaction of an enatiomeric molecule with an enatiomerically pure chiral derivatizing agent (CDA) to form two diastereomeric derivatives that can be separated in this case using GC. A solution in which both enantiomers of a compound are present in equal amounts is called a racemic mixture. Diastereomers are stereoisomers (they have two or more stereo centers) that are not related as object and mirror image and are therefore not enantiomers. In other word, unlike enatiomers which are mirror images of each other and non-sumperimposable, diastereomers are not mirror images of each other and non-

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3. Frequentcalibrationarerequired.
4. Unitsofpartspermillionrange
5. Enviromentaldistraction,especiallywatervapor.
6. Strong electrical fieldsRapid variation in temperature at the detector and naturally occurring compounds may affect instrumental signal.

Applications:

Gas chromatography is a physical separation method in where volatile mixtures are separated. It can be used in many different fields such as pharmaceuticals, cosmetics and even environmental toxins. Since the samples have to be volatile, human breathe, blood, saliva and other secretions containing large amounts of organic volatiles can be easily analyzed using GC. Knowing the amountofwhichcompoundisinagivensamplegivesahugeadvantageinstudyingtheeffects of human health and of the environment as well.

AirsamplescanbeanalyzedusingGC.Mostofthetime,airqualitycontrolunitsuseGC coupled with FID in order to determine the components of a given air sample. Although other detectors are useful as well, FID is the most appropriate because of its sensitivity and resolution andalsobecauseitcandetectverysmallmoleculesaswell.GC/MSisalsoanotheruseful method which can determine the components of a given mixture using the retention times and the abundance of the samples. This method be applied to many pharmaceutical applications such as identifying the amount of chemicals in drugs. Moreover, cosmetic manufacturers also use this method to effectively measure how much of each chemical is used for their products.

HIGHPERFORMANCELIQUIDCHROMATOGRAPHY

1. Introduction

High-performance liquid chromatography (HPLC; formerly referred to as high-pressure liquid chromatography) is a technique in analyticalchemistryused to separate, identify, and quantify each componentinamixture.Itreliesonpumpstopassa pressurized liquid solventcontaining the sample mixture through a column filled with a solid adsorbentmaterial. Each component in the sample interacts slightly differently with the adsorbent material, causing different flow ratesfor the different components and leading to the separation of the components as they flow out of the column.

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2. Principle

The purification takes place in a separation column between a stationary and a mobile phase. The

The mobile phase on the other hand is a solvent or solvent mixture which is forced at highpressure throughthe separationcolumn. Via avalve with a connected sample loop,i.e.asmall tube or a capillary made of stainless steel, the sample is injected into the mobile phase flow from thepumptotheseparationcolumnusing asyringe.Subsequently theindividualcomponentsof the sample migrate through the column at different rates because they are retained to a varying degree by interactions with the stationary phase. After leaving the column the individualsubstances are detected by a suitable detector and passed on as a signal to the HPLC software on thecomputer.AttheendofthisoperationachromatogramintheHPLCsoftwareonthe computer is obtained, which allows the identification and quantification of the differentsubstances.

3. Types

There are following variants of HPLC, depending upon the phase system (stationary) in theprocess :

i. NormalPhaseHPLC

Thismethodseparatesanalytesonthebasisofpolarity.NP-HPLCusespolarstationaryphase and non-polar mobile phase. Therefore, the stationary phase is usually silica and typical mobile phases are hexane, methylene chloride, chloroform, diethyl ether, and mixtures of these.Polar samples are thus retained on the polar surface of the column packing longer than less polar materials.

ii. ReversePhaseHPLC

Thestationaryphaseisnonpolar(hydrophobic)innature,whilethemobilephaseisapolar liquid, such as mixtures of water and methanol or acetonitrile. It works on the principle of hydrophobic interactions hence the more nonpolar the material is, the longer it will be retained.

iii. Size-exclusionHPLC

The column is filled with material having precisely controlled pore sizes, and the particles are separated according to its their molecular size. Larger molecules are rapidly washed through the column; smaller molecules penetrate inside the porous of the packing particles and elute later.

iv. Ion-ExchangeHPLC

The stationary phase has an ionically charged surface of opposite charge to the sample ions. This technique is used almost exclusively with ionic or ionizable samples.

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The stronger the charge on the sample, the stronger it will be attracted to the ionic surface andthus, the longer it will take to elute. The mobile phase is an aqueous buffer, where both pH and ionic strength are used to control elution time.

4. Instrumentation

HPLC instrumentation incorporates a pump, injector, column, finder and integrator or securingand show framework. The core of the framework is the column where division happens.

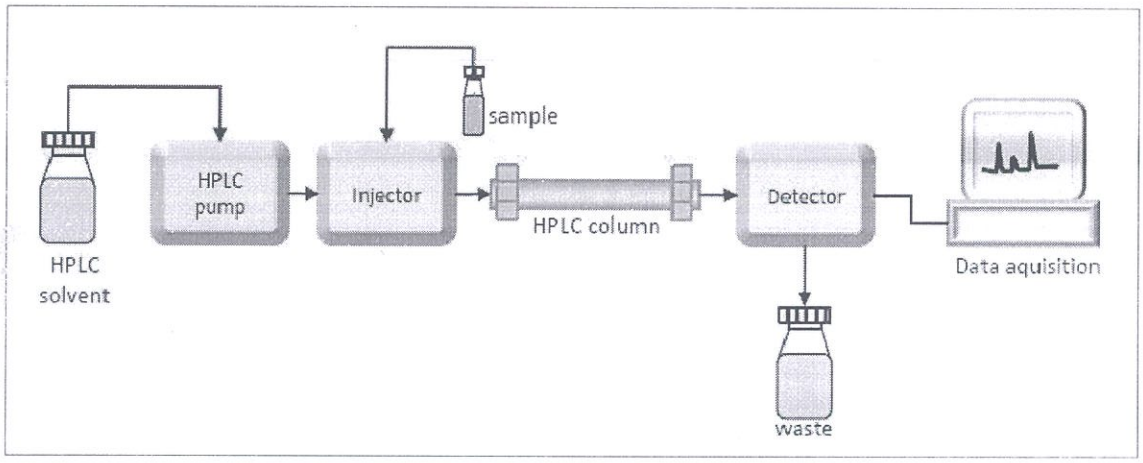

Figure.1 SchematicdiagramofHPLC instrumentation

a. **Solvent Reservoir** : Mobile stage substance are contained in a glass reservoir. The versatile stage, or dissolvable, in HPLC is typically a blend of polar and non-polar liquid segments whose particular fixations are changed relying upon the arrangement of the specimen.

b. **Pump** : A pump suctions the versatile stage from the dissolvable reservoir and drives it through the framework's column and detector. Contingent upon various components including column measurements, molecule size of the stationary stage, the stream rate and sythesis of the versatile stage, working weights of up to 42000 kPa (around 6000 psi) can be created.

c. **Sample Injector** : The injector can be a solitary infusion or a mechanized infusion framework. An injector for a HPLC framework ought to give infusion of the liquid specimen inside the scope of 0.1–100 mL of volume with high reproducibility and under high weight (up to 4000 psi).

d. **Columns** : Columns are generally made of cleaned stainlesssteel, are in the vicinity of 50 and 300 mm long and have an inside distance across of in the vicinity of 2 and 5 mm. They are normally loaded with a stationary stage with a molecule size of 3–10 um. Columns with interior

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world the temperature of the portable stage and the column ought to be kept steady amid an examination.

e. **Detector** : The HPLC indicator, situated toward the finish of the column distinguish theanalytes as they elute from the chromatographic column. Regularly utilized finders are UV- spectroscopy, fluorescence, mass-spectrometric and electrochemical indicators.

f. **Data Collection Devices** : Signals from the indicator might be gathered on outline recorders or electronic integrators that differ in many-sided quality and in their capacity to process, store and reprocess chromatographic information. The PC coordinates the reaction of the identifier to every part and places it into a chromatograph that is anything but difficult to peruse and decipher.

g. Degasser

The eluent used for LC analysis may contain gases such as oxygen that are non-visible to oureyes. When gas is present in the eluent, this is detected as a noise and causes unstable baseline. Generally used method includes sparging (bubbling of inert gas), use of aspirator, distillation system, and/or heating and stirring. However, the method is not convenient and also when the solvent is left for a certain time period (e.g., during the long analysis), gas will dissolve back gradually. Degasser uses special polymer membrane tubing to remove gases. The numerous very small pores on the surface of the polymer tube allow the air to go through while preventing any liquid to go through the pore. By placing this tubing under low pressure container, it created pressure differences inside and outside the tubing (higher inside the tubing). This difference letthe dissolved gas tomove through the poresand remove the gas. Compared to classical batchtype degassing, the degasser can be used on-line, it is more convenient and efficient. Many ofnew HPLC unit system contain a degasser.

h. ColumnHeater

The LC separation is often largely influenced by the column temperature. In order to obtain repeatable results, it is important to keep the consistent temperature conditions. Also for some analysis, such as sugar and organic acid, better resolutions can be obtained at elevatedtemperature (50 to 80°C). It is also important to keep stable temperature to obtain repeatable results even it is analyzed at around room temperature. There are possibilities that small different of temperature causes different separation results. Thus columns are generally kept inside the column oven (column heater).

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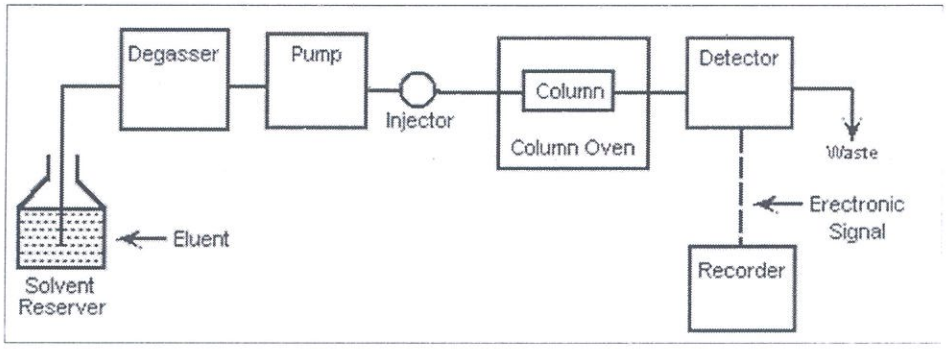

Figure2.ComponentsofHPLCsystem

4. Applications

- Waterpurification.
- Detectionofimpuritiesinpharmaceuticalindustries.
- Pre-concentrationoftracecomponents.
- Ligand-exchangechromatography.
- Ion-exchangechromatographyofproteins.
- High-pHanion-exchangechromatographyofcarbohydratesandoligosaccharides.

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B. ELECTROPHORESIS

Electrophoresis is a physical method of analysis based on themigration of electrically charged proteins, colloids, moleculesor other particles dissolved or dispersed in an electrolytesolution in the direction of the electrode bearing the oppositepolarity when an electric current is passed through it.

The electrophoretic mobility is the rate of movement in metre per second of the charged particles under the action of an electric field of I volt per metre and is expressed in square metres per volt second. For practical reasons it is given in square centimetres per volt second, $cm^2V^{-1}S^{-1}$. The mobility is specific for a given electrolyte under precisely determined operational conditions.

$$\mu = \frac{Q}{6\pi r\eta}$$

Where μ = Electrophoretic mobility

Q – Net charge on the ion

r – Ionic radius of the solute

η – viscosity of the medium

The electrophoretic mobility is directly proportional to net charge and inversely proportional to molecular size and viscosity of the electrophoresis medium.

The pH of the solution affects the mobility of the ion by

Depending on the method used, the electrophoretic mobility is either measured directly or compared with that of a reference substance.

Based upon the type of apparatus used, electrophoretic methods may be divided into two categories, one called free or moving boundary and the other called zone electrophoresis (using a supporting medium). Zone electrophoresis include paper, gel such as agar, starch or poly acrylamide.

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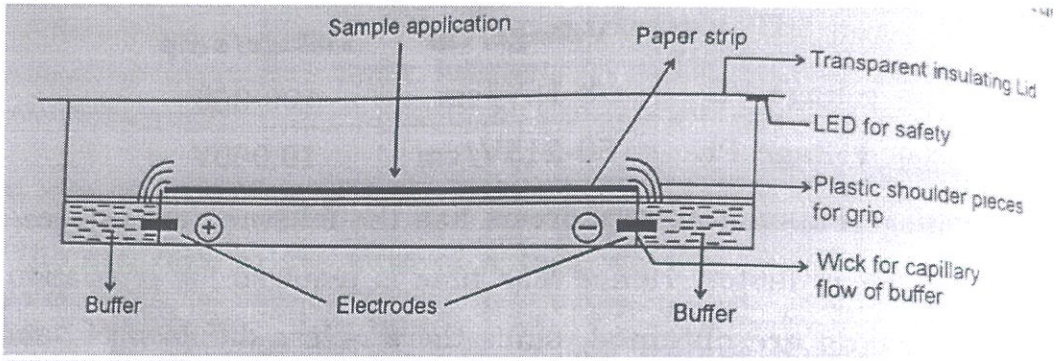
Horizontal and vertical modes are used in analytical scale; whereas continuous electrophoresis is used on a preparative scale (i.e. large amount of sample mixture is used). The principles involved in all the modes are same, but the design of each instrument varies.

In Horizontal type / Vertical (Fig 1 and 2), buffer solution of known pH and ionic strength is filled into two troughs. Appropriate grade of Whatmann filter paper and suitable width and length of filter paper are immersed in buffer solution. **10-20µl** of sample solution is applied at the centre of the paper and fixed in position.

The transparent lid is closed for safety as well as to prevent evaporation of buffer/solvent. A suitable potential (100-300V) is applied across two electrodes dipped in buffer solution.

Fig 1: Horizontal Paper electrophoresis



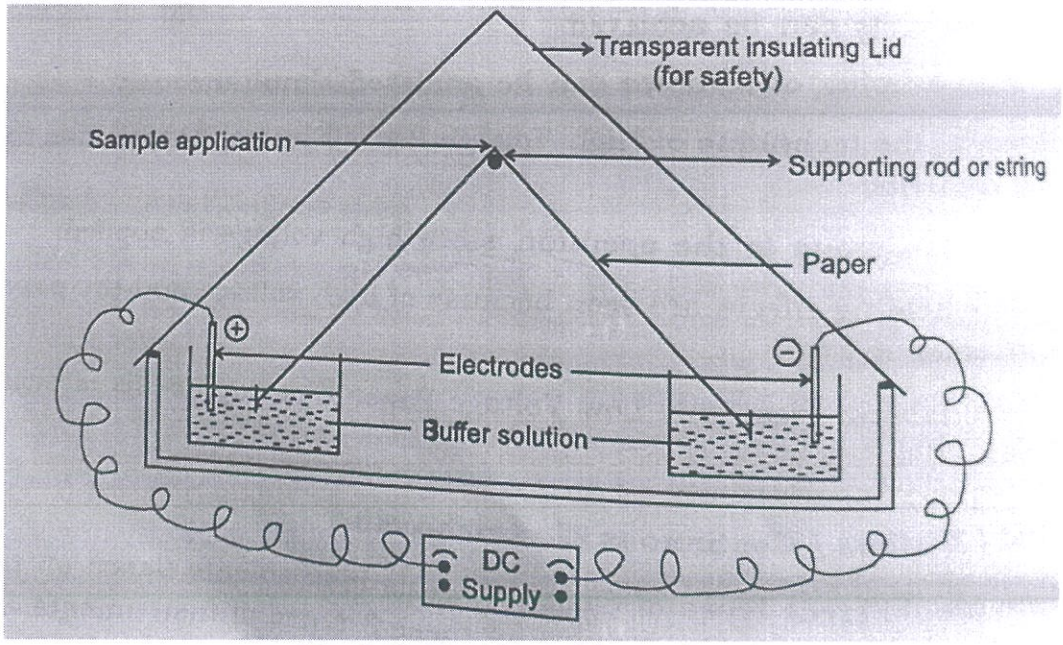


Fig: 2: Vertical Paper Electrophoresis

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When such potential is applied across the electrodes, migration of cations and anions

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In this vertical mode, the migrations of ions are assisted by gravity and hence a typical separation takes place in about 6-8 hours. After sufficient migration, the paper is taken out and dried, to fix the spots / bands. Then the compounds / bands /spots can be visualized by using the visualizing agent. The quantitation of spots can be done by densitometer.

The horizontal mode is similar to the vertical mode, in principle. However, the paper is placed on a flat bed, as shown in Fig 2. The procedure to be followed is same as that of vertical type. In horizontal mode, it takes about 12-14 hours for separation.

Continuous electrophoresis (Fig. 3) is meant for preparative samples, where a predetermined sample volume through a valve device is applied continuously on the centre of paper. The application of voltage causes migration of samples and hence compounds are separated as bands. Thus each band is made to fall down and pure compounds are collected in separate containers. The solvent is evaporated and pure fractions are reused.

Various factors like charge of ions, size of the ions, viscosity of the medium, applied voltage, pH of buffer and ionic strength affect the migration of ions in paper electrophoresis

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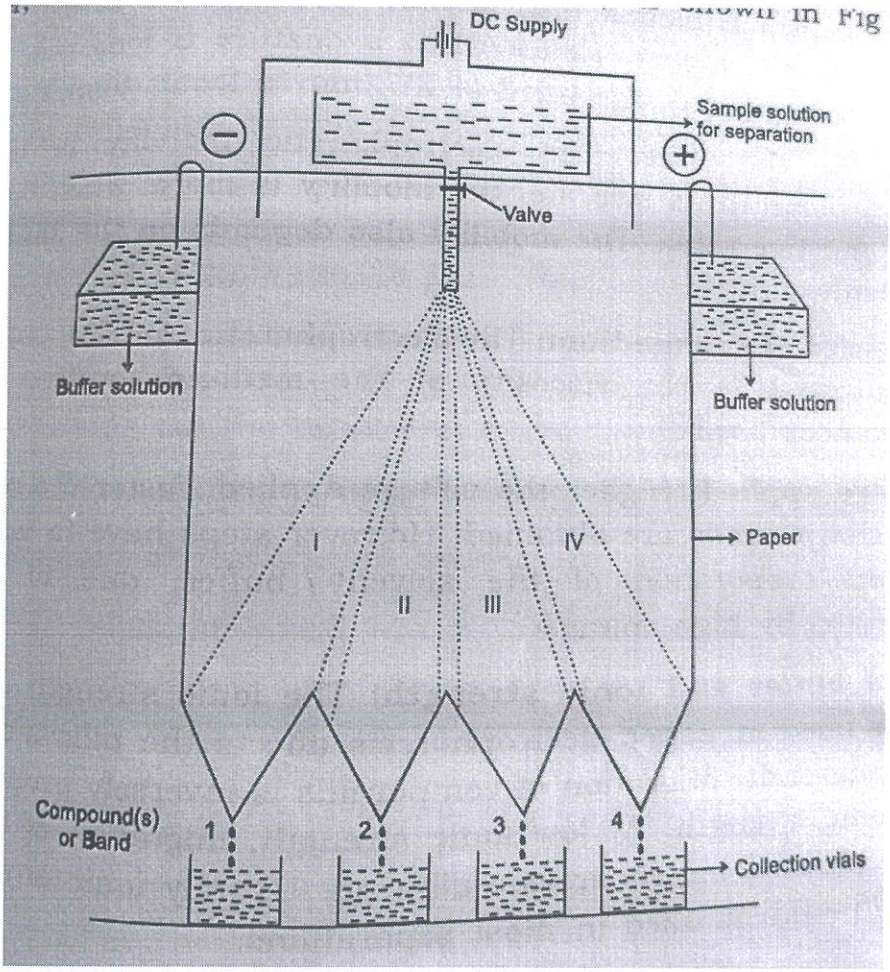

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Fig 3: Continuous paper electrophoresis

B. There are two types of paper electrophoresis based on the voltage applied, i.e. Low voltage or High voltage Paper electrophoresis

	Voltage/cm	Votage/strip
Low voltage PE	8-15 V/ cm	100-300
High voltage PE	50-215V/ cm	10,000v

High voltage paper Electrophoresis has the following advantages:

1. Separation is faster, hence less time is required for separation
2. Sharp bands are obtained, since there is less diffusion of bands.
3. As sharp bands are obtained, separation of closely related compounds can be achieved.
4. More number of samples can be analysed simultaneously.

Disadvantages of High Voltage Paper Electrophoresis

1. It is dangerous to the operator, since high voltage is applied.
2. More heating effects are seen because of high voltage and the paper becomes dry.

So in most of the laboratories, low voltage paper electrophoresis is used.

Advantages of Paper Electrophoresis:

1. The technique is easy to follow
2. Less expenditure
3. Number of samples can be separated on a sample paper, at a time.
4. Wide variety of ionisable substances such as amino acids, proteins and peptides, antibiotics, alkaloids etc., can be separated.

Disadvantages

1. The time required for separation is more, i.e. 6-8 hours in vertical mode and 12-14hours in horizontal mode.
2. Use of high voltage may be dangerous, unless precautions are taken.

Application of Paper Electrophoresis

Paper electrophoresis is used mainly for the separation of ionizable substances, by using buffers of different pH and ionic strength. The following are some of the pharmaceutical applications of paper electrophoresis.

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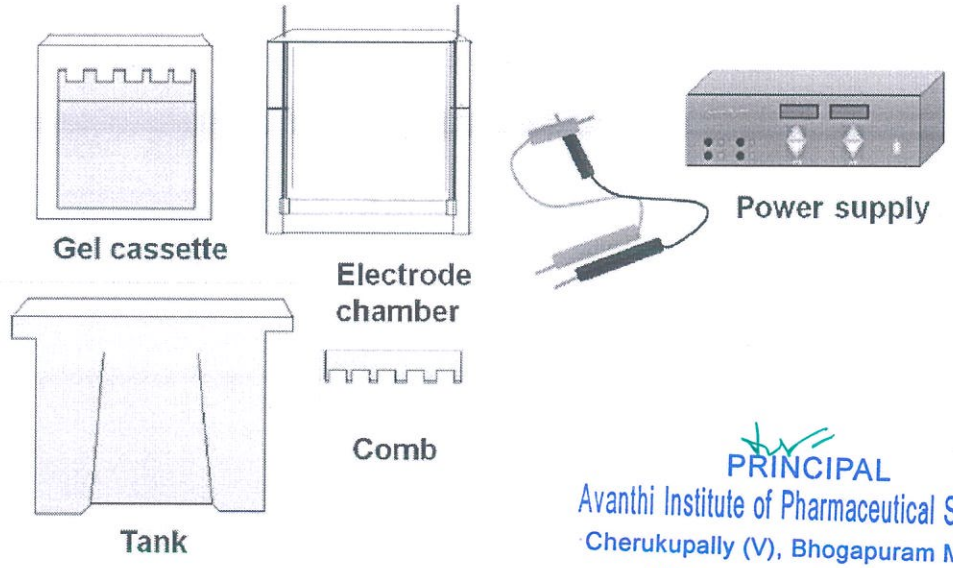
2. Separation of lipoproteins in serum (in case of hyperlipidemia)
3. Separations of enzymes in blood.
4. Separation of alkaloids and antibiotics in different samples can be carried out.

GEL ELECTROPHORESIS:

It is a separation technique. Gel is used as medium. The gel may be agar or agarose gel or polyacrylamide gel.

The device consists essentially of a glass plate over the whole surface ofwhich is deposited a firmly adhering layer of gel of uniform thickness. The connection between the gel and the conducting solution is effected in various ways according to the type of apparatus used. Precautions are to be takento avoid condensation of moisture or drying of the solid layer.

Vertical Gel Instrument- The schematic diagram of a vertical gel electrophoresis apparatus is given in Figure 4. It has two buffer chambers, upper chamber and a lower chamber. Both chambers are fitted with the platinum electrodes connected to the external power supply from a power pack which supplies a direct current or DC voltage. The upper and lower tank filled with the running buffer is connected by the electrophoresis gel casted in between two glass plates (rectangular and notched). There are additional accessories needed for casting the polyacrylamide gel such as comb (to prepare different well), spacer, gel caster etc.



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Casting of the gel: The acrylamide solution (a mixture of monomeric acrylamide and a bi-functional cross linker bis-acrylamide) is mixed with the TEMED and APS and poured in between the glass plate fitted into the gel caster. What is the mechanism of acrylamide polymerization? Ammoinum persulfate in the presence of TEMED forms oxygen free radicals and induces the polymerization of acrylamide monomer to form a linear polymer. These linear monomers are interconnected by the cross linking with bis-acrylamide monomer to form a 3-D mesh with pores. The size of pore is controlled by the concentration of acrylamide and amount of bis-acrylamide in the gel. In a vertical gel electrophoresis system, we cast two types of gels, stacking gel and resolving gel. First the resolving gel solution is prepared and poured into the gel cassette for polymerization. A thin layer of organic solvent (such as butanol or isopropanol) is layered to stop the entry of oxygen (oxygen neutralizes the free radical and slow down the polymerization) and make the top layer smooth. After polymerization of the resolving gel, a stacking gel is poured and comb is fitted intothe gel for construction of different lanes for the samples. Different steps involves the vertical gel electrophoresis is shown in the below Fig 5.

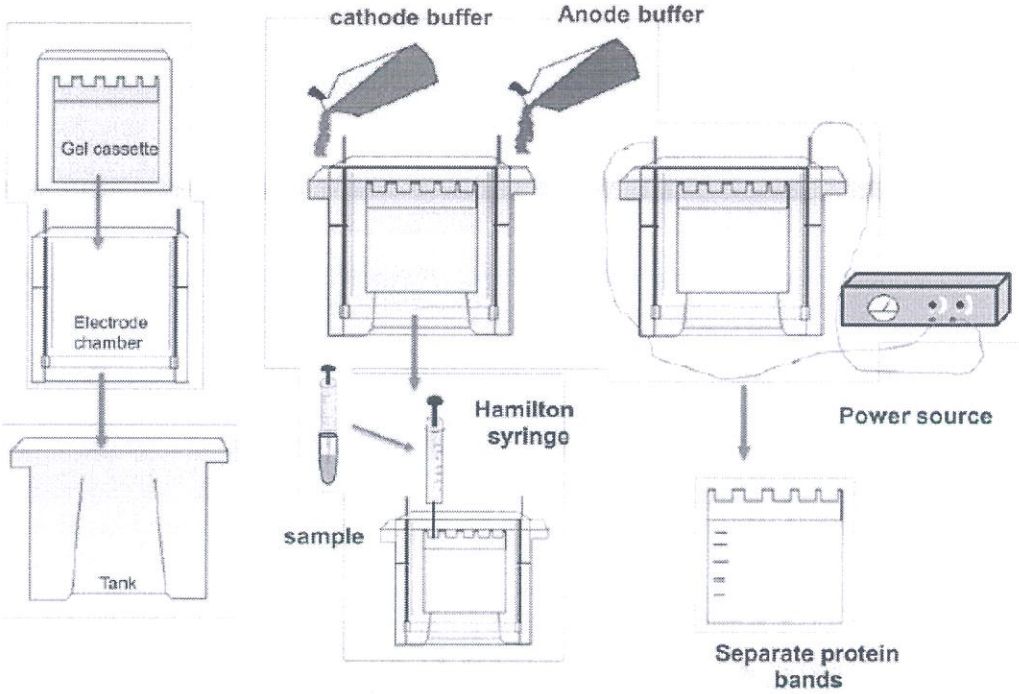

Fig 5: Different steps in performance of vertical gel electrophoresis to resolve sample.

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Vs at the bottom in a lane. This problem is taken care once the samples run through the stacking gel. The pH of the stacking gel is 6.8 and at this pH, glycine is moving slowly in the front whereas Tris-HCl is moving fast. As a result, the sample gets sandwiched between glycine-Tris and get stacked in the form of thin band. As the sample enters into the resolving gel with a pH 8.8, the glycine is now charged, it moves fast and now sample runs as per their molecular weight (due to SDS they have equal negative charge). After tracking dye reaches to the bottom of the gel, gel is taken out from the glass plate with the help of a spatula. Gel is stained with coomassie brilliant blue R250 dye. The dye stains protein present on the gel. A typical SDS-PAGE pattern is given in the Fig. 6.

Potentials of discontinuous PAGE:

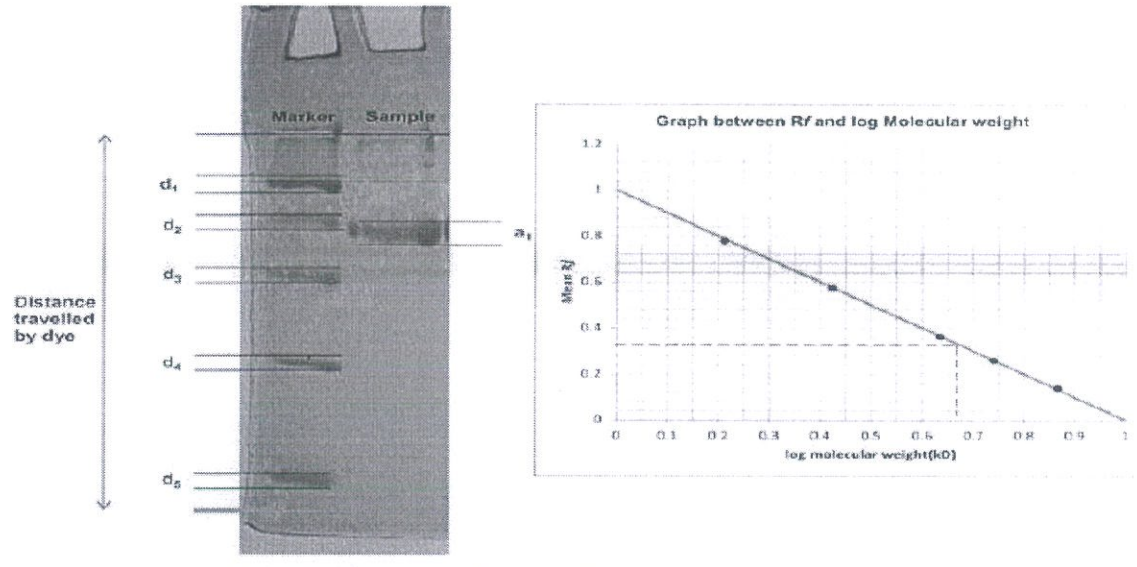
1. Number of disulfide bonds: Comparison of reducing and non-reducing denaturing gels can be used to provide information related to the number of disulfide bonds present in the protein.

2. Seperating Proteins based on size alone: In the presence of SDS and reducing environment, PAGE gel resolves two proteins of on the basis of molecular masses and the concentration of gel concentration. In SDS-PAGE, the relative mobility and the log molecular weight as given by

$$v' = \mathbf{Vo}^{\frac{A - logM}{A}}$$

Molecular weight of a protein can be determined by plotting relative migration Rf with the log molecular weight of standard protein.

$$Rf = \frac{\text{migration of protein from the lane}}{\text{migration of tracking dye}}$$



d_1, d_2, d_3, d_4 & d_5 = mean distance travelled by marker protein

$$R_f = \frac{\text{Mean distance travelled by protein}}{\text{Distance travelled by dye}}$$

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Calculation of molecular weight of the unknown protein sample is a 5 step process:

1. Resolve the protein sample on the SDS-PAGE along with the molecular weight markers.
2. Calculate the relative mobility (Rf) using the following formula:

$$Rf = \text{migrationofproteinfromthelane/migrationoftrackingdye}$$

3. Plotlog molecular mass (y-axis) versus relative mobility (x-axis) of the standards.
4. Perform a linear regression using a calculator or using regression software such as Microsoft Excel.
5. Use the linear regression equation **(Y = mx + c)** to estimate the mass of the unknown protein.

Log Molecular Weight = (slope) (mobility of the unknown) + Y intercept

Buffer and reagent for electrophoresis- The different buffer and reagents with their purpose for vertical gel electrophoresis is as follows-

1. N, N, N', N'-tetramethylethylenediamine (TEMED)-it catalyzes the acrylamide polymerization.

2. Ammonium Persulfate (APS)-it is an initiator for the acrylamide polymerization.

3. Tris-HCl- it is the component of running and gel casting buffer.

4. Glycine-it is the component of running buffer

5. Bromophenol blue- it is the tracking dye to monitor the progress of gel electrophoresis.

6. Coomassie brilliant blue R250-it is used to stain the polyacrylamide gel.

7. Sodium dodecyl sulphate-it is used to denature and providenegative charge to the protein.

8. Acrylamide- monomeric unit used to prepare the gel.

9. Bis-acrylamide- cross linker for polymerization of acrylamide monomer to form gel.

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Capillary Electrophoresis

Capillary electrophoresis employing a narrow bore fused quartz silica capillary tube usually 50-75cm long with an i.d. of 25-100µm (and an o.d. of 400 µm) containing an appropriate electrolyte using a direct current (DC) high voltage source, capable of producing a current of 250 µA at voltage ranging from 1000 to 30,000volts and on-line detector that similar to those HPLC are involved (high voltage electrophoresis).

A cross – sectional view of such a capillary is shown in the Fig 7. The capillary is protected with an outer layer of a polyimide (polymer of imide monomer)

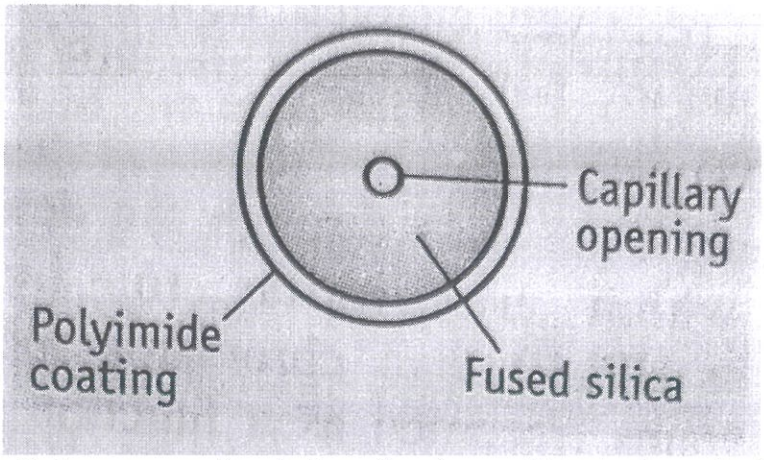

Fig 7: A cross – sectional view of such a capillary is shown in the

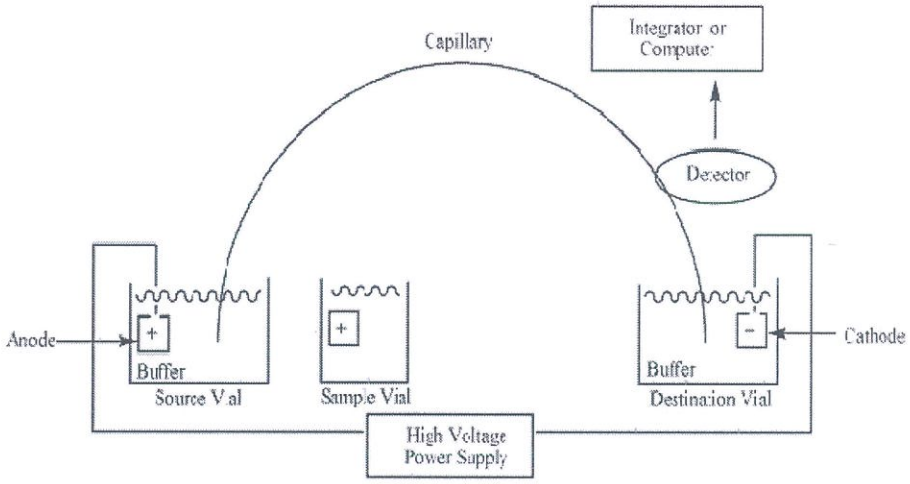

Fig 8: Capillary electrophoresis system

A basic schematic of a capillary electrophoresis system is shown in fig. 8. The system's main components are a sample vial, source and destination vials, a capillary, electrodes, a high voltage power supply, a detector, and a data output and handling device. The source vial, destination vial

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returned to the source vial. The migration of the analytes is initiated by an electric field that is applied between the source and destination vials and is supplied to the electrodes by the high-voltage power supply. In the most common mode of CE, all ions, positive or negative, are pulled through the capillary in the same direction by electroosmotic flow (EOF) (Fig 9). The analytes separate as they migrate due to their electrophoretic mobility, and are detected near the outlet end of the capillary. The output of the detector is sent to a data output and handling device such as an integrator or computer. The data is then displayed as an electropherogram, which reports detector response as a function of time. Separated chemical compounds appear as peaks with different retention times in an electropherogram.

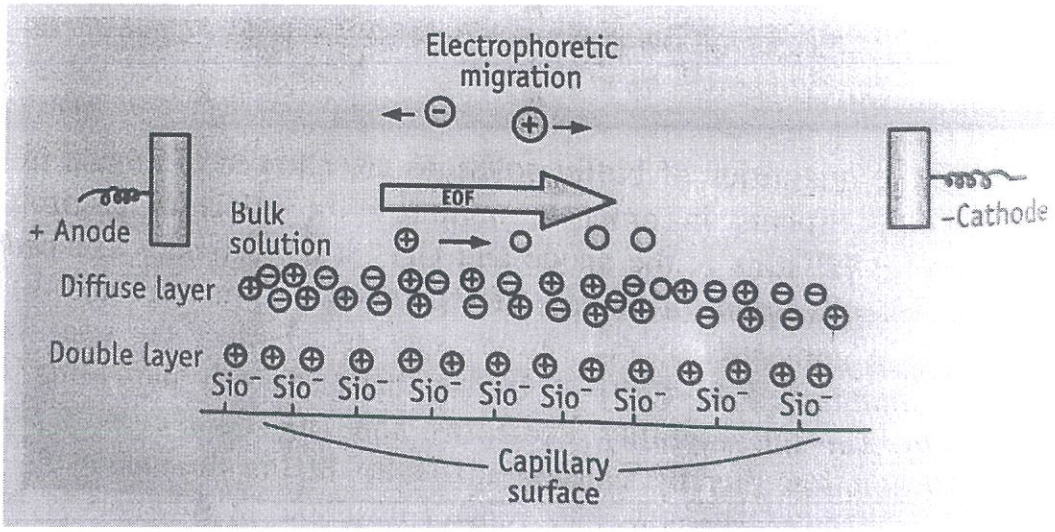

Fig 9: Various events of migration of species and EOF in capillary electrophoresis

The efficiency, N (Number of theoretical plates) may be expressed by the equation:

$$N = \frac{\mu E d}{2\,D}$$

Where, D = the diffusion coefficients of migration species,

d = the distance travelled

μ = electrophoretic mobility of the species, and

E = the applied electric field

CE mechanism is entirely different from a chromatographic distribution mechanism, in that it is readily applicable smaller as well as macromolecules. Thus it is used for the separation of large biomolecules.

Detection in CE: The most commonly used detectors are a UV absorbance or a fluorescence monitor or a diode array spectrometer producing absorbance data at multiple wavelengths, on account of the very small volume (< 10^{-9}L) of the separated analytes, the detection is carried out on column (or on-line detection). For this a small outer part of the protective polyimide coating from

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utilizes the small volumes. One example of representative Electropherogram which was obtained from the seized heroin sample is showing in the Fig 10.

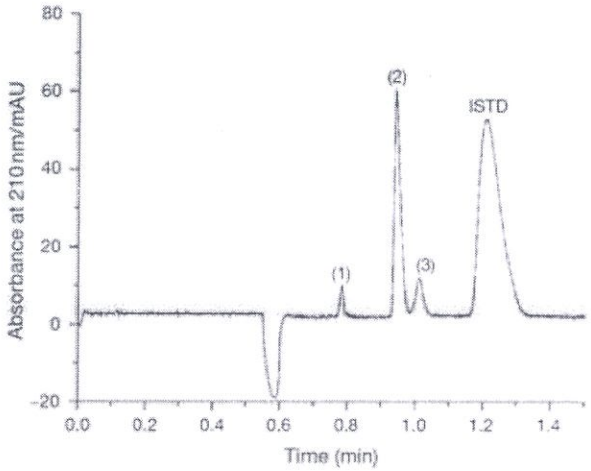

Fig. 10: Representative Electropherogram showing the separation of a seized heroin sample byusing MEKC with short end injection (1) morphine, (2) heroin, (3) acetylcodeine, ISTD = internal standard (N, N-dimethyl-5-methoxytryptamine). UV absorbance at 210 nm, uncoated fused silica capillary 50 cm × 50 μm I.D. ×360μm O.D., effective separation length 8 cm, back- ground electrolyte: 15 mM sodium borate, 25 mM sodium dodecylsulfate, 15% (v/v) acetonitrile, pH 9.5, 25 °C.–25 kV, hydrodynamicinjection.

Application:

1. Capillary electrophoresis (CE) is the primary methodology used for separating and detecting short tandem repeat (STR) alleles in forensic DNA laboratories.
2. Capillary electrophoresis may be used for the simultaneous determination of the ions NH^{+4}, Na^{+}, K^{+}, Mg^{+2} and Ca^{+2} in saliva.
3. Illicit Drug Analysis: Applications of capillary electrophoresis to illicit drugs in seizures and toxicology samples

Analytes	Matrix	Method
Coca alkaloids and sugars	Illicit cocaine	MEKC (Micellar electrokinetic chromatography) with indirect UV detection
Heroin, morphine, acetylcodeine,caffeine, paracetamol	Heroin seizures	MEKC with short-end injection,detection by UV absorbance

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Methamphetamine, amphetamine,dimethylamphetamine, and p-hydroxymethamphetamine	Urine from subjects using methamphetamine and dimethylamphetamine	CZE using cyclodextrins for separationof enantiomers with MSdetection

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UNIT-6

Immunoassays

- An immunoassay is a biochemical test that measures the concentration of a substance in a liquid (a portion of a biological specimen) using the reaction of an antibody or antibodies to its antigen (drug).
- They are used in a lot of laboratories, including hospitals labs, and have been widely used in the special area of Forensic toxicology to screen for drugs and other chemicals in the body.
- Immunology is a laboratory science that studies the body's immunity to disease.
- The basic mechanism of immunity is the binding of drugs or other chemical compounds to antibodies (large proteins produced by the body's immune system).

Principle of Immunoassay:

- An assay is a general term for an analytical laboratory procedure designed to detect the presence of and/or the quantity of a drug in a biological fluid such as urine or serum (the fluid component of the blood obtained after removal of blood cells and fibrin clot).
- An Immunoassay, therefore, Is an analytical procedure which has as its basis the principles of immunology- specifically the binding of drugs to antibodies.
- This binding of antibodies to drugs forms the basis for immunoassay.
- In the development of an immunoassay, the first step is to inject an animal (host) with the drug that we ultimately wish to analyze.
- The host immune system, recognizing the drug as a 'foreigner', generates antibodies to this drug, and these antibodies can then be harvested from the serum of the animal.
- In the test-tube environment of the laboratory (in vitro), these antibodies can be recombined with the appropriate drug.
- Just as it did inside the body (in vivo), the antibody will recognize the drug based on the lock and key fit and will spontaneously bind to it.
- The second step in the development of an immunoassay is to synthesize a 'labelled' drug.
- This involves the chemical addition of a 'marker' to the drug.
- This marker can be small, such as an atom of radioactive iodine, or it can be large, such as an enzyme, which is a fairly large protein.
- Irrespective of its size, this marker is added on such a way that it doesn't interfere with the lock-and-key recognition between the antibody and the drug.
- All immunoassays work in the same basic fashion.
- They differ in the types of labels that are added to the labeled drug and in the analytical methods by which the amount of binding of labeled drug to the antibody is measured.

Types of Immunoassay

- Several different types of immunoassay are routinely performed in the laboratory.
- Although they differ in the types of reagents and instrumentation used, they are all based on the same scientific principle (the binding of drugs to antibodies).
- The three types of immunoassay that are commonly used for drug testing are the radioimmunoassay (RIA), enzyme multiplied immunoassay (EMIT), and fluorescence polarization immunoassay (FPIA).

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- The immunoassay is based on the competitive or non-competitive binding of the antigen with the antibody.

1. Competitive immunoassay

- (*Competition between tagged and un-tagged antigen for the antibody)*
- Competitive Immunoassays are always designed so that there are fewer antibody-binding sites present in the reaction mixture than there are molecules of (labeled plus unlabeled) drug.
- Because the label and unlabeled drug appear the same to the anti-body, they will compete equally for the limited number of available binding sites on the antibody.
- By measuring the amount of labeled drug bound to the antibody, the analyst can calculate the amount of unlabeled drug in the biological specimen.
- Commercially available immunoassay kits contain the antibody (which the company has prepared described above) and the labeled drug (which has been chemically synthesized) necessary to perform the assay.
- In the laboratory, a fixed amount of antibody and a fixed amount of labeled drug are placed into a reaction vessel (test tube).
- If these were the only two ingredients, all the binding sites on the antibody would react with (bind) to the labeled drug.
- A third ingredient added to the assay is, however the unlabeled drug (i.e., the urine, saliva, or serum specimen containing the drug that is being measured).
- Because the label on the labeled drug is placed in a position that doesn't interfere with binding to the antibody (i.e., it is 'hidden'), the antibody cannot distinguish between the labeled and unlabeled drug.
    - Mix the three components together.
    - Allow the antigens to compete for the limited antibody
    - Antibody will bind with tagged or untagged antigen
    - Separation step: antibody-antigen complexes are separated from free antigens
    - Tagged antibody-antigen complex is measured.
    - The tagged antigen and antibody from the reagent kit are constant.
    - The only variable is the concentration of the patient antigen (the thing we want to measure)
- A standard curve can be made with known antigen concentrations giving the following general **results:**
    - High concentrations of patient antigen mean that more of the antibody-antigen complexes are untagged
    - Low concentrations of patient antigen mean that more of the antibody-antigen complexes are tagged
    - There is an inverse relationship between patient antigen concentration and tag activity after the separation process.
- The activity of the tag is measured twice:
    - Before separation step= Total tag activity
    - After separation step = Bound tag activity (antibody-antigen complex)
- Note that the separation process removes all unbound (free) tagged antigen before testing
    - %B= B/T X 100
- The ratio of the bound activity to the Total activity (B/T) decreases as the concentration of the patient's (untagged) antigen increases.

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- Using standard solutions of known antigen concentrations, the %B is plotted against the concentrations of the standards.

2. Non-competitive immunoassays:

- Noncompetitive (sandwich) immunoassays generally provide the highest level of assay sensitivity and specificity.
- This format is referred to as a 'sandwich' assay because the analysis id bound (sandwiched) between two highly specific antibody reagents.
- The reaction mixture typically includes an excess of labeled antibody, so that all drug/metabolite is bound.
- The amount of antibody-antigen complex is then measured to determine the amount of drug present in the sample.
- The measurement of labeled analyte, usually antibody, is directly proportional to the amount of antigen present in the sample.

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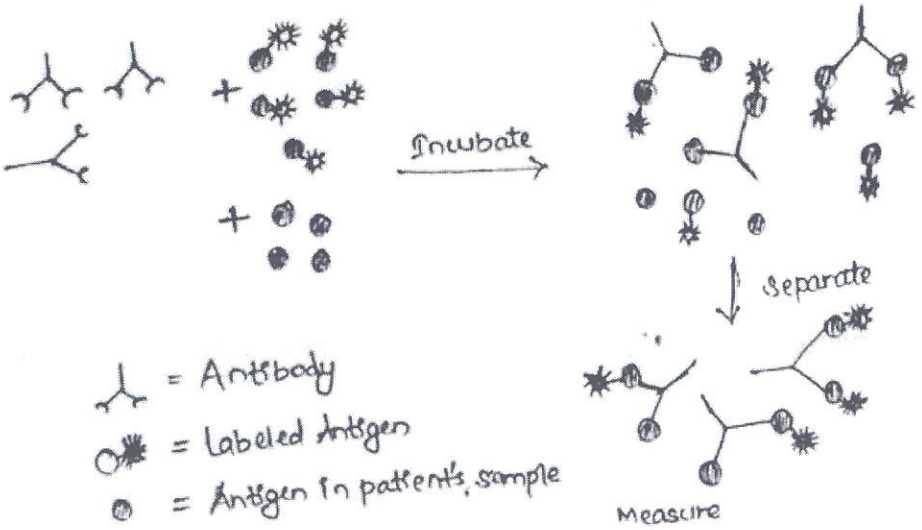
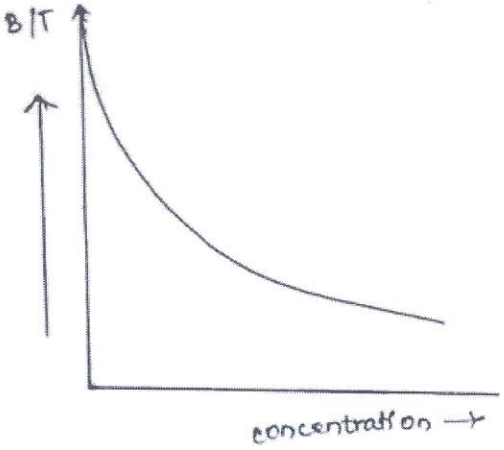


Fig: A competition between tagged antigens (reagent) and untagged antigens (patient) for a limited amount of antibody (reagent).



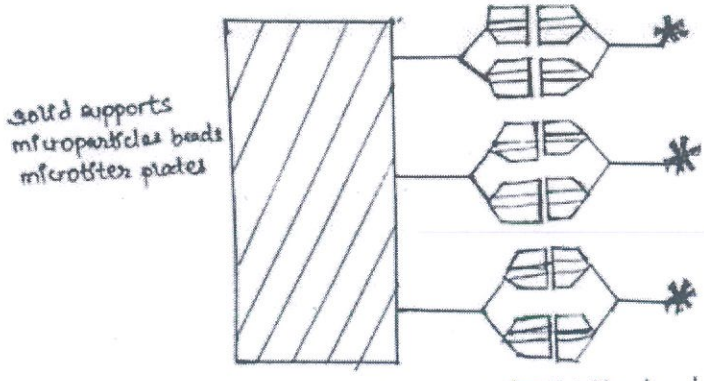


Fig: Sandwich Assays: Antibodies bind to two sites on analyte

3. Homogeneous and Heterogeneous Immunoassay methods:

- Immunoassay methods that require separation of bound Ab-Ag* complex are referred to as heterogeneous immunoassays.
- Those that do not require separation are referred to as homogeneous immunoassays.
- Homogeneous methods have been generally applied to the measurement of small analytes such as abused and therapeutic drugs.
- As homogeneous methods do not need the separation of the bound Ab-Ag* from the free Ag*, they are generally much easier and rapid to perform.

Types of Immunoassays used for drug assay:

i. **Radioimmunoassay:**

- Radio-immunoassays (RIAs) utilize a radioactive label (usually 125I, 3H or 14C), which emits radiation that can be measured with a beta or gamma counter.

ii. **Enzyme multiplied immunoassay:**

- In the Enzyme multiplied Immunoassay (EMIT), the drug in the sample and the drug labeled with G6PD compete for antibody binding sites.
- Binding inhibits enzyme activity, while free enzyme remains active to interact with.
- Enzyme activity/absorbance is directly proportional to drug concentration.

iii. **Fluorescence Polarization Immunoassay:**

- In the Fluorescent Polarized Immunoassay, the drug in the sample competes with fluoresce labeled drug for antibody binding sites.
- Reaction mixture is excited by plane polarized light.
- As the tracer returns to a lower energy state, it emits light, polarization is measured.

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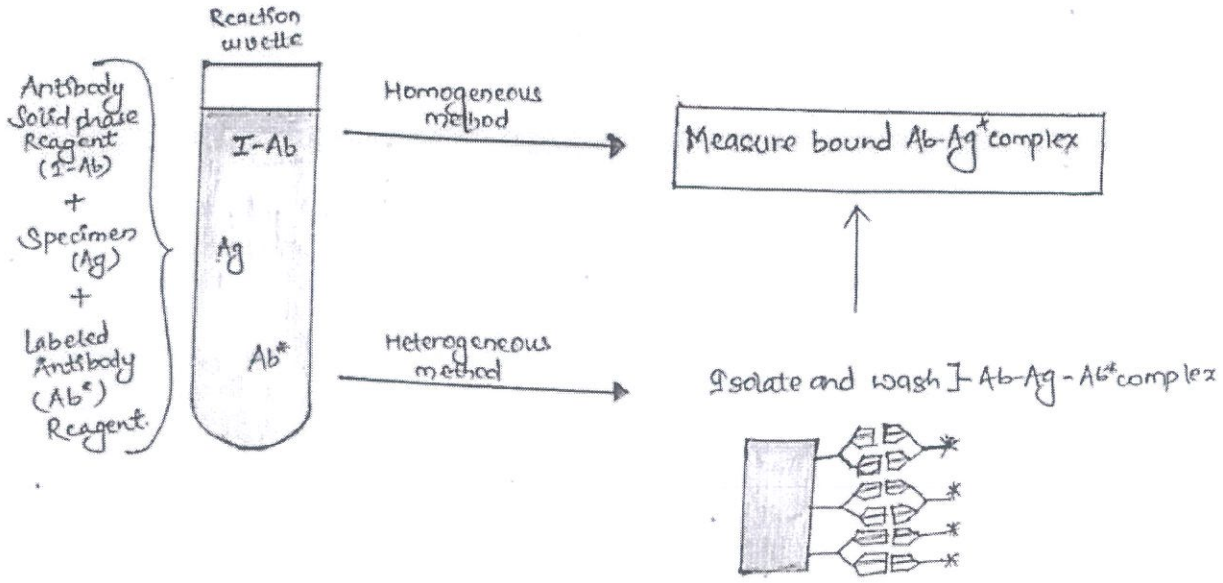

Fig: Homogeneous and heterogeneous Immunoassay methods.

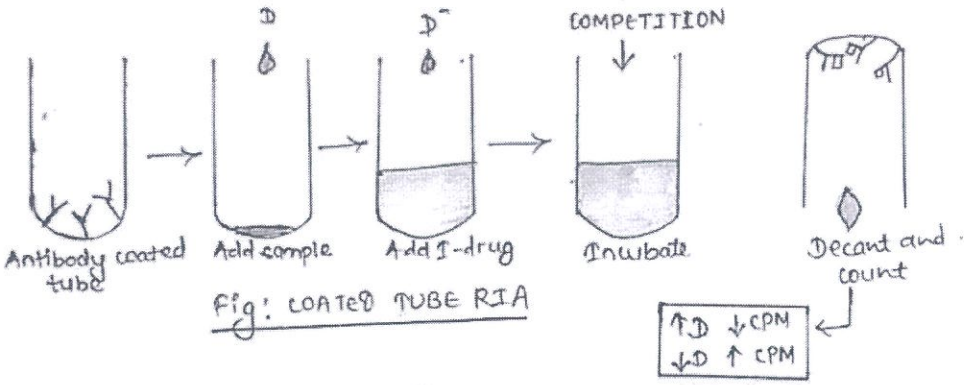

Fig: COATED TUBE RIA

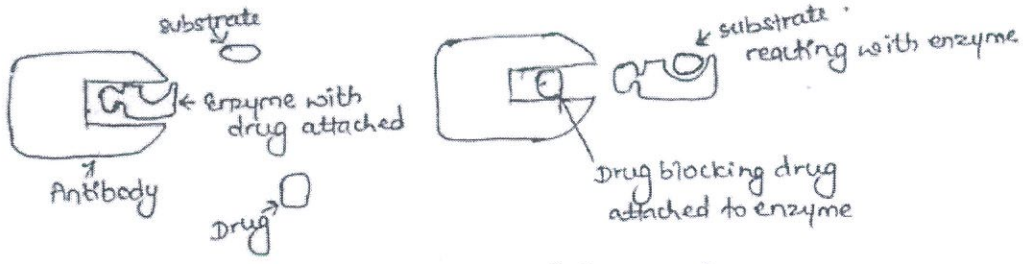

Fig: Enzyme multiplied Immunoassays

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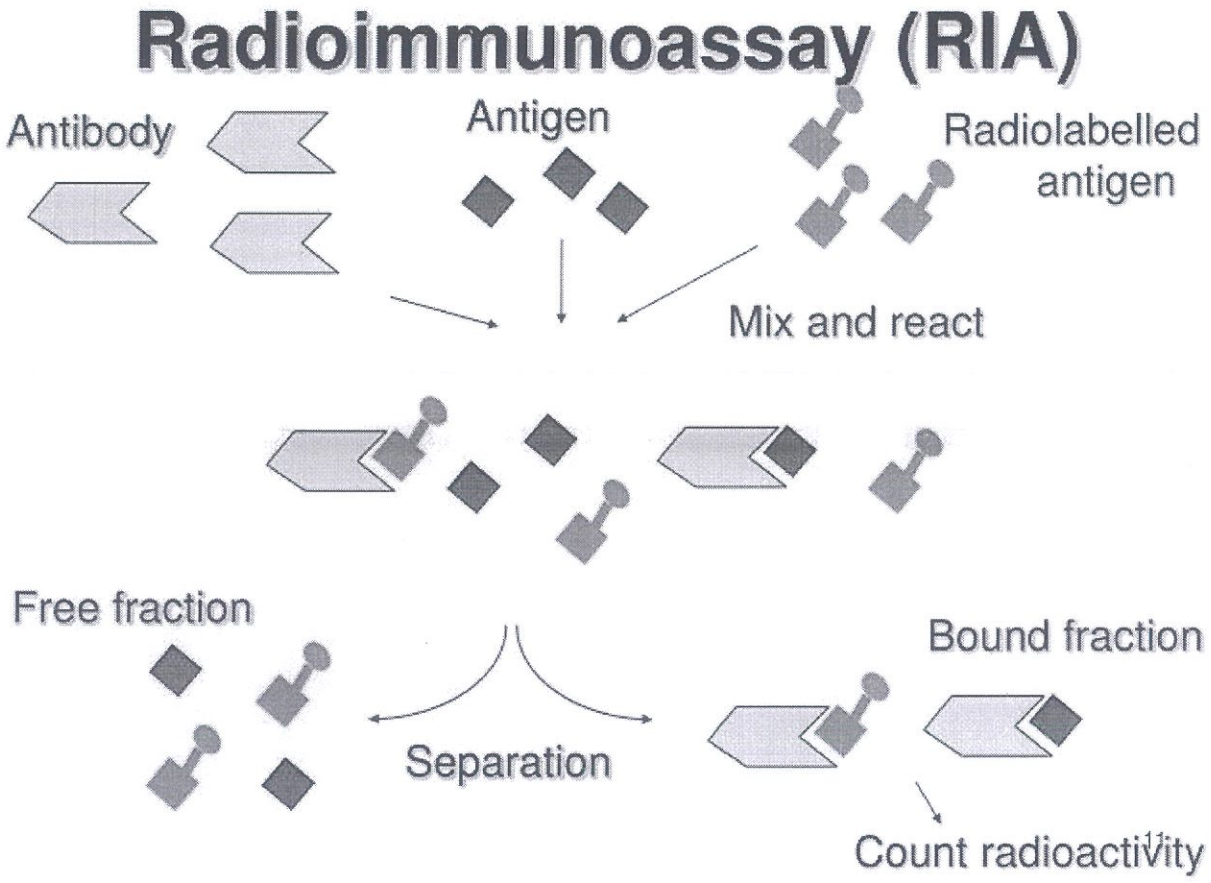

Radioimmunoassay (RIA)

Radioimmunoassay (RIA) is an *in vitro* assay that measures the presence of an antigen with very high sensitivity. Usually presence of any antigen and antibody can be determined and measured even in minute concentration. RIA is one of the most sensitive & specific methods of immune assays available and the first technique to analyzeupto picomolar concentration of any biologically substances. Furthermore, as the name indicates, it is an immunological assay to analyze any antigen or anti-body in the patient's serum to diagnose the disease.

History: The technique was developed on 1960 by S. A. Berson and Rosalyn Yalow and Rosalyn R. Yalow who received the Nobel Prize for it in 1977. It was the first assay technique to determine the presence of hormone level in blood using invitro assay.

Principle: Basically Radioimmunoassay (RIA) depends upon three principles which have made it most specific and sensitive technique with the sensitivity range is 0.0006–0.006 µg antibody/ml. immune reaction, a competitive binding and measurement of radio emission assay are the three principles which in sum execute the RIA.

- Needed substances and equipment: Specific antiserum to the antigen to be measured, availability of a radioactive labeled form of the antigen, a method in which the antibody-

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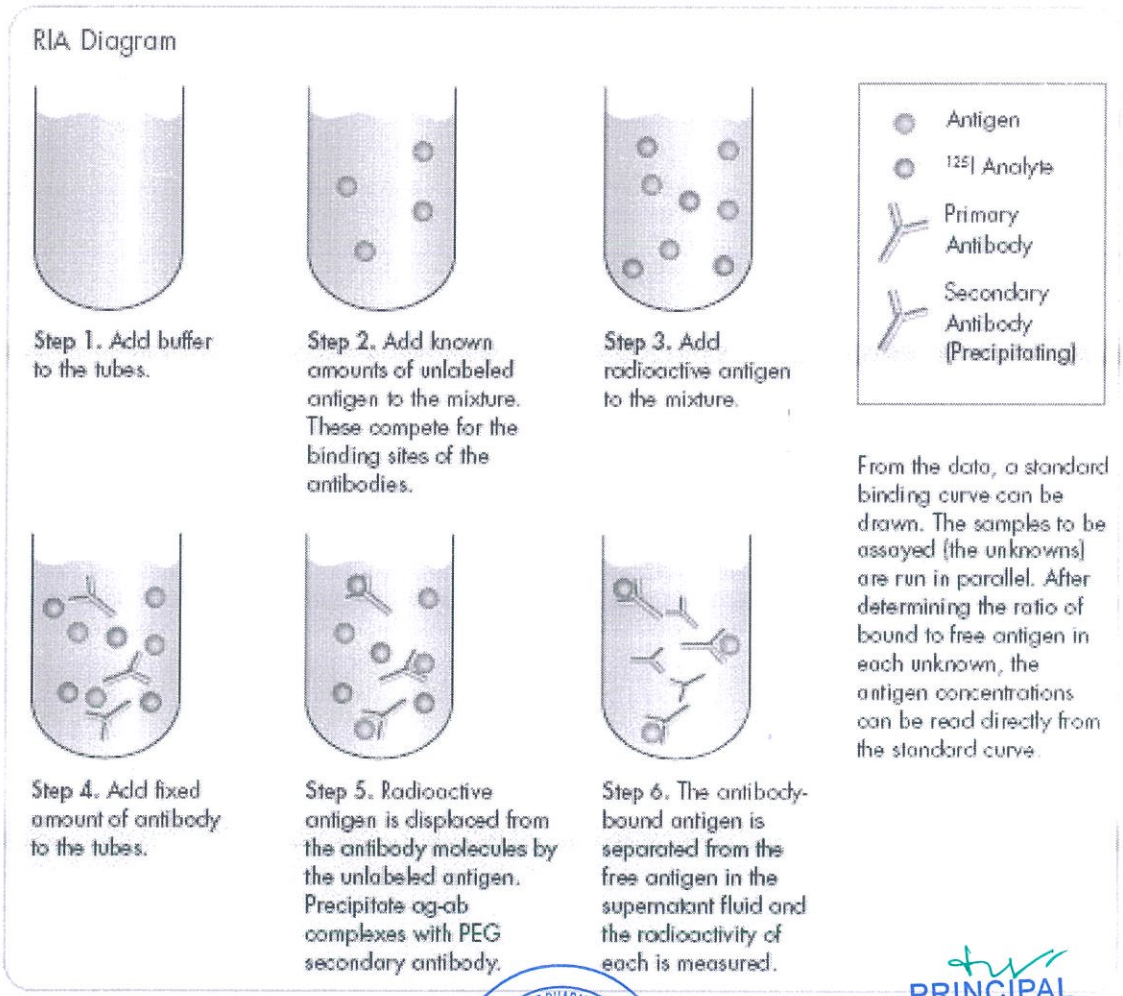
bound tracer can be separated from the unbound tracer, an instrument to count radioactivity.

- RIA involves the separation of protein from the mixture using the specific reaction of antigen-antibody reaction and quantitation using radioactivity.
- Radioactivity: 125-I labels are usually applied although other isotopes such as C14 and H3 have also been used. Usually iodination are used to label the antigen by chloramine-T or peroxidase methods and then separating the radio-labeled antigen from free-isotope by gel-filtration or HPLC. The target antigen is labeled radioactively and bound to its specific antibodies (a limited and known amount of the specific antibody has to be added).
- During competitive binding and displacement, there are two antigens which can bind to same antibody, the antigen with more concentration binds extensively with the limited antibody displacing other.
- Antigen–antibody complexes are precipitated either by crosslinking with a second antibody or by means of the addition of reagents that promote the precipitation of antigen–antibody complexes. Counting radioactivity in the precipitates allows the determination of the amount of radiolabeled antigen precipitated with the antibody.
- After the washing to remove the unbound antigens, RIA utilizes a radioactive label which emits radiation that can be measured with a beta or gamma counter.



Calibration curve:

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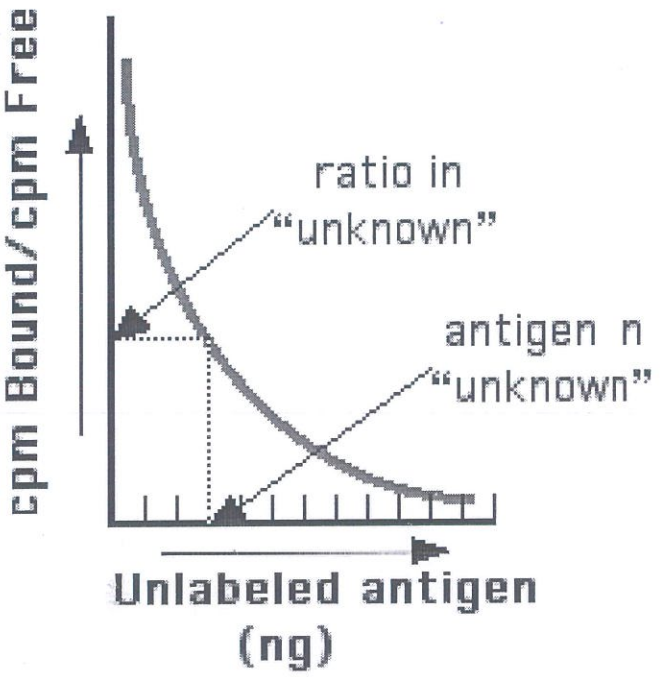
A standard curve can be constructed by plotting the percentage of antibody-bound radiolabeled antigen against known concentrations of a standardized unlabeled antigen as shown in figure. Also, the curve allows determining the unknown antigen concentration directly from the standard curve.



Uses of Radioimmunoassay (RIA):

RIA has revolutionized research and clinical practice specially in blood banking, diagnosis of allergy and endocrinology. Furthermore it is used to:

1. The test can be used to determine very small quantities (e.g. nanogram) of antigens and antibodies in the serum.
2. The test is used for quantitation of hormones, drugs, HBsAg, and other viral antigens.
3. Analyze nanomolar and picomolar concentrations of hormones in biological fluids.

Limitations of Radioimmunoassay (RIA):

1. The expenses of equipment and reagents along with hazards if preparing and handling the radioactive antigens.
2. Short shelf-life of radiolabeled compounds
3. Requirements of special counter for radioisotopes.
4. The problems associated with the disposal of radioactive waste.

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M.Pharmacy,I Sem I Mid Examinations July-2021

Subject: Modern Pharmaceutical Analytical Techniques (MPH 101T)

Exam Time: 2hrs **Dt:06-04-2021** **Marks: 30 M**

Answer any two questions from the following **2X15=30**

1. Write the theory and instrumentation associated with UV-Visible spectroscopy. And write the applications of UV-Visible spectroscopy.
2. Write the quantum numbers and their role in NMR. What is the chemical shift in NMR and write the factors influencing chemical shift.
3. Write the theory and instrumentation associated with Mass spectroscopy. And write the applications of Mass spectroscopy.

Scheme of Evaluation

1. Write the theory and instrumentation associated with UV-Visible spectroscopy. And write the applications of UV-Visible spectroscopy.
   Spectroscopy Definition, Types – 4 M
   Principle - 3 M
   Instrumentation - 6 M
   Applications of UV-Visible spectroscopy- 2 M

2. Write the quantum numbers and their role in NMR. What is the chemical shift in NMR and write the factors influencing chemical shift.
   Principle of NMR – 4 M
   Quantum numbers and their role in NMR- 3 M
   Chemical shift in NMR- 4 M
   Factors influencing chemical shift- 4 M
3. Write the theory and instrumentation associated with Mass spectroscopy. And write the applications of Mass spectroscopy.
   Principle - 5 M
   Instrumentation - 6 M
   Applications of Mass spectroscopy - 4 M

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(Approved by AICTE, PCi & Govt.of A.P. Affiliated to JNTUK, Kakinada)

SUBJECTIVE TEST

ESTD : 2005

JNTUK Reg. No.	:	20T51S0601	Date	: 06/04/2021
Student Name	:	K. MOULIKA Year : 1st	Sem	: 1st
Branch	:	B. Pharm / Pharm D. / Pharm D. (P.B) / M. Pharm		
Specialization	:	Pharmacology	Time	: 2 hrs
Subject Name	:	Modern Pharmaceutical Analytical	Total Marks	: 20/25
Marks Secured	:	12/15 + 8/10 = 20/25	Invigilators Signature	: S. Ch.

1(a) UV Spectroscopy: 24/30 12/15

Spectroscopy is a study of science dealing with the Electro Magnetic Radiation with matter. Spectroscopy deals with the absorption and Emission of Radiation.

PRINCIPLE:

When a beam of light passes through the homogenous absorbing medium and light ray passes through the sample and a graph is plotted against absorption Radiation & Emission Radiation V/s frequency or wavelength.

ABSORPTION SPECTROSCOPY:

Absorption spectroscopy concerns with the Measurement of Electromagnetic Radiation. Eg: UV Region of (1 - 200 nm), Visible Region (400 - 800 nm) Etc.

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EMISSION SPECTROSCOPY :

Emission spectroscopy deals with the Emission of Radiation from the sample is observed.

Eg: Mass spectroscopy.

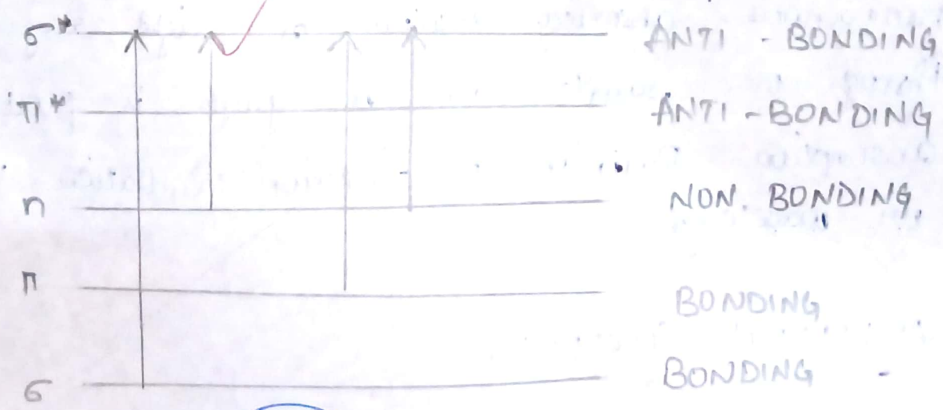
ELECTRO MAGNETIC RADIATION :

Electro Magnetic Radiation generally consists of discrete packets called photons.

ELECTRONIC TRANSISTIONS :

Electronic transistions are of following types:

- ✓ σ to σ^*
- ✓ n to σ^*
- ✓ π to π^*
- ✓ n to π^*



1) $\sigma - \sigma^*$

- ✓ Requires highest Energy
- ✓ vaccum UV (1-200nm) is used.

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✓ An Electron from an bonding s-orbital shifts to a corresponding non-bonding orbital and saturated compounds are observed.

2) n to σ^*

✓ Saturated compounds contains lone pair of Electrons like O, N, S, and other Halogens.

✓ Requires highest Energy for this transistion.

3) $\pi - \pi^*$

✓ An Electron jumps from an bonding site to non-bonding site and conjugated compounds are observed.

✓ Requires lowest Energy.

4) $n - \pi^*$

✓ An Electron promotes from non-bonding site to Anti bonding site and requires lowest Energy for this transistion.

Beer's lambert's law → $A = \varepsilon ct$ → Absorbance

INSTRUMENTATION:

The uv spectrophotometer contains various parts like

✓ source of light

✓ collimating system

✓ Monochromators

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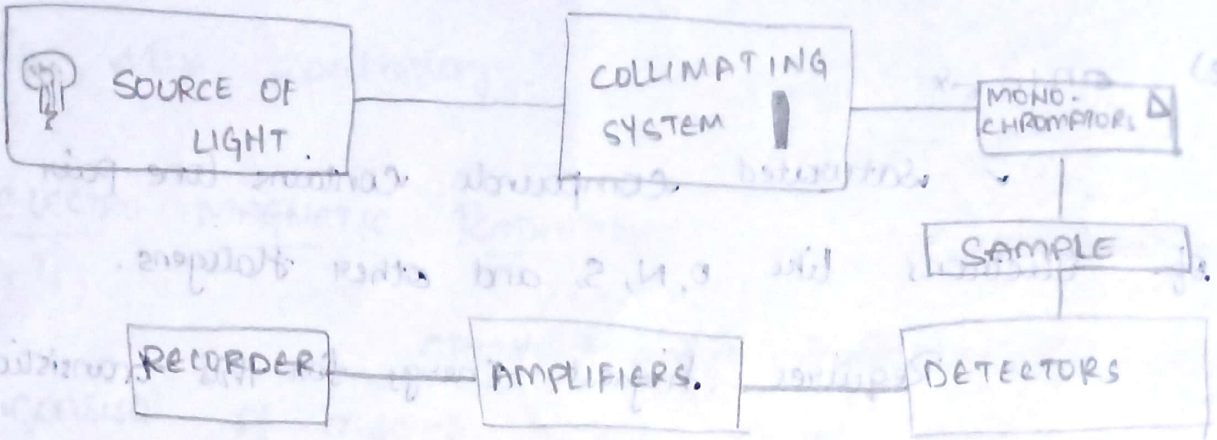
- ✓ Sample Holders.
- ✓ Detectors
- ✓ Recorder



1) SOURCE OF LIGHT:

Source of light can be from various forms.

- ✓ Tungsten lamp
- ✓ Hydrogen discharge lamp.
- ✓ Xenon - Arc lamp
- ✓ Mercury lamp.

* TUNGSTEN LAMP:

- ✓ This lamp contains a filament of tungsten fixed in an Evacuated chamber and filled with gas.
- ✓ This can be heated upto 3000 K and upon it starts sublimating.

Remarks: This produces Radiation near to IR Region.

* Hydrogen discharge lamp:

✓ In this lamp, two ~~glass rods~~ Electrodes are fixed in a glass rod and Hydrogen gas is filled under pressure.

✓ When the current is applied Externally to the Electrodes, it produces charge and Emission of Radiation takes place i.e Hydrogen gets excited and Reaches the UV Region. and sample is detected.

✓ This source is stable and widely used.

* Xenon - Arc lamp:

✓ In this source, two Electrodes are placed seperately with some distance.

✓ And inert gas is filled under pressure.

✓ When the voltage is applied, the current passes through the Electrode and arc is formed.

Demerits:

This is not used because it takes lot of Energy i.e it produces more heat during operation and Requires thermal insulation.

* Mercury lamp:

In this Mercury vapour is stored and filled under Pressure. This is not used.

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De merits:

- ✓ Not used because it cannot produce continous spectrum.

2) Collimating System:

Collimating system consists of lenses, Mirrors and Slits.

Lenses:

- ✓ Lenses are generally made of transperency for Radiation.
- ✓ Material used is Quartz & silica and the Radiation observed is 300 - 3000 nm.
- ✓ For visible Region, 3500 nm is required. so fused silica is used in the preparation of lenses.
- ✓ useful in Polychromatic Radiation.

Mirrors:

- ✓ Mirrors are used to focus, transmit
- ✓ use ful in polychromatic Radiation.
- ✓ Mirrors are coated with aluminium to avoid losses.

Slits:

Slits are generally used to seperate polychromatic light into mono chromatic light.

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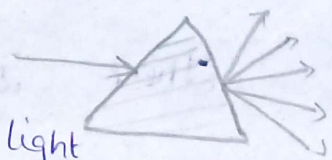
* 3) Monochromators:

Monochromators are of following types.

1) Prism
2) Filters
3) Gratings.

1) prism:



When a beam of light Passes through the prism, it splits into different directions to reach the sample. It converts the light into different regions.

✓ And also produces different colours when passes through prism.

2) FILTERS:

Filters are of 2 types.

✓ Dispersive
✓ Interface filters.

→ Filters are generally used to remove unwanted Radiation and Recfid the sample. ie passes the Required ~~sample~~ Radiation towards the sample.

3) Gratings:
- Reflective
- Refractive

Gratings are generally used a monochromater which cuts the Polychromatic light to Monochromatic light.

4) Sample Holder or cuvets

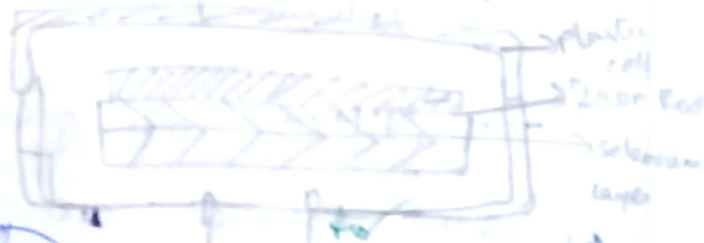
- ✓ The sample Holder or cuvets are generally made of Quartz & fused silica
- ✓ They are Rectangular & cylindrical
- ✓ They should be handled with care.
- ✓ There should be no finger prints on cuvets : If present, sample is not recorded.

5) Detectors:

1) photovolatic cell / Barrier layer
2) photo tube
3) photo Multiplier tube.

1) photo volatic cell / Barrier layer

It contains a barrier layer. In between selenium layer is present.



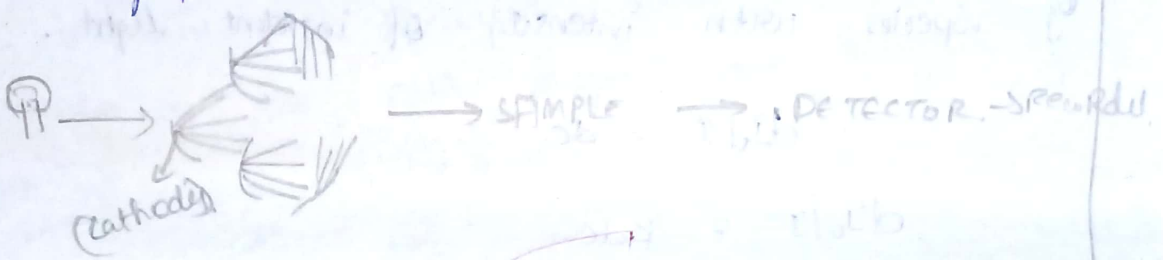
✓ on applying voltage, Electrons move to the Excited state and sample is detected.

2) photo tube:

The light beam is passed through the absorbing media, and the cells are excited by reaching higher energy levels. When current is passed through the tube, electrons get excited.

3) Photo multiplier tube:

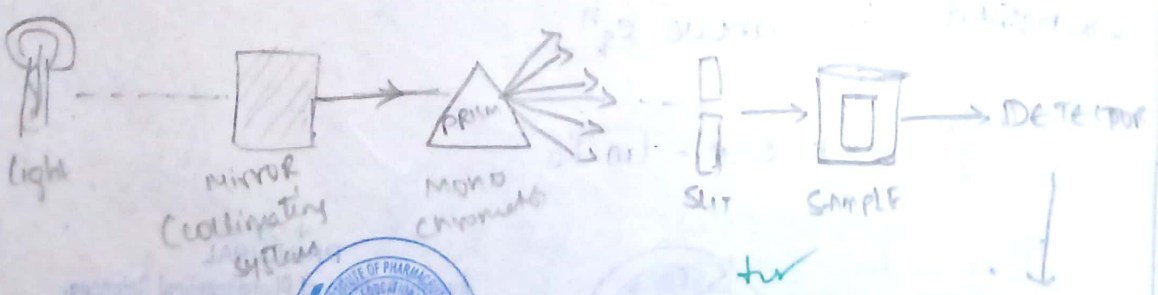
In this the electrons are multiplied by secondary maximization of ~~electrons~~ wavelength.



6) Amplifier and Recorder:

Signals are received through amplifier and recorded using Recording pen.

SINGLE BEAM SPECTROSCOPY.



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Double beam spectrometer:

same as single beam but contain Reference sample in it and values are compared & Recorded.

THEORY:

BEER'S LAMBER'S LAW:

Beer's law:- When a ~~MON~~ light beam passes through a homogenous absorbing medium with the intensity of Radiation with decrease concentration of species with intensity of incident light.

$$dI_0/I = dc$$

$$dI_0/I = k\,dc$$

On Integration.

$$\ln I_0/I = k \cdot c + b.$$ → Integration constant

consider $c = 0$; $I = I_0$

$$\ln \frac{I_0}{I} = k \times 0 + b \quad \rightarrow (1)$$

$$\ln I_0/I = b$$

Substitute in above Eqn.

$$\ln \frac{I_0}{I} = k \cdot c + - \ln I_0$$

$$\ln I_0 - \ln I = k \cdot c$$

$$\ln I_0 - \ln I = \varepsilon t c.$$

on applying log

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$$\log \frac{I_0}{I} = \log e^{kc}$$

$$\log \frac{I_0}{I} = 10^{kc}$$

Removing Natural log

$$\log \frac{I_0}{I} = 10^{-kc} \rightarrow (2)$$

Lambert's law :-

When a light passes through a homogenous absorbing medium, the decrease in intensity of Radiation with increase in thickness of the path length with intensity of radiation.

$$\frac{dc}{t} \quad \frac{dI}{t} = dc.$$

$$dI/t = k \cdot dt \rightarrow (3)$$

Combining (1) & (3)

$$\frac{dI}{I} = k \cdot dt$$

$$\frac{I_0}{I} = k \cdot dt$$

Applying log

$$\log \frac{I_0}{I} = k \cdot dt$$

$$\log \frac{I_0}{I} = 10^{dt}$$

Combining the Equations we get

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$$\log \frac{I_0}{I} = 10^{kct}$$

(8)

$$\log \frac{I_0}{I} = \varepsilon^{kct}$$

Transmittence (T) : $\log \frac{I_0}{I}$:

Absorbance (A) = $\log 1/T$

$$A = \log \frac{I_0}{I} \cdot \varepsilon^{kct}$$

→ UV Spectroscopy involves Electronic shifts like -

- ✓ Batho chromic shift
- ✓ Hypso chromic shift
- ✓ Hyper chromic shift
- ✓ Hypo chromic shift

1) Bathochromic shift :

Also known as Red shift.

~~Electron~~ ~~moves~~ λmax of a compound moves to longer wave length.

2) Hypso chromic shift :

Also known as Blue shift

λmax of a compound moves to shorter wave length.

3) Hyper chromic shift : intensity decreases, wavelength ↓es

4) Hypo Chromic shift : intensity ↑es, wavelength ↑es

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5) Application of UV - Spectroscopy:

✓ Quantitative Analysis and Qualitative Analysis used in the study of Quality and Quantity of the sample and also used to determine the molecular structure.

✓ Detection of Impurities:-

✓ Impurities can be detected in the sample by observing the Reference Sample Parallely.

✓ More peaks are observed, if impurities are present.

✓ Structural Elucidation:-

The structure of a compound can be Elucidated using Spectro-scopy.

✓ Organic compounds can be determined using UV - spectroscopy.

✓ UV - Spectroscopy is also used in the medical field.

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✓ Effect of conjugation:

Effect of conjugation based on Bathochromic and Hypso chromic shifts.

2(a) Quantum Numbers and their Role in NMR:

NMR – Nuclear Magnetic Resonance

1) NMR is an analytical study of Chemistry which deals with the Quality control and Research of a compound. It also checks the purity of a sample being observed.

PRINCIPLE:

Nuclei contains Nucleus, atoms, Molecules or ions and contains some charge in it. when an External voltage is applied, the electrons in ground state i.e base layer gets excited and jumps to higher energy levels. i.e jumps from One Energy level to another Energy level on applying of External field.

→ Nuclei itself contains some charge and moves when excited from one layer to another.

Quantum Numbers:

The Electrons are Represented by some value of Number of sub-atomic, Molecular, or ions in a compound. They are Represented by using Quantum Numbers. They contain some charge in itself and spins around the Nuclei. They are of following types:

1) principle Quantum Number
2) Angular Quantum Number
3) Magnetic Moment Quantum Number
4) Spin Quantum Number.

1) principle Quantum Number.

- ✓ Requires Higher Energy levels.
- ✓ Denoted by n.
- ✓ n is NO: of Electrons.

2) Angular Quantum Number.

- ✓ orientation of shape of Orbital
- ✓ Alignment is made in this type of Quantum Number
- ✓ It depends on
- ✓ Denoted by (l)

✓ Denoates $l = 0, 1, 2, \ldots (n+1)$

3) Magnetic momentum Quantum Number;

In this type, the electrons itself contains some charge. ie own magnetic moment, and spins itself around the Nuclei.

They are of following types.

$l = 0$ - s-type - one orientation - ○

$l = 1$ - p-type - three orientation - ⊖ ⊖ ⊖

$l = 2$ - d-type - five orientation - ⊖ ⊖ ⊖ ⊖ ⊖

$l = 3$ - f-type - Seven orientation unknown,

4) Spin Quantum Number;

It is determined by No: of spins occured.. No: of spins around the Nucleus is previously fixed.

Spin:

✓ Form of Angular momentum.

✓ It moves from +½ to -½

✓ Alignment of Electrons occurs.

Activity of NMR Signal.

Mass Number	Atomic Number	Angular Momentum	Activity.
odd	odd / even	Integral	Active
Even	Even	-	Inactive
Even	odd	Half integral	Active

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✓ NMR is a physical phenomena, i.e the Electric current is applied the Electrons starts Resonating and moves around the Nucleus.

✓ The Electrons contains a Partial charge from the starting and moves on its own.

✓ The No: of spins allowed are fixed before applying voltage.

✓ On applying voltage, they move from lower Energy state to higher Energy state.

2(b) Chemical Shift

It refers to difference in shifts in the position of NMR signal when compared to reference compounds due to shielding and de-shielding Effects by the Electron.

→ It has no dimmensions and gives Parts per Million (ppm) with Reference factor to 10^6

→ Chemical shift will be measured with Ref. to an internal standard (TMS)

→ Helps to determine the Electronic Environment of Proton which, in turn gives the region where the Proton present.

→ In simple terms, chemical shift, helps to indicate the position of an absorbed peak relative to that exhibited by the internal standard in NMR spectrum.

→ The chemical shift is due to the small magnetic fields that get generated when the electrons revolve round the Nuclei

→ These magnetic fields are relatively smaller than applied magnetic field.

→ The magnitude of the field developed internally is directly proportional to applied

$$B_0 = B_{applied} - B_{induced}$$

But $B_{induced} \propto B_{0\ applied}$

$$B_{induced} = \sigma B_{0\ applied}$$

Substituting $B_{induced}$ in above eqn

$$B_0 = B_{applied} - \sigma B_{applied}$$

$$B_0 = B_{applied}(1 - \sigma)$$

where $B_{applied}$ = Magnitude of applied field

B_0 = Magnitude of Resultant field

σ = Screening constant

$$\sigma = \frac{B_{Reference} - B_{Sample}}{B_{Reference}} \times 10^6 \text{ ppm}$$

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Factors influencing Chemical shift

1) Inductive Effect:

Presence of an Electronegative group in an atom deshields the Proton, As Electronegetivity ↑ses, the deshielding Effect of Proton also ↑ses, Hence δ value also ↑ses,

Conversely, Electronegetivity ↓ses, deshielding of Protons ↓ses, & values ↓ses.

2) Vanderwaals Deshielding:

Some of the protons in the over Crowded Molecules occupy sterically hindered Position. The bulky groups Exhibit an Electron cloud which repels the Electron Cloud present around proton.

3) Anisotropic Effect.

→ Refers to shielding & deshielding Effects
→ On the proton due to induced Magnetic fields which prevails in diff Parts of molecule

→ Aldehyde & aromatic Compounds are more deshielded.

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MPharmacyI Sem II Mid Examinations July-2021

Subject: Modern Pharmaceutical Analytical Techniques(MPH101T)

Exam Time: 2hrs **Dt: 19-07-2021** **Marks: 30 M**

Answer any two questions from the following **2X15=30 M**

1. What is chromatography? What is the basis (principle) of chromatographic progress? What are the main differences between HPLC and Gas chromatography?
2. Define electrophoresis. What are the types of electrophoresis? What is the importance of gel electrophoresis?
3. Explain the principle involved in TLC and Paper chromatography and write the differences between TLC and Paper chromatography.

Scheme of Evaluation

1. What is chromatography? What is the basis (principle) of chromatographic progress? What are the main differences between HPLC and Gas chromatography?

   Chromatography Definition, Types – 2 M
   Principle - 3 M
   HPLC principle, working - 5 M
   GC principle, working - 3 M
   Differences between HPLC and Gas chromatography- 2 M

2. Define electrophoresis. What are the types of electrophoresis? What is the importance of gel electrophoresis?

   Electrophoresis Definition, Types – 4 M
   Principle - 3 M
   Working - 6 M
   Importance of gel electrophoresis- 2 M

3. Explain the principle involved in TLC and Paper chromatography and write the differences between TLC and Paper chromatography.

   TLC principle, working - 5 M
   PC principle, working - 3 M
   Differences between TLC and Paper chromatography - 2 M

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mPH-16-05

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(Approved by AICTE, PCi & Govt.of A.P. Affiliated to JNTUK, Kakinada)

ESTD : 2005

SUBJECTIVE TEST

JNTUK Reg. No. : 20T51S1605
Student Name : CH Sai Lavanya
Year : 1 year
Branch : B. Pharm / Pharm D. / Pharm D. (P.B) / M. Pharm
Specialization : Pharmaceutical Analysis
Subject Name : Modern Pharmaceutical Analytical Techniques
Marks Secured : 22

Date : 19/09/2021
Sem : II M.Pd
Time :
Total Marks : 22
Invigilators Signature :

14/15 + 8/10 = 22/25

27/30

1 Chromatography:

The word 'chromatography' is derived from two Greek words

Chromos = Colour
graphos = written

So, chromatography is known as "Colour written"

⇒ It is a unique & analytical technique which is mainly used for seperation and analysis of analytical (or) complex mixtures

Definition:

⇒ It is defined as a analytical technique which is used for seperation of complex mixture into individual components by using stationary phase and mobile phase

(or)

⇒ It is defined as a proces of seperation (or) analytical proces for the complex of organic/inorganic solvents in which dissolves (or) moves to a stationary phase into individual components

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Basis principles of chromatographic progress:

⇒ It is catigoried into (2) types:

Mobile phase:

It is mobility in nature

⇒ In this mixture, impurities / analytes are dissolved in the solvents of liquid and gases

Stationary phase:

It is stable in nature

⇒ It consits of fixed amounts of solids and liquid medium

It is classified into (4) types:

I) Based on the nature of Stationary phase (SP) and Mobile phase (MP)

① Gas - Solid Chromatography :-
(MP) (SP)

⇒ In this chromatography process gas acts as mobile phase & Solid phase

② Gas - liquid Chromatography :-
(MP) (SP)

⇒ In this process, Gas acts as MP & liquid acts as Stationary phase

③ Solid - liquid Chromatography :-
(SP) (MP)

⇒ In this type, Solid acts as stationary phase & liquid acts as mobile phase

Ex: Paper chromatography
Column Chromatography
High Pressure liquid Chromatography (HPLC)
Thin Layer Chromatography (TLC)

④ Liquid - liquid Chromatography :-
(SP) (MP)

⇒ In this type of liquid Solvents acts as SP & Solute particles is MP

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Ex: Paper partition Chromatography
Column partition chromatography

II) Based on the principle of Separation:

It is divided into (2) types

(a) Adsorption chromatography:

⇒ It is a chromatographic process, in which the compler mixture are dissolved in MP and moves through Stationary phase (SP) according to their relative affinities and then gets Seperated into individual components

⇒ Compound with higher affinity, travels slow and elutes last

⇒ Compounds with lower affinity, travels faster and elutes first

⇒ No two Compounds will have Same relative affinity

Relative affinity:

⇒ It is defined as a tendency of molecule that dissociate with another molecule

→ It has binding forces and acts blw analyte & SP

(b) Partition Chromatography:

⇒ Two immiscible liquids gets Seperated out based on their partition coefficients

⇒ They are given by a compler mixture by their partition coefficients and are Seperated out by a column liquid Stationary phase (SP)

⇒ No two particles will have Same partition coefficients and differences occur by their partition

⇒ Compounds having high Solubility travels Slow & elutes last

⇒ Compounds having low solubility travels fast & elutes first

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III Based on the mode of chromatography:

① Normal phase:

In the normal phase, polar compounds acts as mobile phase

Ex: Octacetcyl Silica

Non-polar compounds acts as Stationary phase

Ex: Toulene

② Reverse phase:

In the reverse phase, non-polar compounds acts as mobile phase

Ex: C_4, C_8, C_{18} Compounds

Polar compounds acts as Stationary phase

Ex: H_2O-methane

Polar compounds:

Atoms do not share the lone pair of electrons in covalent bond are called polar

Non-polar compounds:

Atoms which share the lone pair of e^- called non-polar

IV other type chromatography:

① Ion-exchange chromatography:

In this process, complex mixtures are seperated into individual components by using "ion exchange resin"

⇒ Cations exchange resin are seperated into cations and Anion exchange resin are seperated into anions

② Gel permeation chromatography

⇒ Complex mixture are seperated into individual components based on their molecular wt

⇒ MP consists of polyvinyl acetate, polydextrans, cross-linked dextrans & SP acts as organic buffer & Solvents

③ Chiral chromatography

⇒ Polar ligands (levo, dextro) are seperated into Chiral Stationary phase (CSP)

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Differences between Gas Chromatography & High Pressure liquid Chromatography (HPLC)

GC	HPLC
1) mobile phase & Stationary phase:	1) mobile phase & Stationary phase:
⇒ In this Chromatography, GC carrier gas acts as a MP & pass through a column present in SP	⇒ Liquid present in the MP is pumped with a high pressure in the column present in SP
2) ~~Nature~~ Principle	2) Principle
⇒ The basic principle involved in GC is adsorption chromatography	⇒ The basic principle involved in HPLC is adsorption chromatography, affinity, ion-exchange & GPC chromatography
3) GC was earlier used in 1940's - 1943's	3) HPLC is a modern technique used in 1968's - 1969's
4) Cost of the equipment is low and it ranges from 8-10L	4) Cost of the equipment is high and it ranges from 10-25L
5) Gas & voltaile liquids can be easily seperated out	5) Gas & voltaile liquid cannot be easily seperated
6) Instrumentation: It Consists of a) Gas Supply unit b) Column c) detectors d) Analytical Columns e) Injector	6) Instrumentation: It consists of a) Sample delivery system b) Columns c) detectors d) Injector e) Analytical Columns
7) Pre-columns are not used	7) Pre-columns are used for Chromatographic purpose

GC	HPLC
8) Thermostable compounds are most used in GC	8) Thermolabile compounds are used for the seperation of volatile & non-volatile liquids
9) Preparation of the MP is easy	9) Preparation of the MP is time consuming proces
10) Pore size 2-5 μm	10) Pore size 3-10 ~~15~~ μm
11) Recovery of the MP is difficult	11) Recovery of MP is easy
12) Samples are to be heated if they are not dissolved in gases	12) Samples are not be heated & dissolved in aqueous / non-aqueous solvents
13) It requires a temperature sensing detector Ex: linear mode	13) It do not require a temperature sensing detector
14) Glass columns are widely used in GC	14) Stainless steel columns are used in HPLC
15) Sample units, detectors, analytes requires oven for constant temperature	15) Only columns in HPLC requires oven for constant temperature
16) Columns used: Packing columns	16) Columns used are multibore columns
Detectors:	
17) Concentration flow Ion-capture detector -Analytical Columns detector mass-flow detectors Photoelectric detector Nitrogen-phosphorous detectors	17) Detectors Bulk flow: Refractive index detector free-flow / Solvent flow detector UV-visible detector flourescence detector

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2) ② Electrophoresis:

It is defined as a technique in which the immigration of ions / colloidal aggregate flows to an electrolyte solution under the influence of applied electric field

→ Immigration is mainly based on

i) Size & Shape of the particle

ii) Temperature & nature of the Solvent

iii) pH & ionic solution of the Solvents

Types of Electrophoresis:

It is mainly classified into (2) types

a) Slab electrophoresis:
(with stabilising medium)
Ex: Paper electrophoresis, Gel electrophoresis

b) free flow electrophoresis
(without stabilising medium)
Ex: Capillary electrophoresis

a) Slab electrophoresis:

→ A rectangular, flat surface area consists of a Solvents which helps to holds the sample solution and acts as a stabilising / supporting medium

→ The stabilising medium is a rectangular in shape which is placed bto the electrodes

→ In slab electrophoresis, sample is applied in the form of bands / strips and placed in solvents bto the two electrodes

→ A voltage current is applied bto them and after the seperation of sample the current is disconnected.

⇒ The visualization agents are sprayed for detection of the sample.

⇒ filter medium :- agar gels cellulose acetate, Silica gel

⇒ for high mol wt :- Organic Solvents are used

b) free flow electrophoresis.

⇒ In this type, buffer is added to the capillary tube containing high molecular weight of compounds

⇒ Then the sample is added ~~by a air-tight~~ into the capillary tube and is enclosed with a air-tight chamber

⇒ Voltage is applied across the capillary tube and the ion particles are present on the either side of the tube

⇒ The immigration of ions can be determined by the mass/charge ratio

⇒ Cations moves faster than anion charge particles

Paper Electrophoresis

Def:

It is defined as a analytical technique in which the immigration of ions takes place & moves to a electrolyte solution under the influence of applied electric field in which 'Paper' acts as a stabilizing medium.

⇒ It is mainly used for seperation of proteins, nucleic acids, Amino acids

Principle

⇒ Paper do not act as producing electricity, it is placed in the electrolyte solutions like buffer and placed between two electrodes

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⇒ Voltage is applied across the two electrodes forms the Seperation of the Sample and can be detected by Spraying visualising agents

Types of paper chromatography :

(1) Based on the voltage potential:

a) low voltage potential:

Voltage current ranges between 8-15 μm/volt (or) 50-100 μm/pot and the potential difference between the charges ranges from 0.4 Amp/Step (or) 0.5 Amp/Step

b) High voltage potential:

Voltage current ranges between 50-300 μm/volt or potential diff between 0.8 Amp/Step

(2) Based on the Instrument:

a) Horizontal Paper Electrophoresis.

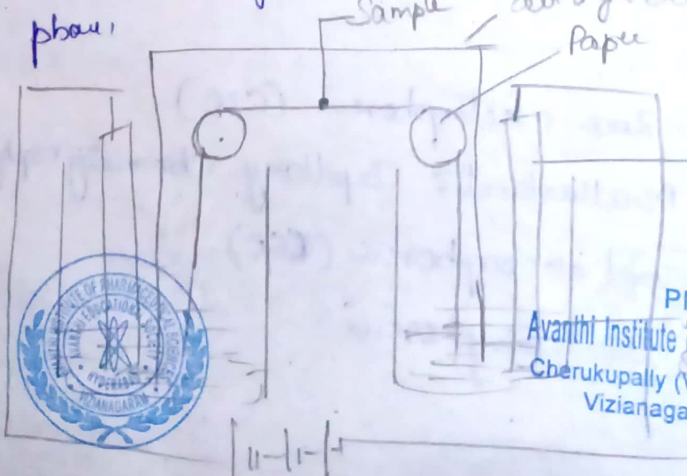
⇒ In this type of electrophoresis, paper is placed in the buffer solution containing beaker

⇒ The electrodes are immersed in the tube containing voltage current

⇒ Sample is placed "horizontally" at the center of the paper & is closed with air-tight chamber

⇒ Voltage is applied b/w two electrodes & the immigration of ion takes places

⇒ Cation moves through cathodic phase & anion through anionic phase.



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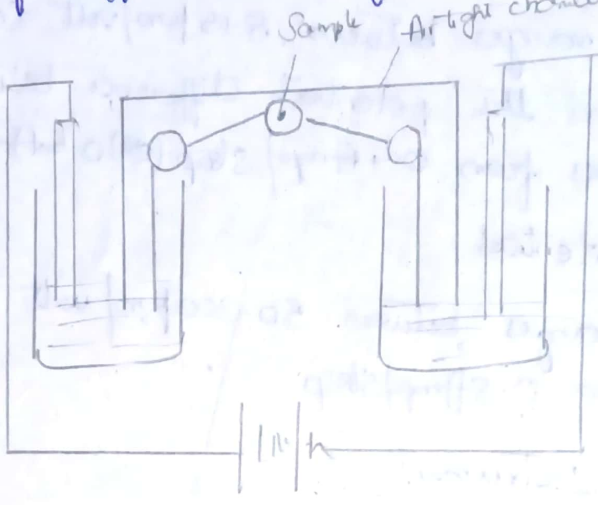
b) Vertical Paper Electrophoresis

→ In this type, sample is applied vertically & are placed btw two electrodes

→ The voltage current is applied & Seperation of sample takes place

→ Whatman filter paper is used for the removal excess of buffer another filter paper used



c) free flow electrophoresis

Charg of ion are seperated by the mass/charge ratio

Capillary Electrophoresis

Def:

It is defined as immigration of ions into electrolyte solution under the influence of applied electric field by "without using a stabilising medium"

Principle:

→ Capillary electrophoresis is mainly used for the seperation of high molecular compounds, proteins, Amino acids, alkali earth metal etc

Types of Capillary electrophoresis:

(A) Types

a) Capillary zone electrophoresis (CZE)

b) Capillary Micellarkinetic Capillary Chromatography (MKEC)

c) Capillary Gel electrophoresis (CGE)

d) Capillary Isotachophoresis

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a) Capillary zone electrophoresis:

⇒ The Solution is placed in the capillary tube & the buffer is added to the Solution

⇒ The Sample is placed & voltage is applied across the buffer medium in which the Separation of the Sample take place

Order of ions:

Cations moves faster → than Electric osmotic flow → Cations elute first

Anion moves Slower → than Electric osmotic flow → Cations elute last

Neutral ion → moves through Electric osmotic flow

Cations > Electric osmotic flow of neutral ion > Anion

Ex: Surfactant, urea

b) Micellar kinetic Capillary Chromatography:

⇒ The buffer Solution is added to the detergents and present in the form of micelli

⇒ The Seperation of ions take place through ion & the nature of Solvents by the electrolyte

Seperation of Organic Compounds

c) Capillary Gel electrophoresis

⇒ Agarose gel, Silica gel are mostly used in the Capillary gel electrophoresis

⇒ It is mainly used for the Seperation of the proteins & Amino acid

Cations through > Neutral > EOF > Anion through Cation > Cationic exchange resin ion from Cation

d) Capillary Isotachophoresis,

It mainly consists of two buffer A, B

Buffer A Solution → more stable in nature → present before cation

Buffer B Solution → less stable in nature → present after Anion

⇒ Capillary electrophoresis is (migration of ion)

(a) directly proportional to the size, shape of electrons and viscosity, pH & ionic buffer

(b) indirectly proportional to the velocity of the electrolyte & potential difference

Gel Electrophoresis,

Def

⇒ It is defined as the migration of the ion by the electrolyte solution under the influence of applied magnetic filed by using gel as stabilising medium

Types.

① One dimensional:

Poly-Acrylamide Gel electrophoresis (PAGE)

Iso electric focusing

② Two dimensional

③ Agarose gel electrophoresis

① One dimensional.

PAGE:

Sodium diacetyl sulphate attaches to protein and helps in formation of micelle

↓

Acrylamide Gel that attaches to metacarpomethanol

↓

Denaturation of proteins takes place

Protein molecule attaches to two disulphide bonds undergo further denaturation of protein

↓

It is heated for 5 mins, cooled & heated for 3 mins & cooled

↓

Then are passed through wells

↓

Cation & Anion with high mol wt pass through well

↓

molecules with low travels last

Isoelectric focussing:

Seperation of Anion by H_3PO_4 & Cation by NaOH from the isoelectric point, voltage is applied at zero

② Two dimensional:

Gel is placed at 90°C another 2D is further developed

③ Agarose gel electrophoresis

⇒ It is used for the seperation of high mol wt Compounds

⇒ Seperation of protein, Amino acid with 25000 Dattons

Agarose gel electrophoresis

Glucocorticoids

The agents which reduces inflammation are called Glucocorticoid and produces immunity system development

Ex: Hydrocortisone, Cortisone.

Application of Gel electrophoresis:

⇒ It is used for the seperation of Anion, cation, protein, nucleic acids, Amino acid

⇒ Used in the Gastric pH, ulcer treatments

⇒ widely used in RNA, DNA technology

⇒ Gel electrophoresis is used in herbicides, pesticides, clinical pharmacy

⇒ It is also used in alkali earth metals, Organic compounds, Solvents

⇒ For Seperation of carbohydrate, protein

⇒ It is used in diagnosis of blood Sample, Arrobosis, cerebrospinal fluid.

⇒ for urine, gastric Sample, Seperation

Uses of Glucorticoids:

Adrenalise insufficiency
Allergic inflammatic
Auto immune disorder
Asthma
Organ transplantation

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Consolidated Internal Marks Statement

S No	Roll No	Mid -I Marks (30 M)	Mid -I Marks (30 M)	Average of 2 mids
1	20T51S1601	10	22	16
2	20T51S1602	22	23	23
3	20T51S1603	23	22	23
4	20T51S1604	22	22	22
5	20T51S1605	23	23	23
6	20T51S1606	22	22	22
7	20T51S0601	23	22	23
8	20T51S0602	9	9	9
9	20T51S0603	21	9	16
10	20T51S0301	20	22	21
11	20T51S0302	20	22	22
12	20T51S0303	22	10	16
13	20T51S0301	21	10	16
14	20T51S0305	22	21	22
15	20T51S0306	21	23	22

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External Marks Statement

SL.NO	REGD.NO	Grade
1	20T51S1601	C
2	20T51S1602	B
3	20T51S1603	B
4	20T51S1604	F
5	20T51S1605	A
6	20T51S1606	A
7	20T51S0601	D
8	20T51S0602	ABSENT
9	20T51S0603	F
10	20T51S0301	F
11	20T51S0302	F
12	20T51S0303	ABSENT
13	20T51S0301	ABSENT
14	20T51S0305	F
15	20T51S0306	F

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Result analysis

Total No.of Students appeared = 12

Total No.of Students passed = 06 .

Pass Percentage = (06/12)*100 = **50%**

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ESTD : 2005

Cherukupally (Village), Chittivalasa (SO), Bhogapuram (Mandal), Vizianagaram (Dist) -531162.

Regulation:PCI(R08) , Subject: Modern Pharmaceutical Analytical Techniques Year : I

Course Outcomes

CO101.1	Recall principle, operation and applications of selected instrumental spectroscopic, chromatographic analysis.
CO101.2	Gain knowledge on interpretation of NMR spectra for determination of molecular structure of compounds.
CO101.3	Build the analytical understanding in the level of ion, atom, group and molecular structure of organic and inorganic compounds with different functional groups by Mass spectroscopy and their applications in pharmacy.
CO101.4	Understand the concept of seperation and identification of compounds by chromatographic techniques.
CO101.5	Categorize different anions and cations by using suitable electrophoresis techniques.
CO101.6	Elaborate principle, theory and instruments employed for the analysis of drugs by thermal techniques.

CO-PO Mapping

CO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO11	PSO 1	PSO 2
CO101.1	-	-	-	2	-	1	-	3	-	-	-	2	1
CO101.2	-	-	-	2	-	1	-	3	-	-	-	2	1
CO101.3	-	-	-	2	-	1	-	3	-	-	-	2	1
CO101.4	-	-	-	2	-	1	-	3	-	-	-	2	1
CO101.5	-	-	-	2	-	1	-	3	-	-	-	2	1
CO101.6	-	-	-	2	-	1	-	3	-	-	-	2	1
	-	-	-	2	-	1	-	3	-	-	-	2	1

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Calculation Standards of Attainment			
	1:Low(40%)	*2:Medium(60%)*	*3: High(75%)*
Descriptive (30M)	12	18	22.5

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ESTD : 2005

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Cherukupally(Village), Near Thagarapuvalasa Bridge, Vizianagaram (Dist)-531162

Branch : Pharmacology

Regulation:PCI , Subject: Modern Pharmaceutical Analytical Techniques Year & Sem: I - I (MID-I)

Calculation standards of attainment

	1:Low (40%)	*2:Medium (60%)*	*3:High (75%)*											
Descriptive (30M)	12	18	22.5											

S.NO	Roll No	CO1 (15 M)		CO2 (15M)		CO3(15 M)		Total Marks (30M)	Mid I Theory Marks (15 M)	Continuous Mode (10 M)	Attainment for continuous mode Level (Avg of CO1, CO2, CO3)	Final Mid I Marks (25 M)	CO1 Average Attainment Level	CO2 Average Attainment Level	CO3 Average Attainment Level
		Q1	Att level	Q2	Att level	Q3	Att Level								
1	20T51S0601	14	3	13	3	0	0	27	14	9	3	23	3	3	1.5
2	20T51S0602	0	0	0	0	0	0	0	0	9	3	9	1.5	1.5	1.5
3	20T51S0603	13	3	0	0	14	3	27	14	9	3	23	3	1.5	3

Attainment Level Summary	CO1	CO2	CO3
Maximum Attainment Level	3	3	3

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Cut-off Attainment Level(60%)	1.8	1.8	1.8
No.of Student >=Cut-off	2	1	1
% of students >=cut-off	67	33	33.33333
Level Attained	2	1	1
Level of Attained			
% of students	<60	60-79	>=80
Level	1	2	3

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Branch : Pharmacology

Regulation:PCI , Subject: Modern Pharmaceutical Analytical Techniques Year & Sem: I - I (MID-II)

Calculation standards of attainment

	1:Low (40%)	*2:Medium (60%)*	*3:High (75%)*
Descriptive (15M)	6	9	11.75
Continuous Mode (10M)	4	6	7.5

S.NO	Roll No	CO1 (15 M)		CO2 (15M)		CO3(15 M)		Total Marks (30M)	Mid I Theory Marks (15 M)	Continuous Mode (10 M)	Attainment for continuous mode Level (Avg of CO1	Final Mid I Marks (25 M)	CO1 Average Attainment Level	CO2 Average Attainment Level	CO3 Average Attainment Level
		Q1	Att level	Q2	Att level	Q3	Att Level								
1	20T51S1601	14	3	12	3	0	0	26	13	9	3	22	3	3	1.5
2	20T51S1602	0	0	0	0	0	0	0	0	9	3	9	1.5	1.5	1.5
3	20T51S1603	0	0	0	0	0	0	0	0	9	3	9	1.5	1.5	1.5

Attainment Level Summary	CO4	CO5	CO6

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Maximum Attainment Level	3	3	3
Cut-off Attainment Level(60%)	1.8	1.8	1.8
No.of Student >=Cut-off	1	1	0
% of students >=cut-off	33	33	0
Level Attained	1	1	1
Level of Attained			
% of students	<60	60-79	>=80
Level	1	2	3

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CGPA CALCULATION:

Marks Range Theory	Marks Range Lab	Letter Grade	Level	Grade Point
>=90	>=90	O	Outstanding	10
>=80 to <90	>=80 to <90	S	Excellent	9
>=70 to <80	>=70 to <80	A	Very Good	8
>=60 to <70	>=60 to <70	B	Good	7
>=50 to <60	>=50 to <60	C	Fair	6
>=40 to <50	>=40 to <50	D	Satisfactory	5
<40	<40	F	Fail	0
			Absent	0

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Cherukupally(Village), Near Thagarapuvalasa Bridge, Vizianagaram (Dist)-531162

Regulation : PCI , Subject : Modern Pharmaceutical Analytical Techniques Year & Sem : I - I

Faculty: Mrs. Sravani Boyapati, Associate Professor, Dept. of Pharmaceutics

SL.NO	REGD.NO	Grade	GRADE WEIGHTAG	60% of External Attainment	Att. Level
1	20T51S0601	D	5	3.00	1
2	20T51S0602	ABSENT	0	0.00	0
3	20T51S0603	F	0	0.00	0

Attainmen	CO1 to CO6
Maximum Attainment Level	3
Cut-off Attainment Level(1.8-Passed)	0
No.of Student >=Cut-off	1
% of students >=cut-off	33
Level Attained	1

Level of Attained			
% of students	<50	50-79	>=80
Level	1	2	3

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Regulation:PCI , Subject:Modern Pharmaceutical Analytical Techniques Year & Sem: I-I

Particulars	Overall Attainment					
	CO1	CO2	CO3	CO4	CO5	CO6
Internal Attaintment Level (INT)	2	1	1	1	1	1
External Attaintment Level (EXT)	1	1	1	1	1	1
TOTAL = INT * 0.25 + EXT * 0.75	**1.25**	**1**	**1.00**	**1**	**3**	**1**
Target Level is 2.2(75%)						

Action taken:Suggestions for further Improvement by Course Teacher

Continuous Quality Improvement for COs:

Target =2.3

Observation: All COs are marginally attained.

To strengthen CO1:Students to be made practice more analysis questions for achieving higher levels of target.

To strengthen CO2:Conduct more number of assignments and practice session to attain the target

To strengthen CO3:Conduct more number of assignments and practice session to attain the target

To strengthen CO4:Conduct guest lectures to attain the target

To strengthen CO5:Conduct more tuitorial classes to attain the target

Murali

Faculty

Principal

PRINCIPAL
Avanthi Institute of Pharmaceutical Sciences
Cherukupally (V), Bhogapuram Mandal
Vizianagaram Dt., - 531162

ESTD : 2005

AVANTHI INSTITUTE OF PHARMACEUTICAL SCIENCES

Cherukupally(Village), Near Thagarapuvalasa Bridge, Vizianagaram (Dist)-531162

Regulation:PCI , Subject:Modern Pharmaceutical Analytical Techniques Year & Sem: I-I

	The Mapping of CO and PO on 3 point scale{high-3,Medium-2,Low-1} is:													
	CO Attainment Level	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2
CO-1	1.25	-	-	-	2	-	1	-	3	-	-	-	2	1
CO-2	1	-	-	-	2	-	1	-	3	-	-	-	2	1
CO-3	1	-	-	-	2	-	1	-	3	-	-	-	2	1
CO-4	1	-	-	-	2	-	1	-	3	-	-	-	2	1
CO-5	3	-	-	-	2	-	1	-	3	-	-	-	2	1
CO-6	1	-	-	-	2	-	1	-	3	-	-	-	2	1
PO/PSO Weightage		0	0	0	12	0	6	0	18	0	0	0	12	6
PO/PSO Co-relation weightage all Cos(1-5)		0	0	0	16.5	0	8.25	0	24.75	0	0	0	16.5	8.25
PO/PSO Attainment Level		-	-	-	1.38	-	1.38	-	1.38	-	-	-	1.38	1.38

Murali
Faculty

AVANTHI INSTITUTE OF PHARMACEUTICAL SCIENCES * AVANTHI EDUCATIONAL SOCIETY * HYDERABAD * VIZIANAGARAM *

Principal
PRINCIPAL
Avanthi Institute of Pharmaceutical Sciences
Cherukupally (V), Bhogapuram Mandal
Vizianagaram Dt., - 531162

JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY: KAKINADA
UNIVERSITY EXAMINATION CENTER, KAKINADA

I B. PHARMACY - I SEMESTER (PCI REGULATION) I MID EXAMINATIONS, APRIL - 2021

TIMETABLE

TIME: 10.00 AM to 12.00 NOON

DATE	06.04.2021 (Tuesday)	07.04.2021 (Wednesday)	08.04.2021 (Thursday)	09.04.2021 (Friday)
SUBJECTS	Human Anatomy and Physiology-I (**BP101T**)	Pharmaceutical Analysis-I (**BP102T**)	Pharmaceutics-I (**BP103T**)	Pharmaceutical Inorganic Chemistry (**BP104T**)

NOTE: (i) ANY OMISSIONS OR CLASHES IN THIS TIME TABLE MAY PLEASE BE INFORMED TO THE CONTROLLER OF EXAMINATIONS IM MEDIATELY.

(ii) EVEN IF GOVERNMENT DECLARES HOLIDAY ON ANY OF THE ABOVE DATES, THE EXAMINATIONS SHALL BE CONDUCTED AS USUAL.

(iii) THE PRINCIPALS ARE REQUESTED TO INFORM THE UNIVERSITY ANY OTHER SUBSTITUTE SUBJECTS THAT ARE NOT INCLUED IN THE ABOVE LIST IMMEDIATELY.

Date: 01-04-2021

Controller of Examinations

PRINCIPAL
Avanthi Institute of Pharmaceutical Sciences
Cherukupally (V), Bhogapuram Mandal
Vizianagaram Dt., - 531162

JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY: KAKINADA

UNIVERSITY EXAMINATION CENTER, KAKINADA

I B. PHARMACY II SEMESTER (PCI REGULATION) I MID EXAMINATIONS, AUGUST/SEPTEMBER - 2021

TIMETABLE

TIME : 10.00 AM TO 12.00 NOON

DATE	31-08-2021 (Tuesday)	01-09-2021 (Wednesday)	02-09-2021 (Thursday)	03-09-2021 (Friday)
SUBJECTS	Human Anatomy and Physiology-II (BP201T)	Pharmaceutical Organic Chemistry-I (BP202T)	Biochemistry (BP203T)	Pathophysiology (BP204T)

NOTE: (i) ANY OMISSIONS OR CLASHES IN THIS TIME TABLE MAY PLEASE BE INFORMED TO THE CONTROLLER OF EXAMINATIONS IM MEDIATELY.

(ii) EVEN IF GOVERNMENT DECLARES HOLIDAY ON ANY OF THE ABOVE DATES, THE EXAMINATIONS SHALL BE CONDUCTED AS USUAL.

(iii) THE PRINCIPALS ARE REQUESTED TO INFORM THE UNIVERSITY ANY OTHER SUBSTITUTE SUBJECTS THAT ARE NOT INCLUED IN THE ABOVE LIST IMMEDIATELY.

DATE: 16 -08-2021

Controller of Examinations

AVANTHI INSTITUTE OF PHARMACEUTICAL SCIENCES * AVANTHI EDUCATIONAL SOCIETY * HYDERABAD * VIZIANAGARAM

PRINCIPAL
Avanthi Institute of Pharmaceutical Sciences
Cherukupally (V), Bhogapuram Mandal
Vizianagaram Dt., - 531162

JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY: KAKINADA

UNIVERSITY EXAMINATION CENTER, KAKINADA

I B. PHARMACY II SEMESTER (PCI REGULATION) II MID EXAMINATIONS, SEPTEMBER - 2021

TIMETABLE

TIME : 10.00 AM TO 12.00 NOON

DATE	20-09-2021 (Monday)	21-09-2021 (Tuesday)	22-09-2021 (Wednesday)	23-09-2021 (Thursday)
SUBJECTS	Human Anatomy and Physiology-II (BP201T)	Pharmaceutical Organic Chemistry-I (BP202T)	Biochemistry (BP203T)	Pathophysiology (BP204T)

NOTE: (i) ANY OMISSIONS OR CLASHES IN THIS TIME TABLE MAY PLEASE BE INFORMED TO THE CONTROLLER OF EXAMINATIONS IM MEDIATELY.

(ii) EVEN IF GOVERNMENT DECLARES HOLIDAY ON ANY OF THE ABOVE DATES, THE EXAMINATIONS SHALL BE CONDUCTED AS USUAL.

(iii) THE PRINCIPALS ARE REQUESTED TO INFORM THE UNIVERSITY ANY OTHER SUBSTITUTE SUBJECTS THAT ARE NOT INCLUED IN THE ABOVE LIST IMMEDIATELY.

DATE: 01-09-2021

Controller of Examinations

AVANTHI INSTITUTE OF PHARMACEUTICAL SCIENCES
AVANTHI EDUCATIONAL SOCIETY
HYDERABAD
VIZIANAGARAM

PRINCIPAL
Avanthi Institute of Pharmaceutical Sciences
Cherukupally (V), Bhogapuram Mandal
Vizianagaram Dt., - 531162

JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY: KAKINADA
UNIVERSITY EXAMINATION CENTER, KAKINADA

II B. PHARMACY - I SEMESTER (PCI REGULATION) I MID EXAMINATIONS, JANUARY - 2021

TIME TABLE

DATE	27-01-2021 (Wednesday)	28-01-2021 (Thursday)	29-01-2021 (Friday)	30-01-2021 (Saturday)
SUBJECTS	Pharmaceutical Organic Chemistry-II (BP301T)	Physical Pharmaceutics-I (BP302T)	Pharmaceutical Microbiology (BP303T)	Pharmaceutical Engineering (BP304T)

NOTE: (i) ANY OMISSIONS OR CLASHES IN THIS TIME TABLE MAY PLEASE BE INFORMED TO THE CONTROLLER OF EXAMINATIONS IM MEDIATELY.

(ii) EVEN IF GOVERNMENT DECLARES HOLIDAY ON ANY OF THE ABOVE DATES, THE EXAMINATIONS SHALL BE CONDUCTED AS USUAL.

(iii) THE PRINCIPALS ARE REQUESTED TO INFORM THE UNIVERSITY ANY OTHER SUBSTITUTE SUBJECTS THAT ARE NOT INCLUED IN THE ABOVE LIST IMMEDIATELY.

DATE: 05-01-2021

Controller of Examinations

PRINCIPAL
Avanthi Institute of Pharmaceutical Sciences
Cherukupally (V), Bhogapuram Mandal
Vizianagaram Dt., - 531162

JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY: KAKINADA
UNIVERSITY EXAMINATION CENTER, KAKINADA

II B. PHARMACY - I SEMESTER (PCI REGULATION) II MID EXAMINATIONS, MARCH - 2021

TIME TABLE

DATE	01-03-2021 (Wednesday)	02-03-2021 (Tuesday)	03-03-2021 (Wednesday)	04-03-2021 (Thursday)
SUBJECTS	Pharmaceutical Organic Chemistry-II (BP301T)	Physical Pharmaceutics-I (BP302T)	Pharmaceutical Microbiology (BP303T)	Pharmaceutical Engineering (BP304T)

NOTE: (i) ANY OMISSIONS OR CLASHES IN THIS TIME TABLE MAY PLEASE BE INFORMED TO THE CONTROLLER OF EXAMINATIONS IM MEDIATELY.

(ii) EVEN IF GOVERNMENT DECLARES HOLIDAY ON ANY OF THE ABOVE DATES, THE EXAMINATIONS SHALL BE CONDUCTED AS USUAL.

(iii) THE PRINCIPALS ARE REQUESTED TO INFORM THE UNIVERSITY ANY OTHER SUBSTITUTE SUBJECTS THAT ARE NOT INCLUED IN THE ABOVE LIST IMMEDIATELY.

DATE: 15-02-2021

Controller of Examinations

PRINCIPAL
Avanthi Institute of Pharmaceutical Sciences
Cherukupally (V), Bhogapuram Mandal
Vizianagaram Dt., - 531162

JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY: KAKINADA
UNIVERSITY EXAMINATION CENTER, KAKINADA

II B.PHARMACY - II SEMESTER (R17 PCI REGULATION) I & II MID EXAMINATIONS, AUGUST - 2021

T I M E T A B L E

T I M E : 10.00 AM TO 12.00 NOON
T I M E : 02.00 PM TO 04.00 PM

DATE	23-08-2021 (Monday)	24-08-2021 (Tuesday)	25-08-2021 (Wednesday)	26-08-2021 (Thursday)	27-08-2021 (Friday)
SUBJECTS	PHARMACEUTICAL ORGANIC CHEMISTRY-III **(BP401T)**	MEDICINAL CHEMISTRY-I **(BP402T)**	PHYSICAL PHARMACEUTICS-II **(BP403T)**	PHARMACOLOGY-I **(BP404T)**	PHARMACOGNOSY AND PHYTOCHEMISTRY -I **(BP405T)**

NOTE: (i) ANY OMISSIONS OR CLASHES IN THIS TIME TABLE MAY PLEASE BE INFORMED TO THE CONTROLLER OF EXAMINATIONS IM MEDIATELY.

(ii) EVEN IF GOVERNMENT DECLARES HOLIDAY ON ANY OF THE ABOVE DATES, THE EXAMINATIONS SHALL BE CONDUCTED AS USUAL.

(iii) THE PRINCIPALS ARE REQUESTED TO INFORM THE UNIVERSITY ANY OTHER SUBSTITUTE SUBJECTS THAT ARE NOT INCLUED IN THE ABOVE LIST IMMEDIATELY.

DATE: 27-07-2021

Controller of Examinations

PRINCIPAL
Avanthi Institute of Pharmaceutical Sciences
Cherukupally (V), Bhogapuram Mandal
Vizianagaram Dt., - 531162

JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY: KAKINADA
UNIVERSITY EXAMINATION CENTER, KAKINADA

III B. PHARMACY - I SEMESTER (PCI REGULATION) II MID EXAMINATIONS, MARCH - 2021

TIME TABLE

DATE	01-03-2021 (Monday)	02-03-2021 (Tuesday)	03-03-2021 (Wednesday)	04-03-2021 (Thursday)	05-03-2021 (Friday)
SUBJECTS	MEDICINAL CHEMISTRY-II (BP501T)	INDUSTRIAL PHARMACY – I (BP502T)	PHARMACOLOGY-II (BP503T)	PHARMACOGNOSY AND PHYTOCHEMISTRY-II (BP504T)	PHARMACEUTICAL JURISPRUDENCE (BP505T)

NOTE: (i) ANY OMISSIONS OR CLASHES IN THIS TIME TABLE MAY PLEASE BE INFORMED TO THE CONTROLLER OF EXAMINATIONS IM MEDIATELY.

(ii) EVEN IF GOVERNMENT DECLARES HOLIDAY ON ANY OF THE ABOVE DATES, THE EXAMINATIONS SHALL BE CONDUCTED AS USUAL.

(iii) THE PRINCIPALS ARE REQUESTED TO INFORM THE UNIVERSITY ANY OTHER SUBSTITUTE SUBJECTS THAT ARE NOT INCLUED IN THE ABOVE LIST IMMEDIATELY.

DATE: 15-02-2021

Controller of Examinations

PRINCIPAL
Avanthi Institute of Pharmaceutical Sciences
Cherukupally (V), Bhogapuram Mandal
Vizianagaram Dt., - 531162

JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY : KAKINADA
UNIVERSI TY EXAMINATION CENTER, KAKINADA

III B. PHARMACY - II SEMESTER (PCI REGULATION) I, II MID EXAMINATIONS & QUIZ (OFF LINE), AUGUST - 2021

TIME TABLE

I MID TIME : 10.00 AM TO 12.00 NOON
II MID TIME : 02.00 PM TO 04.00 PM

DATE	02-08-2021 (Monday)	03-08-2021 (Tuesday)	04-08-2021 (Wednesday)	05-08-2021 (Thursday)	06-08-2021 (Friday)	07-08-2021 (Saturday)
SUBJECTS	Medicinal Chemistry III (BP601T)	Pharmacology III (BP602T)	Herbal Drug Technology (BP603T)	Biopharmaceutics and Pharmacokinetics (BP604T)	Pharmaceutical Biotechnology (BP605T)	Quality Assurance (BP606T)

NOTE: (i) ANY OMISSIONS OR CLASHES IN THIS TIME TABLE MAY PLEASE BE INFORMED TO THE CONTROLLER OF EXAMINATIONS IM MEDIATELY.

(ii) EVEN IF GOVERNMENT DECLARES HOLIDAY ON ANY OF THE ABOVE DATES, THE EXAMINATIONS SHALL BE CONDUCTED AS USUAL.

(iii) THE PRINCIPALS ARE REQUESTED TO INFORM THE UNIVERSITY ANY OTHER SUBSTITUTE SUBJECTS THAT ARE NOT INCLUED IN THE ABOVE LIST IMMEDIATELY.

DATE: 20-07-2021

Controller of Examinations

AVANTHI INSTITUTE OF PHARMACEUTICAL SCIENCES
AVANTHI EDUCATIONAL SOCIETY
HYDERABAD
VIZIANAGARAM

PRINCIPAL
Avanthi Institute of Pharmaceutical Sciences
Cherukupally (V), Bhogapuram Mandal
Vizianagaram Dt., - 531162

JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY KAKINADA

UNIVERSITY EXAMINATION CENTER, KAKINADA

IV B.PHARMACY I SEMESTER (PCI) I MID EXAMINATIONS, JANUARY - 2021

T I M E T A B L E

COURSE	DATE & DAY			
	19-01-2021 (Tuesday)	**20-01-2021 (Wednesday)**	**21-01-2021 (Thursday)**	**22-01-2021 (Friday)**
SUBJECTS	Instrumental Methods of Analysis (BP701T)	Industrial Pharmacy II (BP702T)	Pharmacy Practice (BP703T)	Novel Drug Delivery System (BP704T)

NOTE: (i) ANY OMISSIONS OR CLASHES IN THIS TIME TABLE MAY PLEASE BE INFORMED TO THE CONTROLLER OF EXAMINATIONS IMMEDIATELY.

(ii) EVEN IF GOVERNMENT DECLARES HOLIDAY ON ANY OF THE ABOVE DATES, THE EXAMINATIONS SHALL BE CONDUCTED AS USUAL.

(iii) THE PRINCIPALS ARE REQUESTED TO INFORM THE UNIVERSITY ANY OTHER SUBSTITUTE SUBJECTS THAT ARE NOT INCLUED IN THE ABOVE LIST IMMEDIATELY.

DATE: 04-01-2021

Controller of Examinations

PRINCIPAL
Avanthi Institute of Pharmaceutical Sciences
Cherukupally (V), Bhogapuram Mandal
Vizianagaram Dt., - 531162

JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY KAKINADA
UNIVERSITY EXAMINATION CENTER, KAKINADA

IV B.PHARMACY II SEMESTER (PCI REGULATIONS) I & II MID EXAMINATIONS, JULY - 2021

T I M E T A B L E

I Mid : 10.00 AM TO 12.00 NOON
II Mid : 02.00 PM TO 04.00 PM

DATE & DAY	PCI REGULATION
12.07.2021 (Monday)	Biostatistics and Research Methodology **(BP801T)**
13.07.2021 (Tuesday)	Social and Preventive Pharmacy **(BP802T)**
14.07.2021 (Wednesday)	Elective - I
15.07.2021 (Thursday)	Elective - II

NOTE (i) ANY OMISSIONS OR CLASHES IN THIS TIME TABLE MAY PLEASE BE INFORMED TO THE CONTROLLER OF EXAMINATIONS IMEDIATELY.
(ii) EVEN IF GOVERNMENT DECLARES HOLIDAY ON ANY OF THE ABOVE DATES, THE EXAMINATIONS SHALL BE CONDUCTED AS USUAL.
(iii) FOR ANY OTHER CLARIFICATION IN RESPECT OF THE ABOVE EXAMINATIONS PLEASE CONTACT CONTROLLER OF EXAMINATIONS /OR 9652300902.

DATE: 30-06-2021

Controller of Examinations

PRINCIPAL
Avanthi Institute of Pharmaceutical Sciences
Cherukupally (V), Bhogapuram Mandal
Vizianagaram Dt., - 531162

JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY KAKINADA
UNIVERSITY EXAMINATION CENTER, KAKINADA
M. PHARMACY I SEMESTER (PCI REGULATION) I MID EXAMINATIONS, APRIL - 2021

TIME TABLE

TIME: 10:00 AM TO 12:00 NOON

BRANCH & SPECIALIZATION	06-04-2021 (Tuesday)	07-04-2021 (Wednesday)	08-04-2021 (Thursday)	09-04-2021 (Friday)
PHARMACEUTICAL CHEMISTRY (02)	Modern Pharmaceutical Analytical Techniques (**MPC101T**)	Advanced Organic Chemistry –I (**MPC102T**)	Advanced Medicinal Chemistry (**MPC103T**)	Chemistry of Natural Products (**MPC104T**)
PHARMACEUTICS (03)	Modern Pharmaceutical Analytical Techniques (**MPH101T**)	Drug Delivery Systems (**MPH102T**)	Modern Pharmaceutics (**MPH103T**)	Regulatory Affairs (**MPH104T**)
PHARMACOLOGY (06)	Modern Pharmaceutical Analytical Techniques (**MPL101T**)	Advanced Pharmacology-I (**MPL102T**)	Pharmacological and Toxicological Screening Methods-I (**MPL103T**)	Cellular and Molecular Pharmacology (**MPL104T**)
PHARMACOGNOSY (07)	Modern Pharmaceutical Analytical Techniques (**MPG101T**)	Advanced Pharmacognosy-1 (**MPG102T**)	Phytochemistry (**MPG103T**)	Industrial Pharmacognostical Technology (**MPG104T**)
PHARMACY PRACTICE (08)	Clinical Pharmacy Practice (**MPP101T**)	Pharmacotherapeutics-I (**MPP102T**)	Hospital & Community Pharmacy (**MPP103T**)	Clinical Research (**MPP104T**)
INDUSTRIAL PHARMACY (09)	Modern Pharmaceutical Analytical Techniques (**MIP101T**)	Pharmaceutical Formulation Development (**MIP102T**)	Novel drug delivery systems (**MIP103T**)	Intellectual Property Rights (**MIP104T**)

PRINCIPAL
Avanthi Institute of Pharmaceutical Sciences
Cherukupally (V), Bhogapuram Mandal
Vizianagaram Dt., - 531162

JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY KAKINADA
UNIVERSITY EXAMINATION CENTER, KAKINADA
M. PHARMACY I SEMESTER (PCI REGULATION) II MID EXAMINATIONS, JULY - 2021

TIME TABLE

TIME: 10:00 AM TO 12:00 NOON

BRANCH & SPECIALIZATION	19-07-2021 (Monday)	20-07-2021 (Tuesday)	22-07-2021 (Thursday)	23-07-2021 (Friday)
PHARMACEUTICAL CHEMISTRY (02)	Modern Pharmaceutical Analytical Techniques (**MPC101T**)	Advanced Organic Chemistry –I (**MPC102T**)	Advanced Medicinal Chemistry (**MPC103T**)	Chemistry of Natural Products (**MPC104T**)
PHARMACEUTICS (03)	Modern Pharmaceutical Analytical Techniques (**MPH101T**)	Drug Delivery Systems (**MPH102T**)	Modern Pharmaceutics (**MPH103T**)	Regulatory Affairs (**MPH104T**)
PHARMACOLOGY (06)	Modern Pharmaceutical Analytical Techniques (**MPL101T**)	Advanced Pharmacology-I (**MPL102T**)	Pharmacological and Toxicological Screening Methods-I (**MPL103T**)	Cellular and Molecular Pharmacology (**MPL104T**)
PHARMACOGNOSY (07)	Modern Pharmaceutical Analytical Techniques (**MPG101T**)	Advanced Pharmacognosy-1 (**MPG102T**)	Phytochemistry (**MPG103T**)	Industrial Pharmacognostical Technology (**MPG104T**)
PHARMACY PRACTICE (08)	Clinical Pharmacy Practice (**MPP101T**)	Pharmacotherapeutics-I (**MPP102T**)	Hospital & Community Pharmacy (**MPP103T**)	Clinical Research (**MPP104T**)
INDUSTRIAL PHARMACY (09)	Modern Pharmaceutical Analytical Techniques (**MIP101T**)	Pharmaceutical Formulation Development (**MIP102T**)	Novel drug delivery systems (**MIP103T**)	Intellectual Property Rights (**MIP104T**)

PRINCIPAL
Avanthi Institute of Pharmaceutical Sciences
Cherukupally (V), Bhogapuram Mandal
Vizianagaram Dt., - 531162

JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY KAKINADA
UNIVERSITY EXAMINATION CENTER, KAKINADA
M. Pharmacy II SEMESTER (PCI REGULATION) I MID EXAMINATIONS, AUGUST - 2021
TIME TABLE

TIME : 10.00 AM TO 12.00 NOON

BRANCH & SPECIALIZATION	23-08-2021 (Monday)	24-08-2021 (Tuesday)	25-08-2021 (Wednesday)	26-08-2021 (Thursday)
Pharmaceutics (03)	Molecular Pharmaceutics **(MPH201T)**	Advanced Bio pharmaceutics & Pharmacokinetics **(MPH202T)**	Computer Aided Drug Development **(MPH203T)**	Formulation Development of Pharmaceutical and Cosmetic Products **(MPH204T)**
Industrial Pharmacy (09)	Advanced Bio pharmaceutics and Pharmacokinetics **(MIP201T)**	Scale up and Technology Transfer **(MIP202T)**	Pharmaceutical Production Technology **(MIP203T)**	Entrepreneurship Management **(MIP204T)**
Pharmaceutical Chemistry (02)	Advanced Spectral Analysis **(MPC201T)**	Advanced Organic Chemistry II **(MPC202T)**	Computer Aided Drug Design **(MPC203T)**	Pharmaceutical Process Chemistry **(MPC204T)**
Pharmaceutical Analysis (16)	Advanced Instrumental Analysis **(MPA201T)**	Modern Bio-Analytical Techniques **(MPA202T)**	Quality Control and Quality Assurance **(MPA203T)**	Herbal and Cosmetic Analysis **(MPA204T)**
Pharmaceutical Quality Assurance (15)	Hazards and Safety Management **(MQA201T)**	Pharmaceutical Validation **(MQA202T)**	Audits and Regulatory Compliance **(MQA203T)**	Pharmaceutical Manufacturing Technology **(MQA204T)**
Pharmaceutical Regulatory Affairs (13)	Regulatory Aspects of Drugs and Cosmetics (MRA201T)	Regulatory Aspects of Herbal & Biologicals **(MRA202T)**	Regulatory Aspects of Medical Devices **(MRA203T)**	Regulatory Aspects of Food Neutraceuticals **(MRA204T)**
Pharmacy Practice (08)	Principles of Quality Use of Medicines **(MPP201T)**	Pharmacotherapeutics – II **(MPP202T)**	Clinical Pharmacokinetics and Therapeutic Drug Monitoring **(MPP203T)**	Pharmacoepidemiology & Pharmacoeconomics **(MPP204T)**
Pharmacology (06)	Advanced Pharmacology – II **(MPL201T)**	Pharmacology and Toxicology Screening methods- II **(MPL202T)**	Principles of Drug Discovery **(MPL203T)**	Clinical Research and Pharmacovigilance **(MPL204T)**
Pharmacognosy (07)	Medicinal Plant Biotechnology **(MPG201T)**	Advanced Pharmacognosy – II **(MPG202T)**	Indian system of Medicine **(MPG203T)**	Herbal Cosmetics **(MPG204T)**

NOTE: (i) If Government declares holiday on any of the above dates, the examinations will be conducted as usual

(ii) Any omissions or clashes in this Time Table may please be informed to the Controller of Examinations immediately.

(iii) The Principals are requested to inform the University, if any other substitute subjects that are not included in the above time table immediately

Date: 11-08-2021

Controller of Examinations

PRINCIPAL
Avanthi Institute of Pharmaceutical Sciences
Cherukupally (V), Bhogapuram Mandal
Vizianagaram Dt., - 531162

BRANCH & SPECIALIZATION	06-04-2021 (Tuesday)	07-04-2021 (Wednesday)	08-04-2021 (Thursday)	09-04-2021 (Friday)
PHARMACEUTICAL REGULATORY AFFAIRS (13)	Good Regulatory Practices (**MRA101T**)	Documentation and Regulatory Writing (**MRA102T**)	Clinical Research Regulations (**MRA103T**)	Regulations and Legislation for Drugs & Cosmetics, Medical Devices, Biologicals & Herbals, and Food & Nutraceuticals In India and Intellectual Property Rights (**MRA104T**)
PHARMACY QUALITY ASSURANCE (15)	Modern Pharmaceutical Analytical Techniques (**MQA101T**)	Quality Management System (**MQA102T**)	Quality Control and Quality Assurance (**MQA103T**)	Product Development and Technology Transfer (**MQA104T**)
PHARMACEUTICAL ANALYSIS (16)	Modern Pharmaceutical Analytical Techniques (**MPA101T**)	Advanced Pharmaceutical Analysis (**MPA102T**)	Pharmaceutical Validation (**MPA103T**)	Food Analysis (**MPA104T**)

NOTE: (i) If Government declares holiday on any of the above dates, the examinations will be conducted as usual

(ii) Any omissions or clashes in this Time Table may please be informed to the Controller of Examinations immediately.

(iii) The Principals are requested to inform the University, if any other substitute subjects that are not included in the above time table immediately

Date: 01-04-2021

Controller of Examinations

AVANTHI INSTITUTE OF PHARMACEUTICAL SCIENCES * AVANTHI EDUCATIONAL SOCIETY * HYDERABAD * VIZIANAGARAM *

PRINCIPAL
Avanthi Institute of Pharmaceutical Sciences
Cherukupally (V), Bhogapuram Mandal
Vizianagaram Dt., - 531162

ESTD : 2005

AVANTHI INSTITUTE OF PHARMACEUTICALSCIENCES

(Approved by A.I.C.T.E, PCI, Recognized by the Govt. of A.P. & Affiliated to JNTUK-Kakinada)
Cherukupally (Village), Chittivalasa (SO), Bhogapuram (Mandal), Vizianagaram (Dist.) -531162.
www.avanthipharma.ac.in, principal@avanthipharma.ac.in

Date: 29-03-2021

CIRCULAR

I B PHARM, I SEMESTER, I MID APRIL 2021

First Midterm Examination for I B Pharmacy I semester will commence from 05 April 2021 as per the schedule. Faculty of respective subjects is instructed to submit soft copy of the question paper at least one day before examination. Students shall consult teachers in their respective subject for the syllabus of the examination. Lab internal exam will be conducted immediately after theory mid examinations.

TIMETABLE

S.No.	DATE	SUBJECT
1.	05-04-2021	Human Anatomy and Physiology- I
2.	06-04-2021	Pharmaceutical Analysis I
3.	07-04-2021	Pharmaceutics- I
4.	08-04-2021	Pharmaceutical Inorganic Chemistry
DESCRIPTIVE EXAM		
EXAM TIMINGS : 10 A.M – 12 P.M		

Principal
PRINCIPAL
Avanthi Institute of Pharmaceutical Sciences
Cherukupally (V), Bhogapuram Mandal
Vizianagaram Dt., - 531162

ESTD : 2005

AVANTHI INSTITUTE OF PHARMACEUTICALSCIENCES

(Approved by A.I.C.T.E, PCI, Recognized by the Govt. of A.P. & Affiliated to JNTUK-Kakinada)
Cherukupally (Village), Chittivalasa (SO), Bhogapuram (Mandal), Vizianagaram (Dist.) -531162.
www.avanthipharma.ac.in, principal@avanthipharma.ac.in

Date: 19-05-2021

CIRCULAR

I B PHARM, I SEMESTER, II MID MAY 2021

Second Midterm Examination for I B Pharmacy I semester will commence from 26 May 2021 as per the schedule. Faculty of respective subjects is instructed to submit soft copy of the question paper at least one day before examination. Students shall consult teachers in their respective subject for the syllabus of the examination. Lab internal exam will be conducted immediately after theory mid examinations.

TIMETABLE

S.No.	DATE	SUBJECT
1.	26-05-2021	Human Anatomy and Physiology- I
2.	27-05-2021	Pharmaceutical Analysis I
3.	28-05-2021	Pharmaceutics- I
4.	29-05-2021	Pharmaceutical Inorganic Chemistry
DESCRIPTIVE EXAM		
EXAM TIMINGS : 10 A.M – 12 P.M		

Principal

PRINCIPAL
Avanthi Institute of Pharmaceutical Sciences
Cherukupally (V), Bhogapuram Mandal
Vizianagaram Dt., - 531162

ESTD : 2005

AVANTHI INSTITUTE OF PHARMACEUTICALSCIENCES

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Date: 26-07-2021

CIRCULAR

I B PHARM, II SEMESTER, I MID AUGUST 2021

First Midterm Examination for I B Pharmacy II semester will commence from 02 August 2021 as per the schedule. Faculty of respective subjects are instructed to submit soft copy of the question paper at least one day before examination. Students shall consult teachers in their respective subject for the syllabus of the examination. Lab internal exam will be conducted immediately after theory mid examinations.

TIMETABLE

S.No	DATE	SUBJECT
1.	02-08-2021	Human Anatomy and Physiology II
2.	03-08-2021	Pharmaceutical Organic Chemistry I
3.	04-08-2021	Biochemistry
4.	05-08-2021	Pathophysiology
DESCRIPTIVE EXAM		
EXAM TIMINGS:10 A.M -12 P.M		

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Date: 13-09-2021

CIRCULAR

I B PHARM, II SEMESTER, II MID SEPTEMBER 2021

Second Midterm Examination for I B Pharmacy II semester will commence from 20 September 2021 as per the schedule. Faculty of respective subjects are instructed to submit soft copy of the question paper at least one day before examination. Students shall consult teachers in their respective subject for the syllabus of the examination. Lab internal exam will be conducted immediately after theory mid examinations.

TIMETABLE

S.No.	DATE	SUBJECT
1.	20-09-2021	Human Anatomy and Physiology II
2.	21-09-2021	Pharmaceutical Organic Chemistry I
3.	22-09-2021	Biochemistry
4.	23-09-2021	Pathophysiology
DESCRIPTIVE EXAM		
EXAM TIMINGS: 10 A.M – 12 P.M		

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Date: 21-09-2020

CIRCULAR

II B PHARM, I SEMESTER, I MID SEPTEMBER 2020

First Midterm Examination for II B Pharmacy I semester will commence from 28 September 2020 as per the schedule. Faculty of respective subjects are instructed to submit soft copy of the question paper at least one day before examination. Students shall consult teachers in their respective subject for the syllabus of the examination. Lab internal exam will be conducted immediately after theory mid examinations.

TIMETABLE

S.No.	DATE	SUBJECT
1.	28-09-2020	Pharmaceutical Organic Chemistry II
2.	29-09-2020	Physical Pharmaceutics I
3.	30-09-2020	Pharmaceutical Microbiology
4.	01-09-2020	Pharmaceutical Engineering
DESCRIPTIVE EXAM		
EXAM TIMINGS : 10 A.M – 12 P.M		

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Date: 09-11-2020

CIRCULAR

II B PHARM, I SEMESTER, II MID NOVEMBER 2020

Second Midterm Examination for II B Pharmacy I semester will commence from 16 November 2020 as per the schedule. Faculty of respective subjects are instructed to submit soft copy of the question paper at least one day before examination. Students shall consult teachers in their respective subject for the syllabus of the examination. Lab internal exam will be conducted immediately after theory mid examinations.

TIMETABLE

S.No.	DATE	SUBJECT
1.	16-11-2020	Pharmaceutical Organic Chemistry II
2.	17-11-2020	Physical Pharmaceutics I
3.	18-11-2020	Pharmaceutical Microbiology
4.	19-11-2020	Pharmaceutical Engineering
DESCRIPTIVE EXAM		
EXAM TIMINGS : 10 A.M – 12 P.M		

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Date: 18-01-2020

CIRCULAR

II BPHARM, II SEMESTER, I MID JANUARY 2020

First Midterm Examination for II B Pharmacy II semester will commence from 25 January 2020 as per the schedule. Faculty of respective subjects are instructed to submit soft copy of the question paper at least one day before examination. Students shall consult teachers in their respective subject for the syllabus of the examination. Lab internal exam will be conducted immediately after theory mid examinations.

TIMETABLE

S. No	DATE	SUBJECT
1.	25-01-2020	Ph. Organic Chemistry- III
2.	26-01-2020	Medicinal Chemistry- I
3.	27-01-2020	Physical Pharmaceutics- II
4.	28-01-2020	Pharmacology- I
5.	29-01-2020	Pharmacognosy and Phytochemistry- I
DESCRIPTIVE EXAM		
EXAM TIMINGS : 10 A.M – 12 P.M		

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Date: 02-03-2020

CIRCULAR

II B PHARM, II SEMESTER, II MID, MARCH 2020

Second Midterm Examination for II B Pharmacy II semester will commence from 09 March 2020 as per the schedule. Faculty of respective subjects are instructed to submit soft copy of the question paper at least one day before examination. Students shall consult teachers in their respective subject for the syllabus of the examination. Lab internal exam will be conducted immediately after theory mid examinations.

TIMETABLE

S. No	DATE	SUBJECT
1.	09-03-2020	PH. Organic Chemistry III
2.	10-03-2020	Medicinal Chemistry I
3.	11-03-2020	Physical Pharmaceutics II
4.	12-03-2020	Pharmacology I
5.	13-03-2020	Pharmacognosy and Phytochemistry I
DESCRIPTIVE EXAM		
EXAM TIMINGS : 10 A.M – 12 P.M		

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Date: 21-09-2020

CIRCULAR

III B PHARM, I SEMESTER, I MID, SEPTEMBER 2020

First Midterm Examination for III B Pharmacy I semester will commence from 28 September 2020 as per the schedule. Faculty of respective subjects are instructed to submit soft copy of the question paper at least one day before examination. Students shall consult teachers in their respective subject for the syllabus of the examination. Lab internal exam will be conducted immediately after theory mid examinations.

TIMETABLE

S.No	DATE	SUBJECT
1.	28-09-2020	Medicinal Chemistry II
2.	29-09-2020	Industrial Pharmacy I
3.	30-09-2020	Pharmacology II
4.	01-09-2020	Pharmacognosy and Phytochemistry II
5.	02-09-2020	Pharmaceutical Jurisprudence
DESCRIPTIVE EXAM		
EXAM TIMINGS : 10 A.M – 12 P.M		

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Date: 09-11-2020

CIRCULAR

III B PHARM, I SEMESTER, II MID, NOVEMBER 2020

Second Midterm Examination for III B Pharmacy I semester will commence from 16 November 2020 as per the schedule. Faculty of respective subjects are instructed to submit soft copy of the question paper at least one day before examination. Students shall consult teachers in their respective subject for the syllabus of the examination. Lab internal exam will be conducted immediately after theory mid examinations.

TIMETABLE

S.No	DATE	SUBJECT
1.	16-11-2020	Medicinal Chemistry II
2.	17-11-2020	Industrial Pharmacy I
3.	18-11-2020	Pharmacology II
4.	19-11-2020	Pharmacognosy and Phytochemistry II
5.	20-11-2020	Pharmaceutical Jurisprudence
DESCRIPTIVE EXAM		
EXAM TIMINGS:10 A.M – 12 P.M		

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Date: 18-01-2021

CIRCULAR

III B PHARM, II SEMESTER, I MID, JANUARY 2021

First Midterm Examination for III B Pharmacy II semester will commence from 25 January 2021 as per the schedule. Faculty of respective subjects are instructed to submit soft copy of the question paper at least one day before examination. Students shall consult teachers in their respective subject for the syllabus of the examination. Lab internal exam will be conducted immediately after theory mid examinations.

TIMETABLE

S. No.	DATE	SUBJECT
1.	25-01-2021	Medicinal Chemistry III
2.	26-01-2021	Pharmacology III
3.	27-01-2021	Herbal Drug Technology
4.	28-01-2021	Biopharmaceutics and Pharmacokinetics
5.	29-01-2021	Pharmaceutical Biotechnology
6.	30-01-2021	Quality Assurance
DESCRIPTIVE EXAM		
EXAM TIMINGS : 10 A.M – 12 P.M		

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Date: 19-09-2022

CIRCULAR

III B PHARM, II SEMESTER, II MID, MARCH 2021

Second Midterm Examination for III B Pharmacy II semester will commence from 15 March 2021 as per the schedule. Faculty of respective subjects are instructed to submit soft copy of the question paper at least one day before examination. Students shall consult teachers in their respective subject for the syllabus of the examination. Lab internal exam will be conducted immediately after theory mid examinations.

TIMETABLE

S. No.	DATE	SUBJECT
1.	15-03-2021	Medicinal Chemistry III
2.	16-03-2021	Pharmacology III
3.	17-03-2020	Herbal Drug Technology
4.	18-03-2020	Biopharmaceutics and Pharmacokinetics
5.	19-03-2020	Pharmaceutical Biotechnology
6.	20-03-2020	Quality Assurance
DESCRIPTIVE EXAM		
EXAM TIMINGS : 10 A.M – 12 P.M		

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Date: 20-01-2021

CIRCULAR

IV B PHARM, I SEMESTER, I MID JANUARY 2021

First Midterm Examination for IV B Pharmacy I semester will commence from 27 January 2021 as per the schedule. Faculty of respective subjects are instructed to submit soft copy of the question paper at least one day before examination. Students shall consult teachers in their respective subject for the syllabus of the examination. Lab internal exam will be conducted immediately after theory mid examinations.

TIMETABLE

S.No.	DATE	SUBJECT
1.	27-01-2021	Instrumental Methods of Analysis
2.	28-01-2021	Industrial Pharmacy II
3.	29-01-2021	Pharmacy Practice
4.	30-01-2021	Novel Drug Delivery Systems
DESCRIPTIVE EXAM		
EXAM TIMINGS: 10 A.M – 12 P.M		

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Date: 15-02-2022

CIRCULAR

IV B PHARM, I SEMESTER, II MID, JANUARY 2021

Second Midterm Examination for IV B Pharmacy I semester will commence from 22February 2021 as per the schedule. Faculty of respective subjects are instructed to submit soft copy of the question paper at least one day before examination. Students shall consult teachers in their respective subject for the syllabus of the examination. Lab internal exam will be conducted immediately after theory mid examinations.

TIMETABLE

S.No.	DATE	SUBJECT
1.	22-02-2021	Instrumental Methods of Analysis
2.	23-02-2021	Industrial Pharmacy II
3.	24-02-2021	Pharmacy Practice
4.	25-02-2021	Novel Drug Delivery Systems
DESCRIPTIVE EXAM		
EXAM TIMINGS :10 A.M – 12 P.M		

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Date: 03-05-2021

CIRCULAR

IV B PHARM, II SEMESTER, I MID, MAY 2021

First Midterm Examination for IV B Pharmacy II semester will commence from 10 May 2021 as per the schedule. Faculty of respective subjects are instructed to submit soft copy of the question paper at least one day before examination. Students shall consult teachers in their respective subject for the syllabus of the examination. Lab internal exam will be conducted immediately after theory mid examinations.

TIMETABLE

S.No.	DATE	SUBJECT
1.	10-05-2021	Biostatistics and Research Methodology
2.	11-05-2021	Social and Preventive Pharmacy
3.	12-05-2021	Elective - I
4.	13-05-2021	Elective - II
DESCRIPTIVE EXAM		
EXAM TIMINGS : 10 A.M – 12 P.M		

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Date: 29-06-2021

CIRCULAR

IV B PHARM, II SEMESTER, II MID, JULY 2021

Second Midterm Examination for IV B Pharmacy II semester will commence from 01 July 2021 as per the schedule. Faculty of respective subjects are instructed to submit soft copy of the question paper at least one day before examination. Students shall consult teachers in their respective subject for the syllabus of the examination. Lab internal exam will be conducted immediately after theory mid examinations.

TIMETABLE

S.No.	DATE	SUBJECT
1.	01-07-2021	Biostatistics and Research Methodology
2.	02-07-2021	Social and Preventive Pharmacy
3.	03-07-2021	Elective - I
4.	05-07-2021	Elective - II
DESCRIPTIVE EXAM		
EXAM TIMINGS : 10 A.M – 12 P.M		

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Date: 26-04-2021

CIRCULAR

I PHARM D I MID MAY 2021

First Midterm Examination for I PharmD will commence from 03 May 2021 as per the schedule. Faculty of respective subjects are instructed to submit soft copy of the question paper at least one day before examination. Students shall consult teachers in their respective subject for the syllabus of the examination. Lab internal exam will be conducted immediately after theory mid examinations.

TIMETABLE

S. No	DATE	SUBJECT
1.	03-05-2021	HUMAN ANATOMY AND PHYSIOLOGY
2.	04-05-2021	PHARMACEUTICS
3.	05-05-2021	MEDICINAL BIOCHEMISTRY
4.	06-05-2021	PH.ORGANIC CHEMISTRY
5.	07-05-2021	PH.INORGANIC CHEMISTRY
6.	08-05-2021	REMEDIAL MATHEMATICS /BIOLOGY
DESCRIPTIVE EXAM		
EXAM TIMINGS : 10 A. M - 12 P.M		

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Date: 30-06-2021

CIRCULAR

I PHARM D II MID JULY 2021

Second Midterm Examination for I PharmD will commence from 09 July 2021 as per the schedule. Faculty of respective subjects are instructed to submit soft copy of the question paper at least one day before examination. Students shall consult teachers in their respective subject for the syllabus of the examination. Lab internal exam will be conducted immediately after theory mid examinations.

TIMETABLE

S. No	DATE	SUBJECT
1.	19-07-2021	HUMAN ANATOMY AND PHYSIOLOGY
2.	20-07-2021	PHARMACEUTICS
3.	21-07-2021	MEDICINAL BIOCHEMISTRY
4.	22-07-2021	PH.ORGANIC CHEMISTRY
5.	23-07-2021	PH.INORGANIC CHEMISTRY
6.	24-07-2021	REMEDIAL MATHEMATICS /BIOLOGY
DESCRIPTIVE EXAM		
EXAM TIMINGS : 10 A.M – 12 P.M		

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Date: 27-09-2021

CIRCULAR

I PHARM D III MID OCTOBER 2021

Third Midterm Examination for I PharmD will commence from 04 October 2021 as per the schedule. Faculty of respective subjects are instructed to submit soft copy of the question paper at least one day before examination. Students shall consult teachers in their respective subject for the syllabus of the examination. Lab internal exam will be conducted immediately after theory mid examinations.

TIMETABLE

S. No	DATE	SUBJECT
1.	04-10-2021	HUMAN ANATOMY AND PHYSIOLOGY
2.	05-10-2021	PHARMACEUTICS
3.	06-10-2021	MEDICINAL BIOCHEMISTRY
4.	07-10-2021	PH.ORGANIC CHEMISTRY
5.	08-10-2021	PH.INORGANIC CHEMISTRY
6.	09-10-2021	REMEDIAL MATHEMATICS /BIOLOGY
DESCRIPTIVE EXAM		
EXAM TIMINGS : 10 A.M - 12 P.M		

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Date: 19-10-2021

CIRCULAR

II PHARM D I MID OCTOBER 2021

First Midterm Examination for II PharmD will commence from 26 October 2021 as per the schedule. Faculty of respective subjects are instructed to submit soft copy of the question paper at least one day before examination. Students shall consult teachers in their respective subject for the syllabus of the examination. Lab internal exam will be conducted immediately after theory mid examinations.

TIMETABLE

S. No	DATE	SUBJECT
1.	26-10-2021	PATHOPHYSIOLOGY
2.	27-10-2021	PHARMACEUTICAL MICROBIOLOGY
3.	28-10-2021	PHARMACOGNOSY AND PHYTOPHARMACEUTICALS
4.	29-10-2021	PHARMACOLOGY-I
5.	30-10-2021	COMMUNITY PHARMACY
6.	31-10-2021	PHARMACOTHERAPEUTICS-I
DESCRIPTIVE EXAM		
EXAM TIMINGS : 10 A.M – 12 P.M		

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Date: 11-01-2021

CIRCULAR

II PHARM D II MID JANUARY 2021

Second Midterm Examination for II PharmD will commence from 18 January 2021 as per the schedule. Faculty of respective subjects are instructed to submit soft copy of the question paper at least one day before examination. Students shall consult teachers in their respective subject for the syllabus of the examination. Lab internal exam will be conducted immediately after theory mid examinations.

TIMETABLE

S. No	DATE	SUBJECT
1.	18-01-2021	PATHOPHYSIOLOGY
2.	19-01-2021	PHARMACEUTICAL MICROBIOLOGY
3.	20-01-2021	PHARMACOGNOSY AND PHYTOPHARMACEUTICALS
4.	21-01-2021	PHARMACOLOGY-I
5.	22-01-2021	COMMUNITY PHARMACY
6.	23-01-2021	PHARMACOTHERAPEUTICS-I
DESCRIPTIVE EXAM		
EXAM TIMINGS : 10 A.M – 12 P.M		

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Date: 29-03-2021

CIRCULAR

II PHARM D III MID APRIL 2021

Third Midterm Examination for II PharmD will commence from 05 April 2021 as per the schedule. Faculty of respective subjects are instructed to submit soft copy of the question paper at least one day before examination. Students shall consult teachers in their respective subject for the syllabus of the examination. Lab internal exam will be conducted immediately after theory mid examinations.

TIMETABLE

S. No	DATE	SUBJECT
1.	05-04-2021	PATHOPHYSIOLOGY
2.	06-04-2021	PHARMACEUTICAL MICROBIOLOGY
3.	07-04-2021	PHARMACOGNOSY AND PHYTOPHARMACEUTICALS
4.	08-04-2021	PHARMACOLOGY-I
5.	09-04-2021	COMMUNITY PHARMACY
6.	10-04-2021	PHARMACOTHERAPEUTICS-I
DESCRIPTIVE EXAM		
EXAM TIMINGS : 10 A.M – 12 P.M		

Principal

PRINCIPAL
Avanthi Institute of Pharmaceutical Sciences
Cherukupally (V), Bhogapuram Mandal
Vizianagaram Dt., - 531162

ESTD : 2005

AVANTHI INSTITUTE OF PHARMACEUTICALSCIENCES

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www.avanthipharma.ac.in, principal@avanthipharma.ac.in

Date: 19-10-2020

CIRCULAR

III PHARM D I MID OCTOBER 2020

First Midterm Examination for III PharmD will commence from 26 October 2020 as per the schedule. Faculty of respective subjects are instructed to submit soft copy of the question paper at least one day before examination. Students shall consult teachers in their respective subject for the syllabus of the examination. Lab internal exam will be conducted immediately after theory mid examinations.

TIMETABLE

S. No	DATE	SUBJECT
1.	26-10-2020	PHARMACOLOGY-II
2.	27-10-2020	PHARMACEUTICAL ANALYSIS
3.	28-10-2020	PHARMACOTHERAPEUTICS-II
4.	29-10-2020	PHARMACEUTICAL JURISPRUDENCE
5.	30-10-2020	MEDICINAL CHEMISTRY
6.	31-10-2020	PHARMACEUTICAL FORMULATIONS
DESCRIPTIVE EXAM		
EXAM TIMINGS : 10 A.M - 12 P.M		

Principal

PRINCIPAL
Avanthi Institute of Pharmaceutical Sciences
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Vizianagaram Dt., - 531162

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Date: 11-01-2021

CIRCULAR

III PHARM D II MID JANUARY 2021

Second Midterm Examination for III PharmD will commence from 18 January 2021 as per the schedule. Faculty of respective subjects are instructed to submit soft copy of the question paper at least one day before examination. Students shall consult teachers in their respective subject for the syllabus of the examination. Lab internal exam will be conducted immediately after theory mid examinations.

TIMETABLE

S. No	DATE	SUBJECT
1.	18-01-2021	PHARMACOLOGY-II
2.	19-01-2021	PHARMACEUTICAL ANALYSIS
3.	20-01-2021	PHARMACOTHERAPEUTICS-II
4.	21-01-2021	PHARMACEUTICAL JURISPRUDENCE
5.	22-01-2021	MEDICINAL CHEMISTRY
6.	23-01-2021	PHARMACEUTICAL FORMULATIONS
DESCRIPTIVE EXAM		
EXAM TIMINGS : 10 A.M - 12 P.M		

Principal

PRINCIPAL
Avanthi Institute of Pharmaceutical Sciences
Cherukupally (V), Bhogapuram Mandal
Vizianagaram Dt., - 531162

Dated: 29-03-2021

ESTD : 2005

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www.avanthipharma.ac.in, principal@avanthipharma.ac.in

Date : 29-03-2021

CIRCULAR

III PHARM D III MID APRIL 2021

Third Midterm Examination for III PharmD will commence from 05 April 2021 as per the schedule. Faculty of respective subjects are instructed to submit soft copy of the question paper at least one day before examination. Students shall consult teachers in their respective subject for the syllabus of the examination. Lab internal exam will be conducted immediately after theory mid examinations.

TIMETABLE

S. No	DATE	SUBJECT
1.	05-04-2021	PHARMACOLOGY-II
2.	06-04-2021	PHARMACEUTICAL ANALYSIS
3.	07-04-2021	PHARMACOTHERAPEUTICS-II
4.	08-04-2021	PHARMACEUTICAL JURISPRUDENCE
5.	09-04-2021	MEDICINAL CHEMISTRY
6.	10-04-2021	PHARMACEUTICAL FORMULATIONS
DESCRIPTIVE EXAM		
EXAM TIMINGS : 10 A.M – 12 P.M		

Principal

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www.avanthipharma.ac.in, principal@avanthipharma.ac.in

Date: 19-10-2021

CIRCULAR

IV PHARM D I MID OCTOBER 2021

First Midterm Examination for IV PharmD will commence from 26 October 2021 as per the schedule. Faculty of respective subjects are instructed to submit soft copy of the question paper at least one day before examination. Students shall consult teachers in their respective subject for the syllabus of the examination. Lab internal exam will be conducted immediately after theory mid examinations.

TIMETABLE

S. No	DATE	SUBJECT
1.	26-10-2020	PHARMACOTHERAPEUTICS -III
2.	27-10-2020	HOSPITAL PHARMACY
3.	28-10-2020	CLINICAL PHARMACY
4.	29-10-2020	BIOSTATISTICS AND RESEARCH METHODOLOGY
5.	30-10-2020	BIOPHARMACEUTICS AND PHARMCOKINETICS
6.	31-10-2020	CLINICAL TOXICOLOGY
DESCRIPTIVE EXAM		
EXAM TIMINGS : 10 A.M – 12 P.M		

Principal

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www.avanthipharma.ac.in, principal@avanthipharma.ac.in

Date: 11-01-2021

CIRCULAR

IV PHARM D II MID JANUARY 2021

Second Midterm Examination for IV PharmD will commence from 18 January 2021 as per the schedule. Faculty of respective subjects are instructed to submit soft copy of the question paper at least one day before examination. Students shall consult teachers in their respective subject for the syllabus of the examination. Lab internal exam will be conducted immediately after theory mid examinations.

TIMETABLE

S. No	DATE	SUBJECT
1.	18-01-2021	PHARMACOTHERAPEUTICS -III
2.	19-01-2021	HOSPITAL PHARMACY
3.	20-01-2021	CLINICAL PHARMACY
4.	21-01-2021	BIOSTATISTICS AND RESEARCH METHODOLOGY
5.	22-01-2021	BIOPHARMACEUTICS AND PHARMCOKINETICS
6.	23-01-2021	CLINICAL TOXICOLOGY
DESCRIPTIVE EXAM		
EXAM TIMINGS : 10 A.M – 12 P.M		

Principal
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Date: 29-03-2021

CIRCULAR

IV PHARM D III MID APRIL 2021

Third Midterm Examination for IV PharmD will commence from 05 April 2021 as per the schedule. Faculty of respective subjects are instructed to submit soft copy of the question paper at least one day before examination. Students shall consult teachers in their respective subject for the syllabus of the examination. Lab internal exam will be conducted immediately after theory mid examinations.

TIMETABLE

S. No	DATE	SUBJECT
1.	05-04-2021	PHARMACOTHERAPEUTICS -III
2.	06-04-2021	HOSPITAL PHARMACY
3.	07-04-2021	CLINICAL PHARMACY
4.	08-04-2021	BIOSTATISTICS AND RESEARCH METHODOLOGY
5.	09-04-2021	BIOPHARMACEUTICS AND PHARMCOKINETICS
6.	10-04-2021	CLINICAL TOXICOLOGY
DESCRIPTIVE EXAM		
EXAM TIMINGS : 10 A.M – 12 P.M		

Principal

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Vizianagaram Dt. - 531162

ESTD : 2005

AVANTHI INSTITUTE OF PHARMACEUTICALSCIENCES

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www.avanthipharma.ac.in, principal@avanthipharma.ac.in

Date: 19-10-2021

CIRCULAR

V PHARM D I MID OCTOBER 2021 .

First Midterm Examination for V PharmD will commence from 26 October 2021 as per the schedule. Faculty of respective subjects are instructed to submit soft copy of the question paper at least one day before examination. Students shall consult teachers in their respective subject for the syllabus of the examination. Lab internal exam will be conducted immediately after theory mid examinations.

TIMETABLE

S. No	DATE	SUBJECT
1.	26-10-2020	CLINICAL RESEARCH
2.	27-10-2020	PHARMACOEPIDIMIOLOGY AND PHARMACOECONOMICS
3.	28-10-2020	CLINICAL PHARMACOKINETICS AND PHARMCOTHERAPEUTIC DRUG MONITORING
DESCRIPTIVE EXAM		
EXAM TIMINGS : 10 A.M – 12 P.M		

Principal

PRINCIPAL
Avanthi Institute of Pharmaceutical Sciences
Cherukupally (V), Bhogapuram Mandal
Vizianagaram Dt., - 531162

ESTD : 2005

AVANTHI INSTITUTE OF PHARMACEUTICALSCIENCES

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www.avanthipharma.ac.in, principal@avanthipharma.ac.in

Date: 11-01-2021

CIRCULAR

V PHARM D II MID JANUARY 2021

Second Midterm Examination for V PharmD will commence from 18 January 2021 as per the schedule. Faculty of respective subjects are instructed to submit soft copy of the question paper at least one day before examination. Students shall consult teachers in their respective subject for the syllabus of the examination. Lab internal exam will be conducted immediately after theory mid examinations.

TIMETABLE

S. No	DATE	SUBJECT
1.	18-01-2021	CLINICAL RESEARCH
2.	19-01-2021	PHARMACOEPIDIMIOLOGY AND PHARMACOECONOMICS
3.	20-01-2021	CLINICAL PHARMACOKINETICS AND PHARMCOTHERAPEUTIC DRUG MONITORING
DESCRIPTIVE EXAM		
EXAM TIMINGS : 10 A.M – 12 P.M		

Principal

PRINCIPAL
Avanthi Institute of Pharmaceutical Sciences
Cherukupally (V), Bhogapuram Mandal
Vizianagaram Dt., - 531162

JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY: KAKINADA
UNIVERSITY EXAMINATION CENTER, KAKINADA

I B. PHARMACY - I SEMESTER (PCI, R16, R13 REGULATION) REGULAR/SUPPLEMENTARY EXAMINATIONS, JULY/AUGUST - 2021

REVISED TIME TABLE

TIME : 10.00 AM TO 01.00 PM

DATES	*PCI REGULATION*	*R16 REGULATION*	*R13 REGULATION*
27.07.2021 (Tuesday)	Human Anatomy and Physiology-I **(BP101T)**	English	English
29.07.2021 (Thursday)	Pharmaceutical Analysis-I **(BP102T)**	Remedial Mathematics, Remedial Biology	Remedial Mathematics – I, Remedial Biology – I
31.07.2021 (Saturday)	Pharmaceutics-I **(BP103T)**	Human Anatomy & Physiology – I	Human Anatomy & Physiology – I
05.08.2021 (Thursday)	Pharmaceutical Inorgaic Chemistry **(BP104T)**	General & Dispensing Pharmacy	Dispensing Pharmacy & Ethics
07.08.2021 (Saturday)	---	Pharmaceutical Organic Chemistry-I	Pharmaceutical Organic Chemistry - I

NOTE: (i) ANY OMISSIONS OR CLASHES IN THIS TIME TABLE MAY PLEASE BE INFORMED TO THE CONTROLLER OF EXAMINATIONS IMMEDIATELY.
(ii) EVEN IF GOVERNMENT DECLARES HOLIDAY ON ANY OF THE ABOVE DATES, THE EXAMINATIONS SHALL BE CONDUCTED AS USUAL.
(iii) THE PRINCIPALS ARE REQUESTED TO INFORM THE UNIVERSITY ANY OTHER SUBSTITUTE SUBJECTS THAT ARE NOT INCLUED IN THE ABOVE LIST IMMEDIATELY.

DATE: 22 -07-2021

Controller of Examinations

PRINCIPAL
Avanthi Institute of Pharmaceutical Sciences
Cherukupally (V), Bhogapuram Mandal
Vizianagaram Dt., - 521...

JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY KAKINADA

UNIVERSITY EXAMINATION CENTER KAKINADA

I B.PHARMACY II SEMESTER (PCI, R16, R13) REGULAR /SUPPLEMENTARY EXAMINATIONS, OCTOBER - 2021

T I M E T A B L E

TIME : 10.00 AM TO 01.00 PM

DATE & DAY	(PCI REGULATION) REGULAR/SUPPLEMENTARY	R16 REGULATION SUPPLEMENTARY	R13 REGULATION SUPPLEMENTARY
04-10-2021 (Monday)	Human Anatomy and Physiology-II (BP201T)	Human Anatomy & Physiology-II (PHR16121)	Human Anatomy & Physiology – II (B13204)
06-10-2021 (Wednesday)	Pharmaceutical Organic Chemistry-I (BP202T)	Pharm. Inorganic Chemistry (PHR16122)	Pharm. Inorganic Chemistry (B13201)
08-10-2021 (Friday)	Biochemistry (BP203T)	Pharm. Organic Chemistry-II (PHR16123)	Pharm. Organic Chemistry – II (B13205)
11-10-2021 (Monday)	Pathophysiology (BP204T)	Physical Pharmacy-I (PHR16124)	Physical Pharmacy – I (B13202)
18-10-2021 (Monday)	----	Computer Applications & Biostatistics (PHR16125)	Computer Applications & Biostatistics (B13203)

NOTE:

i. ANY OMISSIONS OR CLASHES IN THIS TIME TABLE MAY PLEASE BE INFORMED TO THE CONTROLLER OF EXAMINATIONS IMMEDIATELY.

ii. EVEN IF GOVERNMENT DECLARES HOLIDAY ON ANY OF THE ABOVE DATES, THE EXAMINATIONS SHALL BE CONDUCTED AS USUAL.

iii. THE PRINCIPALS ARE REQUESTED TO INFORM THE UNIVERSITY ANY OTHER SUBSTITUTE SUBJECTS THAT ARE NOT INCLUED IN THE ABOVE TIME TABLE IMMEDIATELY.

DATE: 20-09-2021

Controller of Examinations

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Avanthi Institute of Pharmaceutical Sciences
Cherukupally (V), Bhogapuram Mandal
Vizianagaram Dt., - 531162

JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY KAKINADA

UNIVERSITY EXAMINATION CENTER, KAKINADA

II B.PHARMACY I SEMESTER (PCI, R16 & R13) REGULAR/SUPPLEMENTARY EXAMINATIONS, MARCH - 2021

T I M E T A B L E

T I M E: 02.00 PM TO 05.00 PM

DATE & DAY	PCI REGULATION REGULAR/ SUPPLEMENTARY	R16 REGULATION SUPPLEMENTARY	R13 REGULATION SUPPLEMENTARY
08-03-2021 (Monday)	PHARMACEUTICAL ORGANIC CHEMISTRY – II (BP301T)	PHARMACEUTICAL UNIT OPERATIONS-I (PHR16211)	PHARMACEUTICAL UNIT OPERATIONS – I (B132101)
12-03-2021 (Friday)	PHYSICAL PHARMACEUTICS – I (BP302T)	PHARMACEUTICAL BIOCHEMISTRY (PHR16212)	PHARMACOGNOSY – I (B132102)
15-03-2021 (Monday)	PHARMACEUTICAL MICROBIOLOGY (BP303T)	PHYSICAL PHARMACY-II (PHR16213)	PHYSICAL PHARMACY – II (B132103)
17-03-2021 (Wednesday)	PHARMACEUTICAL ENGINEERING (BP304T)	PHARMACEUTICAL MICROBIOLOGY (PHR16214)	PHARMACEUTICAL MICROBIOLOGY (B132104)
19-03-2021 (Friday)	---	HEALTH EDUCATION & PATHOPHYSIOLOGY (PHR16215)	ENVIRONMENTAL SCIENCE (B132105)

NOTE:

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ii. EVEN IF GOVERNMENT DECLARES HOLIDAY ON ANY OF THE ABOVE DATES, THE EXAMINATIONS SHALL BE CONDUCTED AS USUAL.
iii. THE PRINCIPALS ARE REQUESTED TO INFORM THE UNIVERSITY ANY OTHER SUBSTITUTE SUBJECTS THAT ARE NOT INCLUED IN THE ABOVE LIST IMMEDIATELY.

DATE: 19-02-2021

Controller of Examinations

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Avanthi Institute of Pharmaceutical Sciences
Cherukupally (V), Bhogapuram Mandal
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JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY KAKINADA
UNIVERSITY EXAMINATION CENTER, KAKINADA

II B.PHARMACY II SEMESTER (PCI, R16 & R13) REGULAR/SUPPLEMENTARY EXAMINATIONS, AUGUST/SEPTEMBER - 2021

T I M E T A B L E

T I M E : 10.00 AM TO 01.00 PM

DATE & DAY	PCI REGULATION REGULAR/SUPPLEMENTARY	R16 REGULATION SUPPLEMENTARY	R13 REGULATION SUPPLEMENTARY
31-08-2021 (Tuesday)	PHARMACEUTICAL ORGANIC CHEMISTRY-III (**BP401T**)	PHARMACEUTICAL UNIT OPERATIONS – II (**PHR16221**)	PHARMACEUTICAL UNIT OPERATIONS – II (**B132201**)
02-09-2021 (Thursday)	MEDICINAL CHEMISTRY-I (**BP402T**)	PHARMACEUTICAL ANALYSIS - I (**PHR161222**)	PHARMACEUTICAL ANALYSIS – I (**B132202**)
04-09-2021 (Saturday)	PHYSICAL PHARMACEUTICS-II (**BP403T**)	PHARMACOGNOSY – I (**PHR161223**)	PHARMACOGNOSY – II (**B132203**)
07-09-2021 (Tuesday)	PHARMACOLOGY-I (**BP404T**)	MEDICINAL CHEMISTRY – I (**PHR161224**)	MEDICINAL CHEMISTRY – I (**B132204**)
09-09-2021 (Thursday)	PHARMACOGNOSY AND PHYTOCHEMISTRY-I (**BP405T**)	PHARMACOLOGY-I (**PHR162225**)	HEALTH EDUCATION & PATHOPHYSIOLOGY (**B132205**)

NOTE:

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ii. EVEN IF GOVERNMENT DECLARES HOLIDAY ON ANY OF THE ABOVE DATES, THE EXAMINATIONS SHALL BE CONDUCTED AS USUAL.

iii. THE PRINCIPALS ARE REQUESTED TO INFORM THE UNIVERSITY ANY OTHER SUBSTITUTE SUBJECTS THAT ARE NOT INCLUED IN THE ABOVE TIME TABLE IMMEDIATELY.

DATE: 05-08-2021

Controller of Examinations

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PRINCIPAL
Avanthi Institute of Pharmaceutical Sciences
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Vizianagaram Dt., - 531162

JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY KAKINADA

UNIVERSITY EXAMINATION CENTER, KAKINADA

III B.PHARMACY I SEMESTER (PCI, R16 & R13) REGULAR/SUPPLEMENTARY EXAMINATIONS, MARCH - 2021

T I M E T A B L E

T I M E : 10.00 AM TO 01.00 PM

DATE & DAY	PCI REGULATION REGULAR/ SUPPLEMENTARY	R16 REGULATION SUPPLEMENTARY	R13 REGULATION SUPPLEMENTARY
09-03-2021 (Tuesday)	Medicinal Chemistry – II (BP501T)	Pharmacognosy-II (PHR16311)	Pharmaceutical Biochemistry (B133101)
13-03-2021 (Saturday)	Industrial Pharmacy – I (BP502T)	Medicinal Chemistry-II (PHR16312)	Medicinal Chemistry. – II (B133102)
16-03-2021 (Tuesday)	Pharmacology – II (BP503T)	Pharm. Technology-I (PHR16313)	Pharmaceutical Technology – I (B133103)
18-03-2021 (Thursday)	Pharmacognosy and Phytochemistry – II (BP504T)	Environmental Sciences (PHR16314)	Pharmacology – I (B133104)
20-03-2021 (Saturday)	Pharmaceutical Jurisprudence (BP505T)	Pharm. Management (PHR16315)	Pharmaceutical Management (B133105)

NOTE:

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DATE: 19-02-2021

Controller of Examinations

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UNIVERSITY EXAMINATION CENTER, KAKINADA

III B.PHARMACY II SEMESTER (PCI,R16 & R13) REGULAR/SUPPLEMENTARY EXAMINATIONS, AUGUST - 2021

TIME TABLE

TIME : 10.00 AM TO 01.00 PM

DATE & DAY	PCI REGULATIONS (R17)	R16 REGULATION SUPPLEMENTARY	R13 REGULATION SUPPLEMENTARY
08-08-2021 (Sunday)	Medicinal Chemistry III **(BP601T)**	PHARMACEUTICAL TECHNOLOGY-II **(PHR16321)**	PHARMACEUTICAL TECHNOLOGY-II **(B133201)**
10-08-2021 (Tuesday)	Pharmacology III **(BP602T)**	PHARM. BIOTECHNOLOGY **(PHR16322)**	PHARM. BIOTECHNOLOGY **(B133202)**
12-08-2021 (Thursday)	Herbal Drug Technology **(BP603T)**	PHARMACOLOGY-II **(PHR16323)**	PHARMACOLOGY-II **(B133203)**
14-08-2021 (Saturday)	Biopharmaceutics and Pharmacokinetics **(BP604T)**	MEDICINAL CHEMISTRY-III **(PHR16324)**	MEDICINAL CHEMISTRY-III **(B133204)**
16-08-2021 (Monday)	Pharmaceutical Biotechnology **(BP605T)**	REGULATORY AFFAIRS, IPR & PATTENTS **(PHR16325)**	REGULATORY AFFAIRS, IPR & PATTENTS **(B133205)**
18-08-2021 (Wednesday)	Quality Assurance **(BP606T)**	--	--

NOTE :

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(ii) EVEN IF GOVERNMENT DECLARES HOLIDAY ON ANY OF THE ABOVE DATES, THE EXAMINATIONS SHALL BE CONDUCTED AS USUAL.

(iii) THE PRINCIPALS ARE REQUESTED TO INFORM THE UNIVERSITY, IF ANY OTHER SUBSTITUTE SUBJECTS THAT ARE NOT INCLUDED IN THE ABOVE LIST IMMEDIATELY.

DATE: 23-07-2021

Controller of Examinations

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JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY KAKINADA
UNIVERSITY EXAMINATION CENTER, KAKINADA

IV B.PHARMACY I SEMESTER (PCI, R16 & R13) REGULAR/SUPPLEMENTARY EXAMINATIONS, MARCH - 2021

T I M E T A B L E

T I M E: 10.00 AM TO 01.00 PM

DATE & DAY	PCI REGULATIONS REGULAR	R16 REGULATIONS SUPPLEMENTARY	R13 REGULATIONS SUPPLEMENTARY
08-03-2021 (Monday)	Instrumental Methods of Analysis (BP701T)	Pharmaceutical Analysis –II (PHR16411)	Pharmaceutical Analysis – II (B134101)
12-03-2021 (Friday)	Industrial Pharmacy II (BP702T)	Biopharmaceutics & Pharmacokinetics (PHR16412)	Bio Assays & Toxicology (B134102)
15-03-2021 (Monday	Pharmacy Practice (BP703T)	Chemistry of Natural Products (PHR16413)	Chemistry of Natural Products (B134103)
17-03-2021 (Wednesday)	Novel Drug Delivery System (BP704T)	Hospital & Community Pharmacy (PHR16414)	Hospital & Community Pharmacy (B134104)
19-03-2021 (Friday)	---	Pharmaceutical Jurisprudence (PHR16415)	Pharmaceutical Jurisprudence (B134105)

NOTE: (i) ANY OMISSIONS OR CLASHES IN THIS TIME TABLE MAY PLEASE BE INFORMED TO THE CONTROLLER OF EXAMINATIONS IMMEDIATELY.

(ii) EVEN IF GOVERNMENT DECLARES HOLIDAY ON ANY OF THE ABOVE DATES, THE EXAMINATIONS SHALL BE CONDUCTED AS USUAL.

(iii) THE PRINCIPALS ARE REQUESTED TO INFORM THE UNIVERSITY ANY OTHER SUBSTITUTE SUBJECTS THAT ARE NOT INCLUED IN THE ABOVE LIST IMMEDIATELY.

DATE: 19-02-2021

Controller of Examinations

PRINCIPAL
Avanthi Institute of Pharmaceutical Sciences
Cherukupally (V), Bhogapuram Mandal
Vizianagaram Dt., - 531162

JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY KAKINADA

UNIVERSITY EXAMINATION CENTER, KAKINADA

IV B.PHARMACY II SEMESTER (PCI) REGULAR EXAMINATIONS, JULY - 2021

T I M E T A B L E

T I M E: 10.00 AM TO 01.00 PM

COURSE	DATE & DAY			
	19.07.2021 (Monday)	**22.07.2021 (Thursday)**	**24.07.2021 (Saturday)**	**26.07.2021 (Monday)**
SUBJECTS	Biostatistics and Research Methodology **(BP801T)**	Social and Preventive Pharmacy **(BP802T)**	Pharma Marketing Management **(BP803ET1)**, Pharmaceutical Regulatory Science **(BP804ET1)**, Pharmacovigilance **(BP805ET1)**, Quality Control and Standardization of Herbals **(BP806ET1)**, Computer Aided Drug Design **(BP807ET1)**, Cell and Molecular Biology **(BP808ET1)**, Cosmetic Science **(BP809ET1)**, Experimental Pharmacology **(BP810ET1)**	Pharmaceutical Regulatory Science **(BP804ET2)**, Pharmacovigilance **(BP805ET2)**, Quality Control and Standardization of Herbals **(BP806ET2)**, Computer Aided Drug Design **(BP807ET2)**, Cell and Molecular Biology **(BP808ET2)**, Cosmetic Science **(BP809ET2)**, Experimental Pharmacology **(BP810ET2)**, Advanced Instrumentation Techniques **(BP811ET2)**, Dietary Supplements and Nutraceuticals **(BP812ET2)**

NOTE: (i) ANY OMISSIONS OR CLASHES IN THIS TIME TABLE MAY PLEASE BE INFORMED TO THE CONTROLLER OF EXAMINATIONS IMMEDIATELY.

(ii) EVEN IF GOVERNMENT DECLARES HOLIDAY ON ANY OF THE ABOVE DATES, THE EXAMINATIONS SHALL BE CONDUCTED AS USUAL.

(iii) THE PRINCIPALS ARE REQUESTED TO INFORM THE UNIVERSITY ANY OTHER SUBSTITUTE SUBJECTS THAT ARE NOT INCLUED IN THE ABOVE LIST IMMEDIATELY.

DATE: 01-07-2021

Controller of Examinations

PRINCIPAL
Avanthi Institute of Pharmaceutical Sciences
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JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY KAKINADA

UNIVERSITY EXAMINATION CENTER, KAKINADA

M. PHARMACY I SEMESTER (PCI REGULATION) IST REGULAR/SUPPLEMENTARY EXAMINATIONS, JULY/AUGUST - 2021

(2018, 2019 & 2020 Admitted Batches only)

TIME TABLE

TIME: 02:00 PM TO 05:00 PM

BRANCH & SPECIALIZATION	27.07.2021 (Tuesday)	29.07.2021 (Thursday)	31.07.2021 (Saturday)	03.08.2021 (Tuesday)
PHARMACEUTICS (03)	Modern Pharmaceutical Analytical Techniques (**MPH101T**)	Drug Delivery Systems (**MPH102T**)	Modern Pharmaceutics (**MPH103T**)	Regulatory Affairs (**MPH104T**)
PHARMACOLOGY (06)	Modern Pharmaceutical Analytical Techniques (**MPL101T**)	Advanced Pharmacology-I (**MPL102T**)	Pharmacological and Toxicological Screening Methods-I (**MPL103T**)	Cellular and Molecular Pharmacology (**MPL104T**)
PHARMACEUTICAL ANALYSIS (16)	Modern Pharmaceutical Analytical Techniques (**MPA101T**)	Advanced Pharmaceutical Analysis (**MPA102T**)	Pharmaceutical Validation (**MPA103T**)	Food Analysis (**MPA104T**)

NOTE: (i) If Government declares holiday on any of the above dates, the examinations will be conducted as usual

(ii) Any omissions or clashes in this Time Table may please be informed to the Controller of Examinations immediately.

(iii) The Principals are requested to inform the University, if any other substitute subjects that are not included in the above time table immediately

Date: 13-07-2021

Controller of Examinations

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Vizianag... 1162

JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY KAKINADA

UNIVERSITY EXAMINATIONS CENTER, KAKINADA

M. PHARMACY I SEMESTER (R16) SUPPLEMENTARY EXAMINATIONS, JULY/AUGUST - 2021

(2017 ADMITTED BATCH ONLY)

T I M E T A B L E

TIME: 02:00 PM TO 05:00 PM

DATE & DAY	27.07.2021 (Tuesday)	29.07.2021 (Thursday)	31.07.2021 (Saturday)	03.08.2021 (Tuesday)
PHARMACEUTICS (03)	Modern Analytical Techniques (**IP31A**)	Research Methodologies (**IP31B**)	Bio-Pharmaceutics & Pharmacokinetics (**PCE31A**)	Advanced Physical Pharmaceutics (**PCE31B**)
PHARMACEUTICAL ANALYSIS & QUALITY ASSURANCE / PHARMACEUTICAL ANALYSIS (04/16)	Modern Analytical Techniques (**IP31A**)	Research Methodologies (**IP31B**)	Advanced Pharmaceutical Analysis – I (**PAQA31A**)	Chromatographic & Other Special Techniques (**PAQA31B**)
PHARMACEUTICAL CHEMISTRY(02)	Modern Analytical Techniques (**IP31A**)	Research Methodologies (**IP31B**)	Advanced Pharmaceutical Organic Chemistry (**PCEC31A**)	Advanced Chemistry of Natural Products (**PCEC31B**)
PHARMACOLOGY / PHARMACOLOGY TOXICOLOGY (06/14)	Modern Analytical Techniques (**IP31A**)	Research Methodologies (IP31B)	Systemic Pharmacology (PMC31A)	Pharmacokinetics and Drug Metabolism (**PMC31B**)
PHARMACEUTICAL TECHNOLOGY(11)	Modern Analytical Techniques (**IP31A**)	Research Methodologies (**IP31B**)	Bio-Pharmaceutics & Pharmacokinetics (**PCE31A**)	Advanced Physical Pharmaceutics (**PCE31B**)
INDUSTRIAL PHARMACY (09)	Modern Analytical Techniques (**IP31A**)	Research Methodologies (**IP31B**)	Advanced Biopharmaceutics,Pharmacokinetics&Physical Pharmaceutics (**IP31C**)	Advanced Pharmaceutical Technology (**IP31D**)

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JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY KAKINADA

UNIVERSITY EXAMINATIONS CENTER, KAKINADA

M. PHARMACY II SEMESTER (R16) SUPPLEMENTARY EXAMINATIONS, OCTOBER – 2021

(2017 ADMITTED BATCH ONLY)

TIMETABLE

TIME: 10:00AM TO 01:00 PM

DATE & DAY	04-10-2021 (Monday)	06-10-2021 (Wednesday)	08-10-2021 (Friday)	11-10-2021 (Monday)
PHARMACEUTICS (03)	Advanced Pharmaceutical Technology (PCE32A)	Advanced in Drug Delivery Systems (IP32A)	Industrial Pharmacy (PCEU32A)	Drug Regulatory Affairs (IP32D)
PHARMACEUTICAL ANALYSIS & QUALITY ASSURANCE (04)	Advanced Pharmaceutical Analysis - II (PAQA32A)	Phytopharmaceutical and Biological Analysis (PAQA32B)	Quality Assurance of Pharmaceuticals - I (PAQA32C)	Drug Regulatory Affairs (IP32D)
PHARMACEUTICAL CHEMISTRY (02)	Advanced Medicinal Chemistry – I (PCEC32A)	Advanced Medicinal Chemistry – II (PCEC32B)	Bioassaya & Pharmacological Screening Methods (PMC32C)	Drug Regulatory Affairs (IP32D)
PHARMACOLOGY (06)	Advanced Pharmacology (PMC32A)	Pathophysiology and KPharmacotherapeutics (PMC32B)	Bioassaya & Pharmacological Screening Methods (PMC32C)	Drug Regulatory Affairs (IP32D)
PHARMACEUTICAL MANAGEMENT AND REGULATORY AFFAIRS (13)	Pharmaceutical Management Science – I (PMRA32B)	International Drug Regulatory Aspects (PMRA32A)	Pharmaceutical Management Science – II (PMRA32C)	Drug Regulatory Affairs (IP32D)
PHARMACOGNOSY (07)	Herbal Drug Technology & Formulation Development (PCG32A)	Indigenous Systems of Medicine (PCG32C)	Bioassays & Pharmacological Screening Methods (PMC32C)	Drug Regulatory Affairs (IP32D)
PHARMACOLOGY AND TOXICOLOGY (14)	Advanced Pharmacology (PMC32A)	Toxicology (PAT32A)	Bioassays & Pharmacological Screening Methods (PMC32C)	Drug Regulatory Affairs (IP32D)

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JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY KAKINADA

UNIVERSITY EXAMINATIONS CENTER, KAKINADA

M. PHARMACY II SEMESTER (PCI) REGULAR/SUPPLEMENTARY EXAMINATIONS, OCTOBER - 2021

(2020, 2019, 2018 ADMITTED BATCHES OF IST, JNTUK)

TIMETABLE

TIME: 10:00 AM TO 01:00 PM

DATE & DAY	04-10-2021 (Monday)	06-10-2021 (Wednesday)	08-10-2021 (Friday)	11-10-2021 (Monday)
PHARMACEUTICAL CHEMISTRY (02)	Advanced Spectral Analysis **(MPC201T)**	Advanced Organic Chemistry II **(MPC202T)**	Computer Aided Drug Design **(MPC203T)**	Pharmaceutical Process Chemistry **(MPC204T)**
PHARMACEUTICS (03)	Molecular Pharmaceutics (Nano Technology and Targeted DDS)(NTDS) **(MPH201T)**	Advanced Biopharmaceutics & Pharmacokinetics **(MPH202T)**	Computer Aided Drug Development **(MPH203T)**	Formulation Development of Pharmaceutical and Cosmetic Products **(MPH204T)**
PHARMACOLOGY (06)	Advanced Pharmacology – II **(MPL201T)**	Pharmacological and Toxicological Screening Methods- II **(MPL202T)**	Principles of Drug Discovery **(MPL203T)**	Clinical Research And Pharmacovigilance **(MPL204T)**
PHARMACY PRACTICE (08)	Principles of Quality Use of Medicines **(MPP201T)**	Pharmacotherapeutics – II **(MPP202T)**	Clinical Pharmacokinetics and Therapeutic Drug Monitoring **(MPP203T)**	Pharmacoepidemiology & Pharmacoeconomics **(MPP204T)**
INDUSTRIAL PHARMACY (09)	Scale up and Technology Transfer **(MIP202T)**	Advanced Biopharmaceutics and Pharmacokinetics **(MIP201T)**	Pharmaceutical Production Technology **(MIP203T)**	Entrepreneurship Management **(MIP204T)**
PHARMACEUTICAL REGULATORY AFFAIRS (13)	Regulatory Aspects of Drugs and Cosmetics **(MRA201T)**	Regulatory Aspects of Herbal & Biologicals **(MRA202T)**	Regulatory Aspects of Medical Devices **(MRA203T)**	Regulatory Aspects of Food Neutraceuticals **(MRA204T)**
PHARMACEUTICAL QUALITY ASSURANCE (15)	Hazards and Safety Management **(MQA201T)**	Pharmaceutical Validation **(MQA202T)**	Audits and Regulatory Compliance **(MQA203T)**	Pharmaceutical Manufacturing Technology **(MQA204T)**

AVANTHI INSTITUTE OF PHARMACEUTICAL SCIENCES * AVANTHI EDUCATIONAL SOCIETY * HYDERABAD * VIZIANAGARAM

PRINCIPAL
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DATE & DAY	04-10-2021 (Monday)	06-10-2021 (Wednesday)	08-10-2021 (Friday)	11-10-2021 (Monday)
PHARMACEUTICAL ANALYSIS & QUALITY CONTROL (12) **PHARMACEUTICAL ANALYSIS (16)**	Advanced Instrumental Analysis **(MPA201T)**	Modern Bio-Analytical Techniques **(MPA202T)**	Quality Control and Quality Assurance **(MPA203T)**	Herbal and Cosmetic Analysis **(MPA204T)**
PHARMACEUTICAL BIOTECHNOLOGY	Proteins and protein Formulation **(MPB201T)**	Immunotechnology **(MPB202T)**	Bioinformatics and Computer Technology **(MPB203T)**	Biological Evaluation of Drug Therapy **(MPB204T)**
PHARMACOGNOSY (07)	Medicinal Plant biotechnology **(MPG201T)**	Advanced Pharmacognosy-II **(MPG202T)**	Indian system of medicine **(MPG203T)**	Herbal cosmetics **(MPG204T)**

NOTE: (I) IF GOVERNMENT DECLARES HOLIDAY ON ANY OF THE ABOVE DATES, THE EXAMINATIONS WILL BE CONDUCTED AS USUAL.

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(III) THE PRINCIPALS ARE REQUESTED TO INFORM THE UNIVERSITY, IF ANY OTHER SUBSTITUTE SUBJECTS THAT ARE NOT INCLUDED IN THE ABOVE LIST IMMEDIATELY.

Date: 18-09-2021

Controller of Examinations

AVANTHI INSTITUTE OF PHARMACEUTICAL SCIENCES * AVANTHI EDUCATIONAL SOCIETY * HYDERABAD * VIZIANAGARAM

PRINCIPAL
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Vizianagaram Dt., - 531162

DATE & DAY	04-10-2021 (Monday)	06-10-2021 (Wednesday)	08-10-2021 (Friday)	11-10-2021 (Monday)
QUALITY ASSURANCE AND REGULATORY AFFAIRS (15)	Advanced Pharmaceutical Analysis (PAQA32A1)	International Drug Regulatory Aspects (PMRA32A)	Quality Assurance of Pharmaceuticals (QARA32A)	Drug Regulatory Affairs (IP32D)
INDUSTRIAL PHARMACY (09)	Industrial Pharmacy – II (IP32C)	Advances In Drug Delivery Systems (IP32A)	Industrial Pharmacy – I (IP32B)	Drug Regulatory Affairs (IP32D)
PHARMACEUTICAL TECHNOLOGY (11)	Advanced Pharmaceutical Technology – I (PCE32A)	Advanced in Drug Delivery Systems (IP32A)	Advanced Pharmaceutical Technology – II (PCE32B)	Drug Regulatory Affairs (IP32D)
PHARMACY PRACTICE (08)	Hospital & Community Pharmacy (PP32A)	Pharmacutherapeutics Includig Clinical Pharmacokinetics (PP32B)	Clinical Research, Pharmacoepidemiology & Pharmacoeconomics (PP32C)	Drug Regulatory Affairs (IP32D)
PHARMACEUTICAL ANALYSIS &QUALITY CONTROL, PHARMACEUTICAL ANALYSIS (12 / 16)	Advanced Pharmaceutical Analysis - II (PAQA32A)	Quality Control of Pharmaceuticals (PAQC32A)	Quality Assurance of Pharmaceuticals – I (PAQA32C)	Drug Regulatory Affairs (IP32D)

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Date: 18-09-2021

Controller of Examinations

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JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY: KAKINADA

UNIVERSITY EXAMINATION CENTER, KAKINADA

PHARM "D" II YEAR REGULAR/SUPPLEMENTARY EXAMINATIONS, AUGUST - 2021

(2019 TO 2012 ADMITTED BATCHES)

TIMETABLE

TIME : 02.00 PM TO 05.00 PM

03-08-2021 (Tuesday)	05-08-2021 (Thursday)	07-08-2021 (Saturday)	10-08-2021 (Tuesday)	12-08-2021 (Thursday)	14-08-2021 (Saturday)
PATHOPHYSIOLOGY (T2101)	PHARMACEUTICAL MICROBIOLOGY (T2102)	PHARMACOGNOSY AND PHYTOPHARMACEUTICALS (T2103)	COMMUNITY PHARMACY (T2105)	PHARMACOTHERAPEUTICS – I (T2106)	PHARMACOLOGY – I (T2104)

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(iii) FOR ANY OTHER CLARIFICATIONS IN RESPECT OF THE ABOVE EXAMINATIONS PLEASE CONTACT CONTROLLER OF EXAMINATIONS

Date: 20.07.2021

PRINCIPAL
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Controller of Examinations

JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY : KAKINADA
UNIVERSITY EXAMINATION CENTER, KAKINADA

PHARM "D" III YEAR REGULAR/SUPPLEMENTARY EXAMINATIONS, AUGUST – 2021
(2018 TO 2012 ADMITTED BATCHES)

TIME TABLE

TIME : 02.00 PM TO 05.00 PM

02-08-2021 (Monday)	04-08-2021 (Wednesday)	06-08-2021 (Friday)	09-08-2021 (Monday)	11-08-2021 (Wednesday)	13-08-2021 (Friday)
PHARMACOTHERAPEUTICS – II (T3103)	PHARMACEUTICAL JURISPRUDENCE (T3104)	PHARMACEUTICAL FORMULATIONS (T3106)	PHARMACOLOGY –II (T3101)	MEDICINAL CHEMISTRY (T3105)	PHARMACEUTICAL ANALYSIS (T3102)

NOTE: (i) ANY OMISSIONS OR CLASHES IN THIS TIME TABLE MAY PLEASE BE INFORMED TO THE CONTROLLER OF EXAMINATIONS IMEDIATELY.

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Date: 20.07.2021

Controller of Examinations

PRINCIPAL
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JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSIT : KAKINADA

UNIVERSITY EXAMINATION CENTER, KAKINADA

PHARM "D" IV YEAR REGULAR/SUPPLEMENTARY EXAMINATIONS, AUGUST - 2021

(2017 TO 2012 ADMITTED BATCHES)

TIME TABLE

TIME : 10.00 AM TO 1.00 PM

03-08-2021 (Tuesday)	05-08-2021 (Thursday)	07-08-2021 (Saturday)	10-08-2021 (Tuesday)	12-08-2021 (Thursday)	14-08-2021 (Saturday)	16-08-2021 (Monday)
CLINICAL TOXICOLOGY **(T4106)**	PHARMACOTHERAPEUTICS –III **(T4101)**	BIOPHARMACEUTICS & PHARMACOKINETICS **(T4105)**	HOSPITAL PHARMACY **(T4102)**	BIOSTATISTICS & RESEARCH METHODOLOGY **(T4104)**	CLINICAL PHARMACY **(T4103)**	PHARMACOTHERAPEUTICS – I & II **(T4111)**

NOTE: (i) ANY OMISSIONS OR CLASHES IN THIS TIME TABLE MAY PLEASE BE INFORMED TO THE CONTROLLER OF EXAMINATIONS IMEDIATELY.

(ii) EVEN OF GOVERNMENT DECLARES HOLIDAY ON ANY OF THE ABOVE DATES ,THE EXAMINATIONS SHALL BE CONDUCTED AS USUAL.

(iii) FOR ANY OTHER CLARIFICATIONS IN RESPECT OF THE ABOVE EXAMINATIONS PLEASE CONTACT CONTROLLER OF EXAMINATIONS

Date: 20.07.2021

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PHARM "D" V YEAR REGULAR/SUPPLEMENTARY EXAMINATIONS, AUGUST - 2021
(2016 TO 2012 ADMITTED BATCH)

TIME TABLE

TIME : 10.00 AM TO 1.00 PM

02-08-2021 (Monday)	04-08-2021 (Wednesday)	06-08-2021 (Friday)
CLINICAL PHARMACOKINETICS & PHARMACOTHERAPEUTIC DRUG MONITORING (**T5103**)	PHARMACOEPIDEMIOLOGY & PHARMACOECONOMICS (**T5102**)	CLINICAL RESEARCH (**T5101**)

NOTE: (i) ANY OMISSIONS OR CLASHES IN THIS TIME TABLE MAY PLEASE BE INFORMED TO THE CONTROLLER OF EXAMINATIONS IMEDIATELY.

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(iii) FOR ANY OTHER CLARIFICATIONS IN RESPECT OF THE ABOVE EXAMINATIONS PLEASE CONTACT CONTROLLER OF EXAMINATIONS

Controller of Examinations

Date: 20.07.2021

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