



## **CURRICULUM AND SYLLABI**

### **CHOICE BASED CREDIT SYSTEM**

#### **(CBCS-PG)**

### **M. Sc. PHARMACEUTICAL CHEMISTRY PROGRAMME**

INTRODUCED FROM 2016 ADMISSION ONWARDS

**BOARD OF STUDIES IN CHEMISTRY**

**Sacred Heart College (Autonomous), Thevara, Kochi, Kerala**

## **SACRED HEART COLLEGE (AUTONOMOUS) –THEVARA, KOCHI -13.**

### **1. SCOPE**

- 1.1. These regulations provided herein shall apply to all post-graduate programmes, conducted by Sacred Heart College (S.H.college), Thevara with effect from the academic year 2016-2017 admission onwards.

### **2. DEFINITIONS**

2.1 'Academic **Committee**' means the Committee constituted by the principal under this regulation to monitor the running of the Post-Graduate programmes under the Choice Based Credit System (CBCS-PG).

2.2 'Programme' means the entire course of study and examinations.

2.3 'Duration of **Programme**' means the period of time required for the conduct of the programme. The duration of post-graduate programme shall be of 4 semesters.

2.4 '**Semester**' means a term consisting of a minimum of 90 working days, inclusive of examination, distributed over a minimum of 18 weeks of 5 working days, each with 5 contact hours of one hour duration

2.5 '**Course**' means a segment of subject matter to be covered in a semester. Each Course is to be designed variously under lectures / tutorials / laboratory or fieldwork / study tour / seminar / project / practical training / assignments/evaluation etc., to meet effective teaching and learning needs.

2.6 '**Credit** (Cr) of a course is the numerical value assigned to a paper according to the relative importance of the content of the syllabus of the programme.

2.7 '**Programme Credit**' means the total credit of the PG Programmes, ie; **80 credits**.

2.8 **Programme Core course'** Programme Core course means a course that the student admitted to a particular programme must successfully complete to receive the Degree and which cannot be substituted by any other course.

2.9 '**Programme Elective course'** Programme Elective course means a course, which can be chosen from a list of electives and a minimum number of courses is required to complete the programme.

- 2.10 'Programme Project'** Programme Project means a regular project work with stated credits on which the student undergo a project under the supervision of a teacher in the parent department / any appropriate Institute in order to submit a dissertation on the project work as specified.
- 2.11 'Plagiarism'** Plagiarism is the unreferenced use of other authors' material in dissertations and is a serious academic offence.
- 2.12 'Tutorial'** Tutorial means a class to provide an opportunity to interact with students at their individual level to identify the strength and weakness of individual students.
- 2.13 'Seminar'** seminar means a lecture expected to train the student in self-study, collection of relevant matter from the books and Internet resources, editing, document writing, typing and presentation.
- 2.14 'Evaluation'** means every course shall be evaluated by 25% internal assessment and 75% external assessment.
- 2.15 'Repeat course'** is a course that is repeated by a student for having failed in that course in an earlier registration.
- 2.16 'Audit Course'** is a course for which no credits are awarded.
- 2.17 'Department'** means any teaching Department offering a course of study approved by the college / Institute as per the Act or Statute of the University.
- 2.18 'Parent Department'** means the Department which offers a particular Post graduate programme.
- 2.19 'Department Council'** means the body of all teachers of a Department in a College.
- 2.20 'Faculty Advisor'** is a teacher nominated by a Department Council to coordinate the continuous evaluation and other academic activities undertaken in the Department.
- 2.21 'College Co-ordinator'** means a teacher from the college nominated by the College Council to look into the matters relating to CBCS-PG System
- 2.22 'Letter Grade'** or simply '**Grade**' in a course is a letter symbol (S, A, B, C, D, etc.) which indicates the broad level of performance of a student in a course.
- 2.23** Each letter grade is assigned a '**Grade point**' (GP) which is an integer indicating the numerical equivalent of the broad level of performance of a student in a course.
- 2.24 'Credit point'** (CP) of a course is the value obtained by multiplying the grade point (GP) by the Credit (Cr) of the course  $CP = GP \times Cr$ .

**2.25 'Extra credits'** are additional credits awarded to a student over and above the minimum credits required for a programme for achievements in co-curricular activities carried out outside the regular class hours as directed by the College/ department.

**2.26 'Semester Grade point average'** (SGPA) is the value obtained by dividing the sum of credit points (CP) obtained by a student in the various courses taken in a semester by the total number of credits taken by him/her in that semester. The grade points shall be rounded off to two decimal places. SGPA determines the overall performance of a student at the end of a semester.

**2.27 Cumulative Grade point average'** (CGPA) is the value obtained by dividing the sum of credit points in all the courses taken by the student for the entire programme by the total number of credits and shall be rounded off to two decimal places.

**2.28 'Grace Marks'** means marks awarded to course/s, as per the orders issued by the college from time to time, in recognition of meritorious achievements in NCC/NSS/Sports/Arts and cultural activities.

**2.29 'Words and expressions'** used and not defined in this regulation but defined in the Mahatma Gandhi University Act and Statutes shall have the meaning assigned to them in the Act and Statute.

### **3. ACADEMIC COMMITTEE**

**3.1** There shall be an Academic Committee constituted by the principal to manage and monitor the working of (CBCS-PG) 2016.

**3.2** The Committee consists of

- (a) The principal
- (b) The vice principal
- (c) Deans of the faculties of science, arts and commerce
- (d) The Controller of Examinations
- (e) IQAC –Co-ordinator
- (f) The superintendent of the college

### **4. PROGRAMME STRUCTURE**

**4.1** Students shall be admitted into post graduate programmes under the various faculties.

**4.2** The programme shall include two types of courses, Program Core (C) courses and Program Elective (E) Courses. There shall be a Program Project (D) with dissertation to be undertaken by all students. The Programme will also include assignments, seminars, practical (P), viva (V), study tour etc., if they are specified in the Curriculum

4.3 There shall be various groups of four Programme Elective courses for a programme such as Group A, Group B etc. for the choice of students subject to the availability of faculty and infrastructure in the institution and the selected group shall be the subject of specialization of the programme.

#### **4.4 Project work**

**4.4.1** Project work shall be completed by working outside the regular teaching hours.

**4.4.2** Project work shall be carried out under the supervision of a teacher in the concerned department.

**4.4.3.** A candidate may, however, in certain cases be permitted to work on the project in an industrial / Research Organization/ Institute on the recommendation of the Supervisor.

**4.4.4** There should be an internal assessment and external assessment for the project work in the ratio 1:3

**4.4.5** The external evaluation of the Project work is followed by presentation of work including dissertation and Viva-Voce.

**4.4.6** The mark and credit with grade awarded for the program project should be entered in the grade card issued by the college.

**4.5. Assignments:** Every student shall submit one assignment as an internal component for every course.

**4.6 Seminar Lecture:** Every PG student may deliver one seminar lecture as an internal component for every course. The seminar lecture is expected to train the student in self-study, collection of relevant matter from the books and Internet resources, editing, document writing, typing and presentation.

**4.7** Every student shall undergo **two class tests** as an internal component for every course.

**4.8** The attendance of students for each course shall be another component of internal assessment.

**4.9** Comprehensive Viva-voce shall be conducted at the end of the programme which covers questions from all courses in the programme as per the syllabus.

#### **5. ATTENDANCE**

**5.1** The minimum requirement of aggregate attendance during a semester for appearing the end semester examination shall be 75%. Condonation of shortage of attendance to a

maximum of 10 days in a semester subject to a maximum of two times during the whole period of Post Graduate programme may be granted by the College as forwarded on the recommendation by the class teacher/HOD.

**5.2** If a student represents the college in University, State or Nation in Sports, NCC, NSS or Cultural or any other officially sponsored activities such as College union / University union activities, he/she shall be eligible to claim the attendance for the actual number of days participated subject to a maximum of 10 days in a Semester based on the specific recommendations of the Head of the concerned Department and Principal of the College.

**5.3** A student who does not satisfy the requirements of attendance shall not be permitted to take the end Semester examinations.

**5.4** Those students who are not eligible even with condonation of shortage of attendance shall repeat the course along with the next batch

## **6. BOARD OF STUDIES AND COURSES.**

**6.1** The Board of Studies concerned shall design all the courses offered in the PG programme. The Boards shall design and introduce new courses, modify or re-design existing courses and replace any existing courses with new/modified courses to facilitate better exposures and training for the students.

**6.2** The syllabus of a course shall include the title of the course, contact hours, the number of credits and reference materials.

**6.3** Each course shall have an alpha numeric code number which includes abbreviation of the subject in two letters, the semester number, the code of the course and the serial number of the course ('C' for Program Core course, 'E' for Program Elective course, 'O' for Open Elective course, 'P' for Practical and 'D' for Project/ Dissertation and 'V' for Comprehensive Viva voce).

**6.4** Every Programme conducted under Choice Based Credit System shall be monitored by Academic committee and the College Council.

## **7. REGISTRATION.**

**7.1** A student shall be permitted to register for the programme at the time of admission. The duration of the PG Programme shall be 4 semesters.

**7.2** A student who registered for the course shall complete the course within a period of 8 continuous semesters from the date of commencement of the programme.

## **8. ADMISSION**

**8.1** The admission to all PG programmes shall be as per the rules and regulations of the college.

**8.2** The eligibility criteria for admission shall be as announced by the college from time to

time.

**8.3** There shall be provision for inter collegiate and inter University transfer within a period of two weeks from the date of commencement of the semester.

**8.4** There shall be provision for credit transfer subject to the conditions specified by the Board of Studies concerned.

## **9. ADMISSION REQUIREMENTS**

**9.1** Candidates for admission to the first semester of the PG programme through CBCS shall be required to have passed an appropriate Degree Examination of Mahatma Gandhi University as specified or any other examination of any recognized University or authority accepted by the Academic council of the college as equivalent thereto.

**9.2** The candidate must forward the enrolment form to the Controller of Examinations of the college through the Head of the Department.

**9.3** The candidate has to register all the courses prescribed for the particular semester. Cancellation of registration is applicable only when the request is made within two weeks from the time of admission.

**9.4** Students admitted under this programme are governed by the Regulations in force.

**10. PROMOTION:** A student who registers for the end semester examination shall be promoted to the next semester

## **11. EXAMINATIONS**

**11.1** There shall be an external examination at the end of each semester.

**11.2** The answers must be written in **English** except for those coming under Faculty of languages.

**11.3** Practical examinations shall be conducted by the college at the end of the semesters as per the syllabus.

**11.4** Project evaluation and Comprehensive Viva -Voce shall be conducted as per the syllabus. Practical examination, Project evaluation and Comprehensive Viva-Voce shall be conducted by two external examiners.( For professional courses, one examiner can be opted from the same college itself)

**11.5** There shall be one end-semester examination of 3 hours duration in each lecture based course (Theory).

**11.6** A question paper may contain multiple choice /objective type, short answer type/annotation, short essay type questions/problems and long essay type questions.

Different types of questions shall have different marks, but a general pattern may be followed by the Board of Studies.

## 12 EVALUATION AND GRADING

**12.1 Evaluation:** The evaluation scheme for each course shall contain two parts; (a) internal evaluation (ISA) and (b) end semester evaluation (ESA). 25 marks shall be given to internal evaluation and 75 marks to external evaluation so that the ratio between internal and external mark is 1:3. Both internal and external evaluation shall be carried out in mark system. Both internal and external marks are to be mathematically rounded to the nearest integer.

**12.2 Internal evaluation:** The internal evaluation shall be based on predetermined transparent system involving periodic written tests, assignments, seminars/viva/field survey and attendance in respect of theory courses and based on written tests, lab skill/records/viva and attendance in respect of practical courses. The marks assigned to various components for internal evaluation is as follows.

### 12.3 Components of Internal Evaluation

All the components of the internal evaluation are mandatory

#### a) For Theory

	Components	Marks
i.	Assignment	5
ii	Seminar/Quiz/Field survey /Viva etc.	5
iii	Attendance	5
iv	Two Test papers(2x5)	10
	Total	25

#### b) For Practical

Components	Marks
Attendance	5
Written/Lab test	5
Laboratory Involvement/ Record*	10
Viva	5
<b>Total</b>	<b>25</b>

\*Marks awarded for Record should be related to number of experiments recorded

#### c) For Project

Components	Marks
Topic/Area selected	2



Experimentation/Data collection	5
Punctuality	3
Compilation	5
Content	5
Presentation	5
<b>Total</b>	<b>25</b>

**12.4 Evaluation of****Attendance**

% of attendance	Mark
Above 90%	5
Between 85 and < 90	4
Between 80 and below 85	3
Between 76 and below 80	2
75	1

**Assignment**

Components	Marks
Punctuality	1
Content	2
Conclusion	1
Reference/Review	1
<b>Total</b>	<b>5</b>

**Seminar**

Components	Marks
Content	2
Presentation	2
Reference/Review	1
<b>Total</b>	<b>5</b>

**12.5** To ensure transparency of the evaluation process, the internal assessment marks awarded to the students in each course in a semester shall be published on the notice board at least one week before the commencement of external examination. There shall not be any chance for improvement for internal mark.

**12.6** The course teacher and the faculty advisor shall maintain the academic record of each student registered for the course which shall be forwarded to the controller of examinations through the Principal and a copy should be kept in the college for at least two years for verification.

**12.7 External Evaluation:** The external examination in theory courses shall be conducted by

the college with question papers set by external experts/ question bank. The evaluation of the answer scripts shall be done by the examiners based on a well-defined scheme of evaluation given by the question paper setters. The external evaluation shall be done immediately after the examination preferably through the centralised valuation.

**12.8** The question paper should be strictly on the basis of model question paper set by BoS with due weightage for each module of the course and there shall be a combined meeting of the question paper setters and experts for scrutiny for finalisation of question paper. Each set of question should be accompanied by its scheme of valuation.

**12.9** For all courses (theory & practical), Letter grades and grade point are given on a 10-point scale based on the total percentage of marks, (ISA+ESA) as given below:-

Percentage of Marks	Grade	Grade Point (GP)
95 and above	O Outstanding	10
85 to below 95	A <sup>+</sup> Excellent	9
75 to below 85	A Very Good	8
65 to below 75	B <sup>+</sup> Good	7
55 to below 65	B Above Average	6
45 to below 55	C Average	5
40 to below 45	D Pass	4
Below 40	F Fail	0
	Ab Absent	0

**Grades for the different semesters and overall programme are given based on the corresponding GPA as shown below:**

GPA	Grade
Equal to 9.5 and above	<b>O Outstanding</b>
Equal to 8.5 and below 9.5	<b>A+ Excellent</b>
Equal to 7.5 and below 8.5	<b>A Very Good</b>
Equal to 6.5 and below 7.5	<b>B+ Good</b>
Equal to 5.5 and below 6.5	<b>B Above Average</b>
Equal to 4.5 and below 5.5	<b>C Average</b>
Equal to 4.0 and below 4.5	<b>D Pass</b>
Below 4.0	<b>F Failure</b>

**12.9** A separate minimum of 40% marks (D grade) required for a pass for both internal evaluation and external evaluation for every course.

**12.11** A candidate who has not secured minimum marks/credits in internal examinations can re-do the same registering along with the end semester examination for the same semester, subsequently.

**12.12** A student who fails to secure a minimum marks/grade for a pass in a course will be permitted to write the examination along with the next batch.

**There will be no improvement examinations**

**12.13** After the successful completion of a semester, Semester Grade Point Average (SGPA) of a student in that semester is calculated using the formula given below. For the successful completion of semester, a student should pass all courses and score a minimum SGPA of 4.0. However, a student is permitted to move to the next semester irrespective of her/his SGPA.

**Credit Point (CP)** of a course is calculated using the formula

$CP = Cr \times GP$ , where Cr = Credit; GP = Grade point

**Semester Grade Point Average (SGPA)** of a Semester is calculated using the formula

$SGPA = TCP/TCr$ , where

$TCP = \text{Total Credit Point of that semester} = \sum_1^n CP_i$ ;

$TCr = \text{Total Credit of that semester} = \sum_1^n Cr_i$

Where  $n$  is the number of courses in that semester

**Cumulative Grade Point Average (CGPA)** of a Programme is calculated using the formula

$CGPA = \frac{\sum(TCP \times TCr)}{\sum TCr}$  GPA shall be round off to two decimal places

#### 12.14 PATTERN OF QUESTIONS

Questions shall be set to assess knowledge acquired, standard, and application of knowledge, application of knowledge in new situations, critical evaluation of knowledge and the ability to synthesize knowledge. The question setter shall ensure that questions covering all skills are set. He/She shall also submit a detailed scheme of evaluation along with the question paper.

A question paper shall be a judicious mix of, multiple /objective, short answer type, short essay type /problem solving type and long essay type questions.

##### Pattern of questions for external examination for theory paper

Type of Questions	Total no. of questions	Number of questions to be answered	Marks of each question	Total marks
Section A – Short Answer	12	8	2	16
Section B- Short essay/ Problems	10	7	5	35
Section C- Long essay	4	2	12	24
	<b>26</b>	<b>17</b>		<b>75</b>

Pattern of questions for external examination of practical papers will be decided by Practical exam board chairman as per the guidelines of Board of Studies.

### 13. GRADE CARD

The colleges under its seal shall issue to the students, a grade card on completion of each semester, which shall contain the following information.

- a) Name of the College
- b) Title of the Postgraduate Programme
- c) Name of the Semester
- d) Name and Register Number of the student
- e) Code, Title, Credits and Max. Marks (Internal, External & Total) of each course (theory& Practical) in the semester.
- f) Internal, External and Total Marks awarded, Grade, Grade point and Credit point in each course in the semester
- g) The total credits, total marks (Max. & Awarded) and total credit points in the semester
- h) Semester Grade Point Average (SGPA) and corresponding Grade.
- i) Cumulative Grade Point Average (CGPA)
- j) The final Mark cum Grade Card issued at the end of the final semester shall contain the details of all courses(theory & practical) taken during the final semester examination and shall include the final grade/marks scored by the candidate from 1st to 3rd semester, and the overall grade/marks for the total programme.

### 14. AWARD OF DEGREE

The successful completion of all the courses with 'D' grade (40%) shall be the minimum requirement for the award of the degree

### 15. MONITORING COMMITTEE

There shall be a Monitoring Committee constituted by the principal consisting of faculty advisors, HOD, a member from teacher learning evaluation committee (TLE) and college coordinator to monitor the internal evaluations conducted by college. The Course teacher, Faculty Advisor, and the College Coordinator should keep all the records of the internal evaluation, for at least a period of two years, for verification.

### 16. GRIEVENCE REDRESSAL MECHANISM

In order to address the grievance of students regarding Continuous internal assessment (CIA) a three-level Grievance Redressal mechanism is envisaged. A student can approach the upper level only if grievance is not addressed at the lower level.

**Level 1:** At the level of the concerned course teacher

**Level 2:** At the level of a department committee consisting of the Head of the Department, a coordinator of internal assessment for each programme nominated by the HoD and the course teacher concerned.

**Level 3:** A committee with the Principal as Chairman, Dean of the concerned Faculty, HOD of concerned department and one member of the Academic council nominated by the principal every year as members.

### **17. TRANSITORY PROVISION**

Notwithstanding anything contained in these regulations, the Principal shall, for a period of three year from the date of coming into force of these regulations, have the power to provide by order that these regulations shall be applied to any programme with such modifications as may be necessary.

### **18. REPEAL**

The Regulations now in force in so far as they are applicable to programmes offered by the college and to the extent they are inconsistent with these regulations are hereby repealed. In the case of any inconsistency between the existing regulations and these regulations relating to the Choice Based Credit System in their application to any course offered in the College, the latter shall prevail.

## FOREWORD

I am greatly privileged in presenting the revised curricula and syllabi of M.Sc. Chemistry and MSc Pharmaceutical Chemistry for the approval of Faculty, Board of Studies and Academic Council of Sacred heart College (Autonomous) Thevara.

Chemistry is beyond the science of mere observation and understanding of nature. In the words of James Watson, a 1962 Nobel Laureate in Physiology or Medicine, put it well: "Life is simply a matter of chemistry". It is with this vision we revised the syllabi for the PG courses, and also we followed the PG Guidelines which was prepared by the dean faculty. The revised syllabi will be implemented with effect from the academic year 2016-17 admission onwards.

The PG Board of Studies in Chemistry was entrusted with the duty of preparing the revised curricula and syllabi for the two M.Sc. Programmes in Chemistry currently approved by the Mahatma Gandhi University. The BoS has taken keen interest in collecting expert opinion from the renowned experts in the field as well as from the faculties of the affiliated colleges handling the subjects. We have also referred to the syllabi of various other Universities such as that of Cochin University of Science and Technology, Calicut University, Pune University, Delhi University besides, that of University Grants Commission and offered in the affiliated colleges.

The BoS prepared draft proposals of revised curricula and syllabi for the two M.Sc. Programmes in Chemistry keeping the Credit and Semester System. The syllabus has been set with an objective of training the students in all the fundamentals of the subject along with good practical exposure. Most of the advanced topics have been incorporated in the fourth semester. In view of creating research aptitude in students, BoS has decided to give sufficient time for project work, at least three months, and as far as possible send the students in reputed research centres/Universities in and outside the state for doing their project. Since specific time is not allotted for project work in the academic calendar, students can go for project after their final semester examinations.

The BoS feels that appreciable updating could be done in keeping with the current developments and trends in chemistry education. The task of preparing the Curricula and Syllabi and bringing it out in the present form was not a simple task but it was possible with dedicated efforts and wholehearted support and involvement of all the members of the faculty and BoS. I would like to express my sincere thanks to all my fellow members of the BoS and faculty for all their whole hearted time-bound help, cooperation and encouragement. I also express my sincere gratitude to Prof. S. Suganan (CUSAT), Prof.(Rtd.) K. K Vijayan (Calicut University), Prof. Abraham Joseph (Calicut University), Dr. M. K Muraleedharan Nair (Maharajas College), Dr. Mahesh Hariharan (IISER – TVM) and Dr. Pramod Padmanabhan (IISER – Pune) for their meaningful contributions.

Dr. Joseph John  
Chairman  
PG & UG Board of Studies  
Sacred Heart College (Autonomous). Thevara.

### Board of Studies in Chemistry

1. **Dr. Joseph John (HoD). Chairman.**
2. **Prof. (Dr.) P Raveendran**  
Department of Chemistry.  
University of Calicut.
3. **Dr. Jude Martin Mendez.**  
Associate Prof .Department of Chemistry.  
St. Alberts College, Ernakulam.
4. **Prof.(Dr.) Abraham Joseph**  
Department of Chemistry  
University of Calicut.
5. **Dr. K.B. Jose.**
6. **Dr. Joseph T Moolayil.**
7. **Dr.Thommachan Xavier.**
8. **Dr. V. S. Sebastian.**
9. **Dr. M. George.**
10. **Dr. Jorphin Joseph.**
11. **Dr. Franklin J.**
12. **Dr. Jinu George.**
13. **Dr. Grace Thomas.**
14. **Dr. Ignatious Abraham.**
15. **Mr. Midhun Dominic C D.**
16. **Mr. SenjuDevasykutty.**
17. **Ms. June Cyriac.**
18. **Dr. Ramakrishnan.S.**
19. **Dr. Abi T.G.**
20. **Dr. Kochubaby Manjooran.**  
Manager, Energy and Environmental Division.  
Kochi Refineries Ltd. Ambalamukal, Kochi.
21. **Dr. K Krishnakumar. I. M.**  
General Manager, R&D  
AkayFlavours and Aromatics Pvt. Ltd.

## Distribution of course, teaching Hours and credit for PG Pharmaceutical Chemistry

Semester	Code	Course	Hours/ Week	Total Hours	Credit	Remarks
SEM.I	16P1CPHT01	Inorganic Chemistry-I	4	72	4	
	16P1CPHT02	Basic Organic Chemistry	4	72	4	
	16P1CPHT03	Physical Chemistry-I	3	54	3	
	16P1CPHT04	Quantum chemistry and group theory	4	72	3	
	16P2CPHP01	Inorganic Chemistry Practical-I	3	54	Evaluation at the end of 2 <sup>nd</sup> Semester.	
	16P2CPHP02	Organic Chemistry Practical-I	3	54		
	16P2CPHP03	Physical Chemistry Practical-I	4	72		
	<b>Total</b>	<b>25</b>	<b>450</b>	<b>14</b>		
SEM.II	16P2CPHT05	Inorganic Chemistry-II	4	72	4	
	16P2CPHT06	Organic Reaction Mechanism.	4	72	4	
	16P2CPHT07	Physical Chemistry-II	3	54	3	
	16P2CPHT08	Theoretical and Computational Chemistry	4	72	3	
	16P2CPHP01	Inorganic Chemistry Practical-I	3	54	3	
	16P2CPHP02	Organic Chemistry Practical-I	3	54	3	
	16P2CPHP03	Physical Chemistry Practical-I	4	72	3	
	<b>Total</b>	<b>25</b>	<b>450</b>	<b>23</b>		
SEM.III	16P3CPHT09	Pharmaceutical Chemistry-I	4	72	4	
	16P3CPHT10	Organic Syntheses.	4	72	4	
	16P3CPHT11	Physical Chemistry-III	4	72	4	
	16P3CPHT12	Spectroscopic methods in Chemistry	3	54	3	
	16P4CPHP04	Pharmaceutical Practical-1 (Pharma)	3	54	Evaluation at the end of IV <sup>th</sup> Semester.	
	16P4CPHP05	Pharmaceutical Practical-2 (drug Synthesis)	3	54		
	16P4CPHP06	Pharmaceutical Practical-3 (Biochemistry)	4	72		
	<b>Total</b>	<b>25</b>	<b>450</b>	<b>15</b>		
SEM.IV	16P4CPHT13 EL	Pharmaceutical Chemistry II (Elective 1)	5	90	4	
	16P4CPHT14 EL	Pharmaceutical Chemistry III(Elective 2)	5	90	4	
	16P4CPHT15 EL	Pharmaceutical Chemistry IV (Elective 3)	5	90	4	
	16P4CPHP04	Pharmaceutical Practical-1 (Pharma)	3	54	3	
	16P4CPHP05	Pharmaceutical Practical-2 (Drug Synthesis)	3	54	3	
	16P4CPHP06	Pharmaceutical Practical-3 (Biochemistry)	4	54	3	
	16P4CPHCV	Comprehensive Subject Viva Voce			2	
	16P4PRCPH0 7	Project			5	
		<b>Total</b>	<b>25</b>		<b>28</b>	
	<b>Grand Total</b>			<b>80</b>		



**Unit 1: Organometallic Compounds- Synthesis, Structure and Bonding** **18 Hrs****SEMESTER I****16P1CPHT01 - INORGANIC CHEMISTRY-I****Credits: 4****Total Contact Hours 72**

- 1.1 Hapto nomenclature of organometallic compounds and 16 and 18 electron rule, Organometallic compounds with linear pi donor ligands-olefins, acetylenes, dienes and allyl complexes-synthesis, structure and bonding. Complexes with cyclic pi donors-metallocenes and cyclic arene complexes-structure and bonding. Metal carbene and alkylidenes, carbene and alkylidynes complexes, Fisher- type and Schrock- type complexes.
- 1.2 Metal Carbonyls: CO- as a  $\pi$  acid ligand, synergism, Molecular electronic structure and 18-electron rule. Binary Carbonyl complexes- Mononuclear and Binuclear carbonyls. Preparation, properties, structure, bonding in metal carbonyls, bridging modes of CO, Polynuclear metal carbonyls with and without bridging, oxygen bonded metal carbonyls, Ligands similar to CO- Cyanide, nitrosyls, dinitrogen, Hydrogen and dihydrogen complexes.
- 1.3 Carbonyl clusters-LNCCS and HNCCS, Isoelectronic and isolobal analogy, Wade-Mingos rules, cluster valence electrons, Synthesis of clusters.

**Unit 2: Reactions and catalysis of Organometallic Compounds** **18 Hrs**

- 2.1 Substitution reactions-nucleophilic ligand substitution, nucleophilic and electrophilic attack on coordinated ligands. Carbonylate anions as nucleophiles.
- 2.2 Addition and elimination reactions-1,2 additions to double bonds, carbonylation and decarbonylation, oxidative addition and reductive elimination, insertion (migration) and elimination reactions.
- 2.3 Redistribution reactions, fluxional isomerism.
- 2.4 Homogeneous and heterogeneous organometallic catalysis-alkene hydrogenation using Wilkinson catalyst, Tolman catalytic loops.
- 2.5 Reactions of carbon monoxide and hydrogen-the water gas shift reaction, synthesis gas based reactions - the Fischer-Tropsch reaction(synthesis of gasoline).
- 2.6 Hydroformylation of olefins using cobalt or rhodium catalyst. Application - Synthesis of diethylhexylphthalate.
- 2.7 Polymerization by organometallic initiators and templates for chain propagation-Ziegler Natta catalysts.
- 2.8 Carbonylation reactions-Monsanto acetic acid process, Alkoxy carbonylation

reactions-carbonylation of butadiene using  $\text{Co}_2(\text{CO})_8$  catalyst in adipic ester synthesis.

- 2.9 Olefin methathesis, photodehydrogenation catalyst ("Platinum Pop"). Palladium catalysed oxidation of ethylene-the Wacker process.

### References

1. J.E. Huheey, E.A. Keiter, R.L. Keiter, Inorganic Chemistry Principles of Structure and Reactivity, 4th Edn., Harper Collins College Publishers, 1993.
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### Unit 3: Nuclear Chemistry

18 hrs

- 3.1 Radioactive decay. Alpha decay-Alpha ray spectrum, Beta decay-Types of beta decay,  $\beta^+$ ,  $\beta^-$ ,  $\beta^-$ -ray spectrum, neutrino antineutrino and Positron emission, Dirac theory, pair production, positron-electron annihilation, electron capture, double  $\beta$  decay. Gamma decay- de-excitation of excited molecules, change of Energy, spin, parity during photon emission, nuclear isomerism and isomeric transition, internal conversion, auger electrons and auger effect.
- 3.2 Nuclear reactions.  
Q-Value and reaction threshold, reaction cross section-definition, and units, cross section and reaction rate, neutron capture cross section, variation of neutron cross section with energy(  $1/V$  law). Photonuclear, Thermonuclear and Fusion reactions, Magnetic confinement, internal confinement.  
Nuclear fission - Fission fragment and mass distribution, fission yield, fission energy, fission cross section and threshold, fission neutrons, prompt and delayed neutrons, fission by high energy neutrons.
- 3.3 Nuclear Reactors.  
Fissile and fissionable nuclei, fast and thermal neutrons, Terms and symbols used in reactor technology- average no. of fission neutrons, fast fission factor, fast neutrons loss factor, resonance capture, thermal neutrons loss factor, thermal utilization factor, relative fission cross section, reproduction factor, critical size of reactor. Breeder reactor, fast breeder test reactor.

- 3.4 Reactor Safety precaution, Management of radioactive waste- Low level Waste, Intermediate level Waste, High level Waste.
- 3.5 Principles of counting techniques- G.M. counter, proportional, ionization and scintillation counters.
- 3.6 Applications of radioisotopes.  
Physico-chemical study-Solubility of sparingly soluble salts. Analytical applications- Isotope dilution analysis, radiometric titrations, Neutron Activation Analysis, Prompt Gama Neutron Activation Analysis and Neutron Absorptiometry.  
Applications of radio isotopes medicine-Thyroiditis, Tumour identification, Determination of volume of blood in patient.

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1. G. Friedlander, J.W. Kennedy, E.S. Macias, and J.M. Miller, Nuclear and Radiochemistry, John Wiley and Sons, 2<sup>nd</sup> Ed. 1981.
2. H.J. Arnikaar, Essentials of Nuclear Chemistry, New Age International, 4<sup>th</sup> Edn., 2011.
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4. S.N. Goshal, Nuclear Physics, S. Chand and Company, 2006.

**Unit 4: Bioinorganic Chemistry.****18 Hrs**

- 4.1 Biochemistry of Iron  
Oxygen Carriers- Structure and functions of haemoglobin and myoglobin, Oxygen transport mechanism of Hemoglobin, cooperativity in haemoglobin. Hemerythrin Structure and function. Bohr effect and phosphate effect.  
Redox Metalloenzymes-Cytochromes, Classification, Structure and function, Role in oxidative Phosphorylation of ADP to ATP.  
Iron Sulphur Proteins-Rubredoxin, Ferredoxin, Nitrogenase, Structure and function, Nitrogen Fixation. Peroxidases and catalases, Cytochrome P<sub>450</sub>- Structure and functions. Storage and transport of iron in biological systems-Ferritin, transferrin and Siderophores.
- 4.2 Biochemistry of Zn and Copper.  
Structure and functions of carboxypeptidase and carbonicanhydrase, Superoxide dismutase.  
Structure and functions of various Copper proteins and enzymes.  
Blue copper proteins (Type-1) - Electron transfer agents - Plastocyanin, Stellacyanin and Azurin.  
Blue copper Enzymes (Type II) - Ascorbateoxidase, Laccase and ceruloplmin.  
Non Blue copper enzyme (Type III) - Cytochrome oxidase, Amine oxidases, Structure and functions of Hemocyanin.
- 4.3 Other Important metal containing Biomolecules.  
Vitamin B<sub>12</sub>- Structure and biological importance. Chlorophyll-Photosynthesis, PS I & PS II.
- 4.4 Metals in medicine - Therapeutic applications of *cis*-platin, Mechanism of action,

MRI agents, Mechanism of muscle contraction, blood clotting mechanism.

- 4.5 Essential and trace elements in biological systems, Toxic effects of metals (Cd, Hg, Cr and Pb). Mechanism of ion transport across membranes, Sodium Potassium pump.

**References.**

1. G. Wulfborg, Inorganic Chemistry, Ind. Edition, Viva, 2014.
2. Shiver & Atkins, Inorganic Chemistry, 4<sup>th</sup> Edn. Oxford University Press, 2006.
3. K.F. Purcell, J.C. Kotz, Inorganic Chemistry, Cengage Learning 2<sup>nd</sup> Edn., 2014.
4. J.E. Huheey, E.A. Keiter, R.A. Keiter, Inorganic Chemistry Principles of Structure and Reactivity, 4<sup>th</sup> Edn., Pearson Education India, 2006.
5. F.A. Cotton, G Wilkinson, C.A. Murillo, M. Bochmann, Advanced Inorganic Chemistry, 6<sup>th</sup> edition, Wiley-Interscience, 1999.
6. G.L. Miessler, D. A. Tarr, Inorganic Chemistry 3<sup>rd</sup> Ed., Pearson Education, 2007.
7. B.E. Douglas, D.H. McDaniel, J. J. Alexander, Concepts and Models of Inorganic Chemistry, 3<sup>rd</sup> Edn., Wiley-India, 2007.
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**16P1CPHT02 BASIC ORGANIC CHEMISTRY****Credit : 4****Contact Lecture Hours: 72****Unit 1: Basic Concepts in Organic Chemistry****(12 Hrs)**

- 1.1 IUPAC nomenclature of polycyclic, heterocyclic, benzenoid, non-benzenoid and spiro compounds.
- 1.2 Review of basic concepts in organic chemistry: Electron displacement effects-inductive effect, electrometric effect, resonance effect, hyperconjugation, steric effect. Steric inhibition of resonance.
- 1.3 Bonding weaker than covalent bonding- H-bonding,  $\pi$ -  $\pi$  interactions, Other non-covalent interactions
- 1.4 Concept of aromaticity: delocalization of electrons –Huckel's and Craig rule- criteria for aromaticity -examples of neutral and charged aromatic systems, annulenes[10],[14],[18],[22], Tropolone, Azulene. NMR as a tool for aromaticity. Anti- and homo-aromatic systems–Alternate and non-alternate hydrocarbons, Fullerenes, Carbon nanotubes and Graphene.

**Unit 2: Physical Organic Chemistry****(11 Hrs.)**

- 2.1 Energy profiles. Hammond postulate, Kinetic versus thermodynamic control of product formation, Captodative effect – kinetic isotope effects with examples - Stereochemical studies-use of isotopes Hammett equation, Taft equation, cross-over experiments, Hammond postulates.
- 2.2 Salt and Solvent effect. Intermediates vs. Transition state, linear free energy relationship.
- 2.3 Introduction to carbon acids - pKa of weak acids - Kinetic and thermodynamic acidity.
- 2.4 Introduction to organic bases- pkb.of weak bases.

**Unit 3: Review of basic reaction mechanisms (8 Hrs.)**

- 3.1 Mechanism of SN1, SNAr, SRN1 and Benzyne mechanisms.
- 3.2 Catalysis by acids and bases and nucleophiles with examples from acetal, cyanohydrin and ester formation and hydrolysis reactions – $A_{AC}^2$ ,  $A_{AC}^1$ ,  $A_{AL}^1$ ,  $B_{AC}^2$  and  $B_{AL}^1$  mechanisms.

**Unit4: Stereochemistry of Organic Compounds****(15Hrs.)**

- 4.1 Introduction to molecular symmetry and chirality – examples from common objects to molecules – axis, plane, centre, alternating axis of symmetry.
- 4.2 Centre of chirality – molecules with C, N, S based chiral centres – absolute configuration - enantiomers – racemic modifications - R and S nomenclature using Cahn-Ingold-Prelog rules – molecules with a chiral centre and  $C_n$  – molecules with more than one center of chirality – definition of diastereoisomers – constitutionally symmetrical and unsymmetrical chiral molecules - erythro, threo nomenclature.
- 4.3 Axial, planar and helical chirality – examples – stereochemistry and absolute configuration of allenes, biphenyls and binaphthyls, ansa and cyclophanic compounds, spirans, exo-cyclic alkylidenecycloalkenes.

- 4.4 Identification of enantiotopic, homotopic, diastereotopic hydrogens, prochirality, Topicity and prostereoisomerism – topicity of ligands and faces, and their nomenclature. NMR distinction of enantiotopic/diastereotopic ligands. Stereospecific, stereoselective and asymmetric synthesis.
- 4.5 Geometrical isomerism: Nomenclature - E-Z notation - methods of determination of geometrical isomers. Geometrical isomerism of oximes-Interconversion of geometrical isomers.

**Unit 5: Conformational Analysis****(20Hrs.)**

- 5.1 Stereoisomerism: Definition based on symmetry and energy criteria – configuration and conformational stereoisomers.
- 5.2 Conformational descriptors - factors affecting conformational stability of molecules. potential energy diagrams
- 5.3 Conformational analysis of acyclic systems: substituted ethanes, aldehydes, ketones and olefins.
- 5.4 Conformational analysis of cyclic systems -Cyclohexane and its derivatives. Cyclohexanone.
- 5.5 Conformational analysis of Fused and bridged bicyclic systems.-decalins, adamantane hexamethylene diamine and congressane,
- 5.6 Conformation of sugars-glucose, sucrose and lactose
- 5.7 Conformation and reactivity of elimination -dehalogenation, dehydrohalogenation, dehydration, semipinacolic deamination and pyrolytic elimination-Saytzeff and Hofmann eliminations, substitution and oxidation of 2<sup>o</sup> alcohols.
- 5.8 Chemical consequence of conformational equilibrium - Curtin-Hammett principle.

**Unit 6: Organic Photochemistry****(6Hrs.)**

- 6.1 Jablonski diagram, triplet and singlet states.
- 6.2 Photoreactions of carbonyl compounds: Norrish reactions of acyclic and cyclic ketones. Paterno-Buchi reaction. Barton, Di- $\pi$ -methane and photo reduction of ketones.
- 6.3 Photochemistry of Nitro and Azo groups.
- 6.4 Photochemistry of vision

**References**

1. D. Hellwinkel, Systematic nomenclature of organic chemistry, Springer international edition
2. R.Bruckner, *Advanced Organic Chemistry:Reaction Mechanisms*, Academic Press, 2002.
3. F. A. Carey and R. A. Sundberg, *Advanced Organic Chemistry*, Part A: Structure and Mechanisms, Fifth Edition, Springer, New York, 2007.
4. J.Clayden, N.Greeves, S.Warren, P.Wothers, *Organic Chemistry*, Oxford University Press, New York, 2004.
5. Aditi Sangal, *Krishna's Advanced Organic Chemistry; Volume 1* – Krishna PrakashnMedia(P) Ltd.

6. T. H. Lowry and K. S. Richardson, *Mechanism and Theory in Organic Chemistry*, Second Edition, Harper & Row, New York, 1981.
7. N. S. Isaacs, *Physical Organic Chemistry*, ELBS, Longman, UK, 1987.
8. Jack Hine, *Physical Organic Chemistry*, McGraw-Hill; 2nd Edition, 1962.
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11. E. L. Eliel and S. H. Wilen, *Stereochemistry of Organic Compounds*, John Wiley & Sons, New York, 1994.
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14. K.K.R. Mukherjee, *Fundamentals of Photochemistry*, New Age Publications, New Delhi, 1978.

**16P1CPHT03 PHYSICAL CHEMISTRY I****Credit: 3****Contact Lecture Hours: 54****Unit 1: Classical Thermodynamics -Fundamentals (9Hrs.)**

**1.1 Introduction:** Entropy- Free energy-Systems of Variable Compositions - Fugacity and Activity-Thermodynamics of mixing: Clausius Inequality, Maxwell's relations – significance, Partial molar properties – Chemical potential, Fugacity and Activity.

**1.2 Thermodynamics of mixing:** Thermodynamic functions of mixing, Gibbs-Duhem-Margules equation, Konowaloff's rule, Henry's law, excess thermodynamic functions-free energy, enthalpy, entropy and volume.

**1.3Chemical Equilibrium:** Chemical affinity and thermodynamic functions, effect of temperature and pressure on chemical equilibrium- van't Hoff equations.

**1.4Third law of thermodynamics:** Nernst heat theorem, development of third law of thermodynamics, determination of absolute entropies using third law, entropy changes in chemical reactions.

**1.5Three component systems:** Gibbs phase rule, graphical representation of three component systems. Solid-liquid equilibria, ternary solutions with common ions, hydrate formation, compound formation. Liquid-liquid equilibria-one pair of partially miscible liquids, two pairs of partially miscible liquids, three pairs of partially miscible liquids.

**Unit 2: Thermodynamics of Irreversible Processes & Bioenergetics (10hrs.)**

**2.1 Thermodynamics of Irreversible Processes:** Thermodynamics of irreversible processes with simple examples. Uncompensated heat and its physical significance. Entropy production- rate of entropy production, entropy production in chemical reactions, the phenomenological relations. The Onsager reciprocal relations - principle of microscopic reversibility. Electrokinetic phenomena. Thermoelectric phenomena.

**2.2 Bioenergetics:** Coupled reactions, ATP and its role in bioenergetics, high energy bond, free energy and entropy change in ATP hydrolysis, thermodynamic aspects of metabolism and respiration, glycolysis, biological redox reactions.

**Unit 3: Statistical Thermodynamics (27 Hrs)**

Permutation, probability, apriori and thermodynamic probability, Stirlings approximation, macrostates and microstates, Boltzmann distribution law, partition function and its physical significance, phase space, different ensembles, canonical partition function, distinguishable and indistinguishable molecules, partition function and thermodynamic functions, separation of partition function-translational, rotational, vibrational and electronic partition functions. Thermal de-Broglie wavelength.

Calculation of thermodynamic functions and equilibrium constants, statistical interpretation of work and heat, Sakur-Tetrode equation, statistical formulation of third law of thermodynamics, thermodynamic probability and entropy, residual entropy, heat capacity of gases - classical and quantum theories, heat capacity of hydrogen.

**Need for quantum statistics, Bose-Einstein statistics:** Bose-Einstein distribution, example of particles, Bose-Einstein condensation, difference between first order and higher order phase transitions, liquid helium, and super cooled liquids. Fermi-Dirac distribution: examples of particles, application in electron gas, thermionic emission. Comparison of three statistics.

**Heat capacity of solids-** the vibrational properties of solids, Einstein's theory and its limitations, Debye theory and its limitations.



#### **Unit 4: Gaseous State (8 Hrs.)**

Derivation of Maxwell's law of distribution of velocities, graphical representation, experimental verification of the law, most probable velocity, derivation of average, RMS and most probable velocities, collision diameter, collision frequency in a single gas and in a mixture of two gases, mean free path, effusion, the rate of effusion, transport properties of gases-viscosity, thermal conductivity and diffusion.

#### **References**

1. R.P. Rastogi, R.R. Misra, An introduction to Chemical Thermodynamics, Vikas publishing house, 2009.
2. J. Rajaram, J.C. Kuriakose, Thermodynamics, S Chand and Co., 1999.
3. M.C. Gupta, Statistical Thermodynamics, New age international, 2007.
4. M.W. Zemansky, R.H. Dittman, Heat and Thermodynamics, Tata McGraw Hill, 1981.
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6. K.J. Laidler, J.H. Meiser, B.C. Sanctuary, Physical Chemistry, 4<sup>th</sup>Edn. Houghton Mifflin, 2003.
7. L.K. Nash, Elements of Classical and Statistical Mechanics, 2<sup>nd</sup> Edn. Addison Wesley, 1972.
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9. C. Kalidas, M.V. Sangaranarayanan, Non-equilibrium Thermodynamics, Macmillan India, 2002.
10. R.K. Murray, D.K. Granner, P. A. Mayes, V.W. Rodwell, Harper's Biochemistry, Tata McGraw Hill, 1999.
11. I. Tinoco, K. Sauer, J.C. Wang, J.D. Puglisi, Physical Chemistry: Principles and Applications in Biological Science, Prentice Hall, 2002.
12. F.W. Sears, G.L. Salinger, Thermodynamics, Kinetic Theory and Statistical Thermodynamics, Addison Wesley, 1975.
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**16P1CPHT04 QUANTUM CHEMISTRY AND GROUP THEORY****Credit: 3****Contact Lecture Hours: 72****Unit 1: Postulates of Quantum Mechanics (9 Hrs)**

State function or wave function postulate: Born interpretation of the wave function, well behaved functions, orthonormality of wave functions. Operator postulate: operator algebra, linear and nonlinear operators, Laplacian operator, commuting and non commuting operators, Hermitian operators and their properties, eigen functions and eigen values of an operator. Eigen value postulate: eigen value equation, eigen functions of commuting operators. Expectation value postulate. Postulate of time-dependent Schrödinger equation, conservative systems and time-independent Schrödinger equation.

**Unit 2: Application to Exactly Solvable Model Problems (18 Hrs)**

Translational motion: free particle in one-dimension, particle in a one dimensional box with infinite potential walls, particle in a one-dimensional box with finite potential walls-tunneling, particle in a three dimensional box separation of variables, degeneracy.

Vibrational motion: one-dimensional harmonic oscillator (complete treatment), Hermite equation (solving by method of power series), Hermite polynomials, recursion relation, wave functions and energies-important features, Harmonic oscillator model and molecular vibrations.

Rotational motion: co-ordinate systems, cartesian, cylindrical polar and spherical polar coordinates and their relationships. The wave equation in spherical polar coordinates-particle on a ring, the phi equation and its solution, wave functions in the real form. Non-planar rigid rotor (or particle on a sphere)- separation of variables, the phi and the theta equations and their solutions, Legendre and associated Legendre equations, Legendre and associated Legendre polynomials. Spherical harmonics (imaginary and real forms) - polar diagrams of spherical harmonics.

Quantization of angular momentum, quantum mechanical operators corresponding to angular momenta ( $L_x$ ,  $L_y$ ,  $L_z$  and  $L^2$ )-commutation relations between these operators. Spherical harmonics as eigen functions of angular momentum operators  $L_z$  and  $L^2$ . Ladder operator method for angular momentum. Space quantization.

**Unit 3: Quantum Mechanics of Hydrogen-like Atoms (9 Hrs)**

Potential energy of hydrogen-like systems. The wave equation in spherical polar coordinates: separation of variables-R, theta and phi equations and their solutions, wave functions and energies of hydrogen-like atoms. Orbitals-radial functions, radial distribution functions, angular functions and their plots.

The postulate of spin by Uhlenbeck and Goudsmith, discovery of spin-Stern Gerlach experiment. Spin orbitals-construction of spin orbitals from orbitals and spin functions.

#### **Unit 4 : Group Theory and Molecular Symmetry (18 Hrs)**

Symmetry elements, symmetry operations, point groups and their symbols, subgroups, classes, abelian and cyclic groups, group multiplication tables-classes in a group and similarity transformation.

Matrices: addition and multiplication of matrices, inverse and orthogonal matrices, character of a matrix, block diagonalisation, matrix representation of symmetry operations, and representation of groups by matrices, construction of representation using vectors and atomic orbitals as basis.

Reducible and irreducible representations-construction of irreducible representation by standard reduction formula. Statement of Great Orthogonality Theorem (GOT). Properties of irreducible representations. Construction of irreducible representation using GOT-construction of character tables for  $C_{2v}$ ,  $C_{2h}$ ,  $C_3$ ,  $C_{3v}$  and  $C_{4v}$ . Direct product of representations.

#### **Unit 5 Application of group theory in Spectroscopy and Chemical bonding (18 Hrs)**

Applications in vibrational spectra: transition moment integral, vanishing of integrals, symmetry aspects of molecular vibrations, vibrations of polyatomic molecules-selection rules for vibrational absorption. Determination of the symmetry of normal modes of  $H_2O$ ,  $C_2H_4$ ,  $Trans\ N_2F_2$ ,  $CHCl_3$  and  $NH_3$  using Cartesian coordinates and internal coordinates. Complementary character of IR and Raman spectra-determination of the IR and Raman active vibrational modes.

Application in electronic spectra: selection rules for electronic transition, electronic transitions due to the carbonyl chromophore in formaldehyde.

Applications in chemical bonding, construction of hybrid orbitals with  $H_2O$ ,  $NH_3$ ,  $BF_3$ ,  $CH_4$ ,  $PCl_5$  as examples. Transformation properties of atomic orbitals. Symmetry adapted linear combinations (SALC).

MO diagram for water and ammonia.

#### **Reference**

##### **For Units 1, 2 & 3**

1. F.L. Pilar, *Elementary Quantum Chemistry*, McGraw-Hill, 1968.
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5. M.W. Hanna, *Quantum Mechanics in Chemistry*, 2<sup>nd</sup> Edition, W.A. Benjamin Inc., 1969.
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12. R.K. Prasad, *Quantum Chemistry*, 3rd Edition, New Age International, 2006.
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#### For Units 4&5

1. F.A. Cotton, *Chemical applications of Group Theory*, 3rd Edition, John Wiley & Sons Inc., 2003.
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3. L.H. Hall, *Group Theory and Symmetry in Chemistry*, McGraw Hill, 1969.
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6. Mark Ladd, *Symmetry & Group Theory in Chemistry*, Horwood 1998.
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14. A. Vincent, *Molecular Symmetry and Group Theory: A Programmed Introduction to Chemical Applications*, 2nd Edn., Wiley, 2000.

**SEMESTER 2**  
**16P2CPHT05 INORGANIC CHEMISTRY II**

Credits: 4

Contact Lecture Hours: 72

**Unit 1: Structural Aspects and Bonding (18 Hrs)**

- 1.1 Sigma and pi bonding ligands such as CO, NO, CN<sup>-</sup>, R<sub>3</sub>P, and Ar<sub>3</sub>P Macrocycles-crown ethers, cryptands, macrocyclic effect, applications of crown ethers, template synthesis, Inverse crown ether complexes.
- 1.2 Classification of complexes based on coordination numbers and possible geometries. Stability of complexes, thermodynamic aspects of complex formation, chelate effect, Determination of stability constant. Irving William order of stability.
- 1.3 Splitting of *d* orbitals in octahedral, tetrahedral, square planar, square pyramidal and trigonal bipyramidal fields, CFSE, Jahn Teller (JT) effect, theoretical failure of crystal field theory,
- 1.4 Molecular orbital theory-Evidence of covalency in the metal-ligand bond, nephelauxetic effect, M.O energy level diagrams for octahedral and tetrahedral complexes without and with π-bonding, experimental evidences for pi-bonding.

**Unit 2: Spectral and Magnetic Properties of Metal Complexes (18 Hrs)**

- 2.1 Electronic Spectra of complexes-Term symbols of *d<sup>n</sup>* and *f<sup>n</sup>* system, splitting of terms, *d-d* transition, selection rules for electronic transition-effect of spin orbit coupling and vibronic coupling.
- 2.2 Interpretation of electronic spectra of complexes-Orgel diagrams, demerits of Orgel diagrams, Tanabe-Sugano diagrams, calculation of *Dq*, *B* and *β* (Nephelauxetic ratio) values, Racah parameters,  
  
Charge transfer spectra, luminescence spectra, Intra Valence charge transfer transition Prussian blue.
- 2.3 Magnetic properties of complexes-paramagnetic and diamagnetic complexes, molar susceptibility, Gouy method for the determination of magnetic moment of complexes, spin only magnetic moment. Anomalous magnetic moments, quenching of magnetic moment. Temperature dependence of magnetism-Curie's law, Curie-Weiss law. Temperature Independent Paramagnetism (TIP), Antiferromagnetism-inter and intra molecular interaction. Application of magnetic moment measurement in structural elucidation of complexes.(Co and Ni complexes)

**Unit 3: Kinetics and Mechanism of Reactions in Metal Complexes (18 Hrs)**

- 3.1 Thermodynamic and kinetic stability, kinetics and mechanism of nucleophilic

substitution reactions in square planar complexes, Factors affecting the reactivity of square planar complexes of Pt(II) and other  $d^8$  metal ions, *trans* effect-theory and applications.

- 3.2 Kinetics and mechanism of octahedral substitution- water exchange reactions, Dissociative and associative mechanisms, hydrolysis under acidic conditions, rate and stereochemistry of aquation of cis and trans isomers of Co(III) complexes, base hydrolysis – conjugate base mechanism, base hydrolysis of different isomers of  $[\text{Co}(\text{tren})(\text{NH}_3)\text{Cl}]^{2+}$ , racemization reactions.
- 3.3 Electron transfer reactions: outer sphere mechanism-Marcus theory, inner sphere mechanism-Taube mechanism. Nature of bridging ligand.

#### Unit 4: Stereochemistry of Coordination Compounds

(9 Hrs)

- 4.1 Geometrical and optical isomerism in octahedral complexes, resolution of optically active complexes, determination of absolute configuration of complexes by ORD and circular dichroism, stereoselectivity and conformation of chelate rings, asymmetric synthesis catalyzed by coordination compounds,
- 4.2 Linkage isomerism-electronic and steric factors affecting linkage isomerism. Symbiosis-hard and soft ligands

#### Unit 5: Coordination Chemistry of Lanthanides and Actinides

(9 Hrs)

- 5.1 General characteristics of lanthanides-Electronic configuration, Oxidation state, Lanthanide contraction. Factors that mitigate against the formation of lanthanide complexes. Electronic spectra and magnetic properties of lanthanide complexes. Lanthanide complexes as shift reagents. Separation of Lanthanides.
- 5.2 General characteristics of actinides-difference between  $4f$  and  $5f$  orbitals, comparative account of coordination chemistry of lanthanides and actinides with special reference to electronic spectra and magnetic properties.

#### References

1. F.A. Cotton, G. Wilkinson, Advanced Inorganic Chemistry: A Comprehensive Text, 3<sup>rd</sup> Edn., Interscience, 1972.
2. J.E. Huheey, E.A. Keiter, R.A. Keiter, Inorganic Chemistry Principles of Structure and Reactivity, 4<sup>th</sup> Edn., Pearson Education India, 2006.
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9. G.L. Miessler, D. A. Tarr, Inorganic Chemistry 3<sup>rd</sup> Ed., Pearson Education, 2007.

**16P2CPHT06 ORGANIC REACTION MECHANISM****Credit : 4****Contact Lecture Hours: 72****Unit1: Review of substitution reaction Mechanisms (11Hrs.)**

- 1.1 A comprehensive study on the effect of substrate, reagent, leaving group, solvent, ambident nucleophile and neighbouring group on nucleophilic substitution(SN<sub>1</sub> and SN<sub>2</sub>) and elimination (E<sub>1</sub>, E<sub>2</sub> and E<sub>1cB</sub>) reactions. Stereochemistry of E<sub>2</sub> reaction, Intramolecular pyrolytic elimination, Cope elimination. Elimination vs substitution.
- 1.2 Review of organic reaction mechanisms with special reference to nucleophilic and electrophilic substitution at aliphatic carbon (SN<sup>i</sup>, SE<sub>1</sub>, SE<sub>2</sub> and SE<sup>i</sup>). Substitution at the aromatic centre, unimolecular mechanism, bimolecular mechanism. Kinetics of SE<sub>2</sub>-Ar reaction. Ortho-para selectivity ratio.
- 1.3 Electrophilic substitution via enolization and stork-enamine reaction. Benzyne mechanism. Von Richter, Vilsmeier formylation, Jacobson and Gatterman-Koch reactions.

**Unit2: Chemistry of Carbanions (10Hrs.)**

- 2.1 Formation, structure and stability of carbanions. Reactions of carbanions: C-X bond (X = C, O, N) formations through the intermediary of carbanions. Chemistry of enolates and enamines. Kinetic and Thermodynamic enolates-lithium and boron enolates in aldol Alkylation and acylation of enolates.
- 2.2 Electrophilic additions to alkenes, kinetics, effect of structure, orientation and stereochemistry. Ozonolysis and hydroboration. Nucleophilic additions to carbonyl groups. Named reactions under carbanion chemistry –Mechanism of Claisen, Dieckmann, Knoevenagel, Stobbe, Darzen and acyloin condensations, Shapiro reaction and Julia elimination. Favorski rearrangement.
- 2.3 Ylids: Chemistry of Phosphorous and Sulphur ylids - Wittig and related reactions, Peterson olefination.

**Unit3: Chemistry of Carbocations (9Hrs.)**

- 3.1 Formation, structure and stability of carbocations. Classical and non-classical carbocations.
- 3.2 C-X bond (X = C, O, N) formations through the intermediary of carbocations. Molecular rearrangements including Wagner-Meerwein, Pinacol-pinacolone, semi-pinacol, Dienone-phenol and Benzilic acid rearrangements, Noyori annulation, Prins reaction.
- 3.3 C-C bond formation involving carbocations: Oxymercuration, halolactonisation.
- 3.4 Structure and reactions of α, β- unsaturated carbonyl compounds - electrophilic and nucleophilic addition - Michael addition, Mannich reaction, Robinson annulation.

**Unit4: Carbenes, Carbenoids, Nitrenes and Arynes (9 Hrs)**

- 4.1 Structure of carbenes (singlet and triplet) - generation of carbenes - addition and insertion reactions.
- 4.2 Rearrangement reactions of carbenes such as Wolff rearrangement - generation and reactions of ylids by carbenoid decomposition.
- 4.3 Structure, generation and reactions of nitrene and related electron deficient nitrene intermediates.
- 4.4 Hoffmann, Curtius, Lossen, Schmidt and Beckmann rearrangement reactions.



- 4.5 Arynes: Generation, structure, stability and reactions. Orientation effect- amination of haloarenes.

**Unit5: Radical Reactions (9Hrs)**

- 5.1 Generation of radical intermediates and its (a) addition to alkenes, alkynes (inter & intramolecular) for C-C bond formation - Baldwin's rules (b) fragmentation and rearrangements – Hydroperoxide: formation, rearrangement and reactions. Auto-oxidation.
- 5.2 Named reactions involving radical intermediates: Barton deoxygenation and decarboxylation, McMurry coupling.

5.3

**Unit 6: Concerted reactions: (24Hrs)**

- 7.1 Classification: Electrocyclic, sigmatropic, cycloaddition, chelotropic and ene reactions. Woodward Hoffmann rules - frontier orbital and orbital symmetry correlation approaches - PMO method.
- 7.2 Pericyclic reactions in organic synthesis such as Claisen, Cope, Wittig, Mislow-Evans and Sommelet-Hauser rearrangements. Diels-Alder and Ene reactions (with stereochemical aspects), dipolar cycloaddition (introductory).
- 7.3 Pyrolytic elimination reactions: cheletropic elimination, decomposition of cyclic azo compounds,  $\beta$ -eliminations involving cyclic transition states such as N-oxides, acetates and xanthates.
- 7.4 Introduction to Click reactions -Mechanism of the Huisgen Azide-Alkyne 1, 3-Dipolar Cycloaddition, Staudinger ligation and Staudinger reduction.

**References**

1. R. Bruckner, *Advanced Organic Chemistry: Reaction Mechanism*, Academic Press, 2002.
2. F. A. Carey, R. A. Sundberg, *Advanced Organic Chemistry*, Part B: Reactions and Synthesis, 5<sup>th</sup> Edn., Springer, New York, 2007.
3. W. Carruthers and I. Coldham, *Modern Methods of Organic Synthesis*, First South Asian Edition, Cambridge University Press, 2005.
4. J. March and M. B. Smith, *March's Advanced Organic Chemistry: Reactions, Mechanisms, and Structure*, 6<sup>th</sup> Edn., Wiley, 2007.
5. <http://www.organic-chemistry.org/namedreactions>.
6. R.T. Morrison, R.N. Boyd, S.K. Bhattacharjee, *Organic Chemistry*, 7<sup>th</sup> Edn., Pearson, New Delhi, 2011.
7. J. Clayden, N. Greeves, S. Warren, P. Wothers, *Organic Chemistry*, Oxford University Press, New York, 2004.
8. Fleming, Wiley, *Frontier Orbitals and Organic Chemical Reactions*, London, 1976.
9. S. Sankararaman, *Pericyclic Reactions-A Text Book*, Wiley VCH, 2005.

**16P2CPHT07 PHYSICAL CHEMISTRY II****Credits 3****Contact Lecture Hours 54****Unit 1 Microwave, Infrared and Raman Spectroscopy (14hours)**

**1.1 Origin of spectra:** origin of different spectra and the regions of the electromagnetic spectrum, intensity of absorption, influencing factors, signal to noise ratio, natural line width, contributing factors, Doppler broadening, Lamb dip spectrum, Born Oppenheimer approximation, energy dissipation from excited states (radiative and non radiative processes), and relaxation time.

**1.2 Microwave spectroscopy:** Classification of molecules; rigid rotor model; rotational spectra of diatomics and polyatomics; effect of isotopic substitution and nonrigidity; selection rules and intensity distribution.

**1.3 Vibrational spectroscopy:** Vibrational spectra of diatomics; effect of anharmonicity; Morse potential; Vibration-rotational spectra of diatomics, polyatomic molecules-P,Q,R branches, normal modes of vibration, overtones, hot bands drawbacks of dispersive IR, FTIR

**1.4 Raman spectroscopy:** scattering of light, polarizability and classical theory of Raman spectrum, rotational and vibrational Raman spectrum, complementarities of Raman and IR spectra, mutual exclusion principle, polarized and depolarized Raman lines, resonance Raman scattering and resonance fluorescence. Principle of SERS, selection rules, application. Comparison of IR and Raman.

**Unit 2 Electron & Electronic Spectroscopy & Lasers (13hours)**

**2.1 Electron Spectroscopy:** Basic principles, photoelectron spectra of simple molecules, selection rules-Electron spectroscopy for chemical analysis (ESCA)-UPS, X-ray photoelectron spectroscopy (XPS), Auger electron spectroscopy (AES).

**2.2 Electronic spectroscopy:** Electronic spectra of diatomic molecules, Franck-Condon principle, Vibronic transitions, Spectra of organic compounds,  $\pi \rightarrow \pi^*$ ,  $n \rightarrow \pi^*$  transition.

**2.3 Lasers:** Laser action, population inversion, properties of laser radiation, two stage, three stage-examples of simple laser systems.

**Unit 3: Resonance Spectroscopy (27 Hrs.)**

**3.1 NMR spectroscopy :** interaction between nuclear spin and applied magnetic field, nuclear energy levels, population of energy levels, Larmor precession, relaxation methods, chemical shift, representation, examples of AB, AX and AMX types, exchange phenomenon, factors influencing coupling, Karplus relationship. FTNMR, second order effects on spectra, spin systems (AB, AB<sub>2</sub>), simplification of second order spectra, chemical shift reagents, high field NMR, double irradiation, selective decoupling, double resonance, NOE effect, two dimensional NMR, COSY and HETCOR, <sup>13</sup>C NMR, natural abundance, sensitivity, <sup>13</sup>C chemical shift and structure correlation, <sup>19</sup>F, <sup>31</sup>P, NMR spectroscopy.

**3.2 EPR spectroscopy:** electron spin in molecules, interaction with magnetic field, g factor, factors affecting g values, determination of g values (g<sub>||</sub> and g<sub>⊥</sub>), fine structure and hyperfine structure, Kramers' degeneracy, McConnell equation. An elementary study of NQR spectroscopy.

**3.3 Mossbauer spectroscopy:** principle, Doppler effect, recording of spectrum, chemical

shift, factors determining chemical shift, application to the structural elucidation of metal complexes

### References

1. C.N. Banwell, E.M. McCash, Fundamentals of Molecular Spectroscopy, 4<sup>th</sup> Edn., Tata McGraw Hill, 1994.
2. G. Aruldas, Molecular Structure and Spectroscopy, Prentice Hall of India, 2001.
3. P.W. Atkins, Physical Chemistry, ELBS, 1994
4. R.S. Drago, Physical Methods in Inorganic Chemistry, Van Nostrand Reinhold, 1965.
5. R.S. Drago, Physical Methods in Chemistry, Saunders College, 1992.
6. K.J. Laidler, J.H. Meiser, Physical Chemistry, 2<sup>nd</sup> Edn. CBS, 1999.
7. W. Kemp, NMR in chemistry-A Multinuclear Introduction, McMillan, 1986.
8. H. Kaur, Spectroscopy, 6<sup>th</sup> Edn. Pragati Prakashan, 2011.
9. H. Gunther, NMR Spectroscopy, Wiley, 1995.
10. D.A. McQuarrie, J.D. Simon, Physical Chemistry: A Molecular Approach, University Science Books, 1997.
11. D.N. Sathyanarayan, Electronic Absorption Spectroscopy and Related Techniques, Universities Press, 2001.
12. D.N. Sathyanarayana, Vibrational Spectroscopy: Theory and Applications, New Age International, 2007.
13. D.N. Sathyanarayana, Introduction to Magnetic Resonance Spectroscopy ESR, NMR, NQR, IK International, 2009.
14. J. D. Graybeat. Molecular Spectroscopy, McGraw-Hill International Edition (1988)

**16P2CHET08 Theoretical and Computational Chemistry****Credit: 3****Contact Lecture Hours: 72****Unit 1: Approximate Methods in Quantum Mechanics (21 Hrs)**

Many-body problem and the need of approximation methods, independent particle model. Variation method, variation theorem with proof, illustration of variation theorem using the trial function  $\psi(a-x)$  for particle in a 1D-box and using the trial function  $e^{-ar}$  for the hydrogen atom, variation treatment for the ground state of helium atom.

Perturbation method, time-independent perturbation method (non-degenerate case only), first order correction to energy and wave function, illustration by application to particle in a 1D-box with slanted bottom, perturbation treatment of the ground state of the helium atom.

Hartree-Fock method. Multi-electron atoms. The antisymmetry principle and the Slater determinant. Hartree-Fock equations (no derivation). The Fock operator. Core Hamiltonian. Coulomb operator and exchange operator. Slater-type orbitals (STOs) as basis functions. Orbital energies and total energy. Helium atom example. Koopman's theorem. Electron correlation energy. The Hartree-Fock method for molecules. Restricted and unrestricted HF calculations. The Roothaan equations.

**Unit 2: Chemical Bonding (21 Hrs)**

Schrödinger equation for molecules. Born-Oppenheimer approximation. Valence Bond (VB) theory, VB theory of H<sub>2</sub> molecule, singlet and triplet state functions (spin orbitals) of H<sub>2</sub>.

Molecular Orbital (MO) theory, MO theory of H<sub>2</sub><sup>+</sup> ion, MO theory of H<sub>2</sub> molecule, MO treatment of homonuclear diatomic molecules Li<sub>2</sub>, Be<sub>2</sub>, N<sub>2</sub>, O<sub>2</sub> and F<sub>2</sub> and hetero nuclear diatomic molecules LiH, CO, NO and HF. Bond order. Correlation diagrams, non-crossing rule. Spectroscopic term symbols for diatomic molecules. Comparison of MO and VB theories.

Hybridization, quantum mechanical treatment of sp, sp<sup>2</sup> and sp<sup>3</sup> hybridisation. Semiempirical MO treatment of planar conjugated molecules, Hückel Molecular Orbital (HMO) theory of ethene, allyl systems, butadiene and benzene. Calculation of charge distributions, bond orders and free valency.

Froniter Molecular Orbitals- Woodward-Hoffmann rule-Introduction to global and local reactivity descriptors-electrophilicity index

**Unit 3: Computational Quantum Chemistry (18 hrs)**

Introduction and scope of computational chemistry. Potential energy surface - Conformational search - Global minimum, Local minima, saddle points. Conformational analysis of ethane and butane.

Ab initio methods: A review of Hartree-Fock method. Self Consistent Field Procedure. Roothan concept basis functions. Basis sets, Slater type and Gaussian type basis sets, Minimal basis set. Pople style basis sets - Classification - double zeta, triple zeta, split valence, polarization and diffuse basis sets, contracted basis sets, Hartree-Fock limit. Post Hartree-Fock methods. Introduction to Møller Plesset Perturbation Theory, Configuration Interaction, Coupled Cluster and semi empirical methods.

Introduction to Density Functional Theory (DFT) methods: Hohenberg-Kohn theorems. Kohn-Sham orbitals. Exchange correlation functional. Local density approximation. Generalized gradient approximation. Hybrid functionals (only the basic principles and terms need to be introduced).

Comparison of ab initio, semi empirical and DFT methods.

#### **Unit 4: Model Chemistry and Molecular Simulations (12 Hrs)**

Introduction to computational chemistry software packages. Generating molecular structures Cartesian coordinates, internal coordinates and Z-matrix of simple molecules. Introduction to computational chemistry calculations using simple molecular structures of water, ammonia, methane, butane, benzene. Input file format - Method, Basis Set, Calculation type, Spin Multiplicity, Coordinate format. Single Point Energy, Geometry Optimization, Frequency Analysis.

Computational Chemistry using Statistical mechanics, Features of molecular mechanics force field-bond stretching, angle bending, torsional terms, non-bonded interactions and electrostatic interactions. Commonly used force fields AMBER and CHARMM. Molecular dynamics simulations. Introduction to simulation softwares. Protein data bank (PDB) and Protein structure file (PSF) formats. Practical aspects of computer simulation. Analyzing the results of a simulation.

#### Reference

##### **For Unit 1 & 2**

1. I.N. Levine, Quantum Chemistry, 6th Edn., Pearson Education, 2009.
2. D.A. McQuarrie, Quantum Chemistry, University Science Books, 2008.
3. R.K. Prasad, Quantum Chemistry, 3rd Edn., New Age International, 2006.
4. C.N. Datta, *Lectures on Chemical Bonding and Quantum Chemistry*, Prism Books Pvt. Ltd., 1998.
5. F.L. Pilar, *Elementary Quantum Chemistry*, McGraw-Hill, 1968.
6. P.W. Atkins and R.S. Friedman, *Molecular Quantum Mechanics*, 4th Edition, Oxford University Press, 2005.
7. J.P. Lowe, *Quantum Chemistry*, 2nd Edition, Academic Press Inc., 1993.
8. Horia Metiu, *Physical Chemistry – Quantum Mechanics*, Taylor & Francis, 2006.
9. A.K. Chandra, *Introduction to Quantum Chemistry*, 4th Edition, Tata McGraw-Hill, 1994.
10. L. Pauling and E.B. Wilson, *Introduction to Quantum Mechanics*, McGraw-Hill, 1935 (A good source book for many derivations).
11. Frontier Orbitals and Organic Chemical Reactions, I. Fleming, Wiley, London, 1976.

12. Density functional theory of atoms and molecules, R G Parr and W Yang;
13. Chemical hardness: Applications from Molecules to Solids, R G Pearson.

#### For Unit 3 & 4

1. E.G. Lewars, Computational Chemistry: Introduction to the Theory and Applications of Molecular and Quantum Mechanics, 2nd Edn., Springer, 2011.
2. F. Jensen, Introduction to computational chemistry, 2nd Edn., John Wiley & Sons, 2007.
3. Michael Springborg, Methods of Electronic-Structure Calculations: From Molecules to Solids John Wiley & Sons, 2000.
4. W. Koch, M.C. Holthausen, "A Chemist's Guide to Density Functional Theory", Wiley-VCH Verlag 2000
5. K.I. Ramachandran, G. Deepa, K. Namboori, Computational Chemistry and Molecular Modeling: Principles and Applications, Springer, 2008.
6. A. Hinchliffe, Molecular Modelling for Beginners, 2nd Edn., John Wiley & Sons, 2008.
7. C.J. Cramer, Essentials of Computational Chemistry: Theories and Models, 2<sup>nd</sup> Edn., John Wiley & Sons, 2004.
8. J. Foresman & Aelieen Frisch, *Exploring Chemistry with Electronic Structure Methods*,
9. Gaussian Inc., 2000.
10. D.C. Young, Computational Chemistry: A Practical Guide for Applying Techniques to Real-World Problems, John Wiley & Sons, 2001.
11. D. Rogers *Computational Chemistry Using the PC, 3rd Edition*, John Wiley & Sons (2003).
12. A. Leach, Molecular Modelling: Principles and Applications, 2nd Edn., Longman, 2001.
13. J. M. Haile (2001) *Molecular Dynamics Simulation: Elementary Methods*.
14. Stote, R. H., Dejaegere, A. and Karplus, M. (1997). Molecular Mechanics and Dynamics Simulations of Enzymes. Computational Approaches to Biochemical Reactivity. Netherlands, Kluwer Academic Publishers.  
(For pdb,psf file formats and molecular dynamics simulations )
15. <http://www.ks.uiuc.edu/Training/Tutorials/namd/namd-tutorial-win.pdf>
16. <http://www.ks.uiuc.edu/Training/Tutorials/vmd/vmd-tutorial.pdf>
17. List of some Free and Commercial Computational Chemistry Softwares

#### **Drawing & Visualization**

Chem Draw, Avagadro, Discovery Studio Client, Gabedit, Open Babel, Gauss view, Pymol, VMD

#### **Quantum Chemistry Softwares**

Firefly, Gamess, Spartan, Molpro, Gaussian, Dmol3, Turbomole

#### **Molecular Mechanics and Dynamics Softwares**

NAMD, Tinker, DL-POLY, CHARMM, AMBER

**SEMESTERS 1 AND 2**  
**16P2CPHP01 INORGANIC CHEMISTRY PRACTICAL-1**

**Credit: 3**

**Contact Lab Hours: 54+54=108**

**PART I**

Separation and identification of two less familiar metal ions such as Tl, W, Se, Mo, Ce, Th, Ti, Zr, V, U and Li. Anions which need elimination not to be given.

Minimum eight mixtures to be given.

**PART II**

Colorimetric estimation of Fe, Cu, Ni, Mn, Cr,  $\text{NH}_4^+$ , nitrate and phosphate ions.

**PART III**

Preparation and characterization complexes using IR, NMR and electronic spectra.

- (a) Tris (thiourea) copper(I) complex
- (b) Potassium tris (oxalate) aluminate (III).
- (c) Hexammine cobalt (III) chloride.
- (d) Tetrammine copper (II) sulphate.
- (e) Schiff base complexes of various divalent metal ions.

**PART IV**

Chromatography

Separation, Identification and determination of  $R_f$  values of

- a) Pb, Hg, Cu, Cd ions using paper chromatography
- b) Fe, Al, Cr ions using paper chromatography
- c) Ni, Mn, Co and Zn ions using TLC

**References**

01. A.I. Vogel, G. Svehla, Vogel's Qualitative Inorganic Analysis, 7th Edn., Longman, 1996.
02. A.I. Vogel, A Text Book of Quantitative Inorganic Analysis, Longman, 1966.
03. I.M. Kolthoff, E.B. Sandell, Text Book of Quantitative Inorganic analysis, 3rd Edn., McMillan, 1968.
04. V.V. Ramanujam, Inorganic Semimicro Qualitative Analysis, The National Pub.Co., 1974.

**16P2CPHP02 ORGANIC CHEMISTRY PRACTICAL- 1**

**CREDIT: 3**

**Contact Lab Hours: 54+54=108**

**PART I**

General methods of separation and purification of organic compounds such as:

1. Solvent extraction.
2. Soxhlet extraction of a natural product from its source.
3. Fractional crystallization.
4. TLC and Paper Chromatography
5. Column Chromatography.

**PART II**

1. Separation of Organic binary mixtures by chemical/physical separation methods.
2. Purification of organic compounds by column chromatography.
3. Record the IR spectrum of simple organic compounds and Identification of the functional groups.

**PART III**

Drawing the structures of organic molecules and reaction schemes by Chems sketch.

1. Cycloaddition of diene and dienophile (Diels-Alder reaction)
2. Oxidation of primary alcohol to aldehyde and then to acid
3. Benzoin condensation
4. Esterification of simple carboxylic acids
5. Aldol condensation

**References**

1. A.I.Vogel, *A Textbook of Practical Organic Chemistry*, Longman, 1989.
2. A.I.Vogel, *Elementary Practical Organic Chemistry*, Longman, 1957.
3. F.G.Mann and B.C Saunders, *Practical Organic Chemistry*, 2009.
4. J.R.Johnson, J.F.Wilcox, *Laboratory Experiments in Organic Chemistry*, Macmillan, 1979.



**16P2CPHP03 PHYSICAL CHEMISTRY PRACTICAL-I**

**(Credit: 3 Contact Lab Hours: 72+72 =144**

**(One question each from both parts A and B will be asked for the examination)**

**Part A**

**I. Adsorption**

1. Verification of Freundlich and Langmuir adsorption isotherm: charcoal-acetic acid or charcoal-oxalic acid system.
2. Determination of the concentration of the given acid using the isotherms.

**II. Phase diagrams**

1. Construction of phase diagrams of simple eutectics.
2. Effect of (KCl/succinic acid) on miscibility temperature.
3. Construction of phase diagrams of three component systems with one pair of partially miscible liquids.

**III. Distribution law**

1. Distribution coefficient of iodine between an organic solvent and water.
2. Distribution coefficient of benzoic acid between benzene and water.
3. Determination of the equilibrium constant of the reaction  $KI + I_2 \leftrightarrow KI_3$

**IV. Surface tension**

1. Determination of the surface tension of a liquid by
  - a) Drop number method
  - b) Drop weight method
2. Determination of the composition of two liquids by surface tension measurements
3. To determine the critical Micelle concentration of sodium lauryl sulphate
4. Determine the surface excess of amyl alcohol.

**References**

01. J.B. Yadav, Advanced Practical Physical Chemistry, Goel Publishing House, 2001.
02. G.W. Garland, J.W. Nibler, D.P. Shoemaker, Experiments in Physical Chemistry, 8th Edn. McGraw Hill, 2009.
03. B. Viswanathan, Practical Physical chemistry, Viva Pub., 2005
04. Saroj Kumar and Naba Kumar, Physical Chemistry Practical, New Central Book Agency, 2012
05. Practical Physical Chemistry Paperback, 1974  
by A.M. James , F.E. Prichard.

**Part B**

**List of Computational Chemistry Experiments**

**(Second Module of Physical Chemistry Practical -I )**

(These experiments are related to the topics in organic chemistry and physical chemistry covered in BSc-MSc Chemistry courses. From the list of experiments we can select the performable experiments depend on the availability of time and suitable computational chemistry software)

1. Geometry optimization and single point energy calculations of simple organic molecules
2. Calculation of energy gap between HOMO and LUMO in simple molecules and visualization of molecular orbitals
3. Calculation of dipole moment in polar organic molecules.

4. Calculation of electrostatic charges of atoms in organic molecules using population analysis
5. Calculation of Resonance energy of aromatic compounds
6. Prediction of the stability of ortho,meta, para products of nitration of aromatic ring using computational chemistry calculations.
7. Calculation of IR stretching frequencies of groups and visualization of normal modes of vibration in organic molecules.
8. Calculation of dimerization energy of carboxylic acids
9. Perform the conformational analysis of butane using potential energy scan
10. Find the transition state of simple organic reactions and plot the reaction profile.
11. Determination of heat of hydration of organic molecules.
12. Find the Gibbs free energy of simple gaseous phase reactions and calculate equilibrium constant.
13. Spectral analysis (UV, IR and NMR) of simple organic molecules.
14. Perform molecular dynamic simulations of smaller molecules in water.
15. Calculation of pka of simple organic molecules and compare it with experimental values
16. Docking studies involving protein ligand interactions.
17. Calculation of electrophilicity index in hard-soft acids and bases.

#### **Reference**

1. J. Foresman & Aelieen Frisch, *Exploring Chemistry with Electronic Structure Methods*, Gaussian Inc., 2000.
2. D.C. Young, *Computational Chemistry: A Practical Guide for Applying Techniques to Real-World Problems*, John Wiley & Sons, 2001.
3. D. Rogers *Computational Chemistry Using the PC, 3rd Edition*, John Wiley & Sons (2003).
4. A. Leach, *Molecular Modelling: Principles and Applications*, 2nd Edn, Longman, 2001.
5. J. M. Haile (2001) *Molecular Dynamics Simulation: Elementary Methods*.

**Semester 3**  
**Pharmaceutical Chemistry I**

**Credit: 4**

**Contact Lecture Hours: 72**

**16P3CPHT09 Drug Design and Pharmacology**

**Unit 1: Pharmacology (12 Hrs)**

**1:1 Drugs and Drug targets-** Enzymes: active sites, mechanism of catalysis, Enzyme inhibitors, Enzyme selectivity, Receptors ligand gated ionic channels, G-Protein coupled receptors, Kinase linked receptors. Carrier Proteins, Structural Proteins, Nucleic acids, Lipids and carbohydrates and DNA as drug targets

**1.2 Structure activity relationship,** Binding interactions, Functional groups as binding groups, Concept and definition of pharmacophore

**1: 3 Pharmacokinetic principles:** absorption, distribution, metabolism and excretion of drugs. Dose of drugs and routes of administration. .Drug dosing, drug half life, Steady state concentration, Drug tolerance, Bioavailability, Drug delivery.

**1:4 Pharmacodynamic principles :** Examples of agonists, allosteric modulators, Antagonists, Partial agonists, Inverse agonists, Desensitization and sensitization, Tolerance and dependence, Affinity, efficacy and potency.

**1:5 Dose response relationships,** unusual and adverse responses of drugs, structurally specific and nonspecific drugs. Ferguson's principle.

**UNIT 2: Toxicology and Biotransformations (12 hours)**

**Receptor Theories**

2.1 Receptor theories and receptor models- rate, occupancy, induced fit, activation-aggregation and molecular perturbation theories

2.2 General concepts of toxicity, Acute, subacute & chronic toxicity tests, teratogenicity & carcinogenicity,, LD50, ED50, MIC- anti infectives, habituation & addiction

2.3 Biotransformations of Drugs, factors affecting biotransformation, site of biotransformations, Effect of biotransformation on the biological activity of drugs, alterations in. Phase I biotransformations Biotransformation- Oxidation, reduction, hydroxylation, hydrolysis-illustrate reactions and mechanism with specific drug molecules Phase II biotransformations -glucosidation, sulfation, conjugation with glutathione, acetylation methylation- illustrate with suitable drug molecules. Chemical and pharmacological roles of Phase I & phase II transformations.

**UNIT: 3 Anti infective Agents: (12 Hour)**

3.1. Sulphonamides- structure, chemistry, SAR and mechanism of action Sulfadiazine, sulfamethoxazole, sulfones, cotrimoxazole (sulfamethoxazole + trimethoprim.) Sulfonamides: Synthesis of: Sulfadiazine, sulfamethoxazole, pyrimethamine, Dapsone

3.2. Antifungal agents: study of the following- Amphotericin B, griseofulvin, nystatin, ketoconazole, clotrimazole, fluconazole, 5-fluorouracil.

3.3. Other Antiprotozoal agents: Chemistry, mechanism of action and therapeutic uses of Anti Amoebic and Anthelmintics:

3.4 Antiviral agents: Antiviral drugs- mode of action and therapeutic uses, Chemistry and mechanism of action of- amantadine, ribavirin. Abacavir, acyclovir, oseltamivir, zidovudine, ganciclovir, foscarnet, didanosine. Synthesis of:

3.5.Synthesis of –, Sulphanilamide, Dapsone, Grisofulvin, 5-flucytosine,acyclovir, Adefovir, Combivir, Didanisine, ganciclovir

#### **UNIT 4: Drugs acting on CVS (12 Hrs)**

##### **Pharmacology and SAR/ recent advances of the following classes of drugs**

4.1 Cardiotoxic drugs: cardiac glycosides-their chemistry digoxin and digitoxin.,**synthesis of**Dobutamide,milrinone

4.2Antiarrhythmic drugs: quinidine, disopyramide, lidocaine, phenytoin and procainamide,  $\beta$ -blockers-propranolol. Calcium channel blockers-verapamil **synthesis of** lidocaine,phenytoin,bretilium

Neurone blockers-bretilium.

4.3 Antihypertensive Drugs: peripheral antiadrenergics-prazosin and terazosin. reserpine, clonidine and methyl dopa $\beta$ -atenolol and labetalol. Calcium channel blockers-nifedipineandamlodipine. ACE inhibitors-captopril. Angiotensin receptor blockers- losartan.Diuretics-thiazide diuretics.**Synthesis of:** captopril, methyl DOPA, amlodipine.

4.4.Antianginal drugs: vasodilators-nitrites and nitrates,  $\beta$ -blockers-propranolol.Calcium channel blockers-verapamil and nifedipine. Miscellaneous-dipyridamoland aspirin

**Synthesis :** verapamil

4.5:Anticoagulants: heparin, coumarin derivatives and indanedione derivatives.

4.6:Antilipidemic agents: Statins-lovastatin,simvastatin, fluvastatin.

Synthesis of fluvastatin.

Fibrates-clofibrate, and cholestyramine resin.

**Syntheses of:**fulvastatin, clofibrate, dicoumarol.

#### **UNIT 5: Chemotherapeutic Agents - (12 Hours)**

5.1.Antibiotics- Classification, mechanism of action and therapeutic uses.- penicillin, cephalosporins, Quinolones, Aminoglycosides, Carbapenems, macrolide and others. Antibiotic resistance mechanism and implications in therapeutics.

**Synthetic studies of :**Penicillin V, Cefotaxim, Meropenem, Strptomycine, Ciprofloxacin, Trimethoprim.

5.2. Chemotherapy of Tuberculosis: First line Drugs and second line drugs- chemistry Pharmacology. The problem of MDR tuberculosis.Recent innovations.

**Synthesis of:** isoniazid, pyrazinamide, ethionamide, paraaminosalicylic acid.

5.3. Antimalarials :

Chemotherapy of Malaria, mode of action of the various classes of drugs used, Chemistry, SAR and Drug resistance. Study of the following drugs in the treatment , efficacy , problem of side effects- Quinesulphate, Chloroquine, primaquine, mephloquine, quinacrine ,proguanil, plaquenil and drug combinations in the therapy of Malarial parasite. Treatment of drug resistant malaria, recent progress. **Synthetic studies of** chloroquine, primaquine, proguanil, malarone.

#### **Unit 6: Analgesics, Antipyretic&Antiinflammatory drugs (12Hrs)**

##### **Mechanism of action and SAR of:**

5.1 Different types of analgesia

5.2 Narcotic analgesics - morphine and codeine, phenyl(ethyl) piperidines, Diphenylheptanones, fentanyl analogues, nalfurafine

5.3 Antipyretics and NSAIDs: Basic idea of COX I & II inhibitors, salicylates - aspirin, p-aminophenol derivatives-paracetamol, phenacetin, pyrazolidinediones - phenylbutazone, anthranilic acid derivatives - flufenamic acid, indoleacetic acid derivatives-indomethacin, arylacetic/propionic acid derivatives (ibuprofen, ketoprofen, flubiprofen and diclofenac), oxicams - tenoxicam

5.4 Drugs used for gout - allopurinol, Colchicine, Pegloticase

5.5 Antiinflammatory: Sulindac, Naproxen

5.6 Novel Analgesics: Funapide, Raxatrigine (Structure only).

5.7 **Synthesis of** the following drugs-levorphanol, pethidine, methadone, phenyl butazone, flufenamic acid, diclofenac, tenoxicam, allopurinol and Codeine, Ketoprofen, Naproxen.

### References

01. G. Patrick, Medicinal Chemistry, BIOS. 2001.
02. T. Nogrady, D.F. Weaver, Medicinal Chemistry, Oxford University Press, 2005.
03. W.O. Foye, T.L. Lemke, D.A. Williams, Principles of Medicinal Chemistry, 4<sup>th</sup>Edn., Williams & Wilkins, 1995.
04. J.P. Remington, Remington's Pharmaceutical Sciences, Vol.13, , 19th Edn., Mack,1990.
05. D. Sriram , P. Yogeswari, Medicinal Chemistry, Pearson Education India, 2010.
06. K. D. Tripathi, Essentials of Medical Pharmacology, 6th Edn.,Jaypee, 2008
07. L.S. Goodman, A. Gillman, The Pharmacological Basis of Therapeutics, 10<sup>th</sup>Edn., McGraw Hill, 2001.
08. S.S. Kadam, Principles of Medicinal Chemistry, Vol.I& II, Pragati Books, 2008.
09. A. Kar, Medicinal Chemistry, New Age International, 2007.
10. C.O. Wilson, J.M. Beale, J.H. Block, Textbook of Organic Medicinal and Pharmaceutical Chemistry, 12th Edn., Lippincott Williams and Wilkins, 2010

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**16P3CPHT10 ORGANIC SYNTHESSES****Credit : 4****Contact Lecture Hours: 72 Hrs.****Unit1: Organic Synthesis via Oxidation and Reduction (18 Hrs)**

- 1.1 Survey of organic reagents and reactions in organic chemistry with special reference to oxidation and reduction. Metal based and non-metal based oxidations of (a) alcohols to carbonyls (Chromium, Manganese, aluminium and DMSO based reagents). (b) alkenes to epoxides (peroxides/per acids based)- Sharpless asymmetric epoxidation, Jacobsen epoxidation, Shi epoxidation. (c) alkenes to diols (Manganese and Osmium based)- Prevost reaction and Woodward modification (d) alkenes to carbonyls with bond cleavage (Manganese and lead based, ozonolysis) (e) alkenes to alcohols/carbonyls without bond cleavage- hydroboration-oxidation, Wacker oxidation, selenium, chromium based allylic oxidation (f) ketones to ester/lactones- Baeyer-Villiger.
- 1.2 (a) Catalytic hydrogenation (Heterogeneous: Palladium/Platinum/Rhodium and Nickel. Homogeneous: Wilkinson). (b) Metal based reductions- Birch reduction, pinacol formation, acyloin formation (c) Hydride transfer reagents from Group III and Group IV in reductions -  $\text{LiAlH}_4$ , DIBAL-H, Red-Al,  $\text{NaBH}_4$  and  $\text{NaCNBH}_3$ , Selectrides, trialkylsilanes and trialkylstannane, Meerwein-Ponndorf-Verley reduction, Baker's yeast.

**Unit2: Modern Synthetic Methods and Reagents (15Hrs)**

- 2.1 Baylis-Hillman reaction, Henry reaction, Nef reaction, Kulinkovich reaction, Ritter reaction, Sakurai reaction, Tishchenko reaction and Ugi reaction, Noyori reaction. Brook rearrangement, Tebbe olefination. Metal mediated C-C and C-X coupling reactions: Heck, Stille, Suzuki, Suzuki-Miyaura, Negishi and Sonogashira reactions, Nozaki-Hiyama, Buchwald-Hartwig, Ullmann and Glaser coupling reactions. Wohl-Ziegler reaction. Mitsunobu reaction, Michael addition and Reformatsky reactions
- 2.2 Reagents such as: NBS, DDQ, DCC. Gilman reagent.

**Unit3: Construction of Carbocyclic and Heterocyclic Ring Systems (12Hrs)**

- 3.1 The synthesis of four, five and six-membered rings- ketene cycloaddition (inter- and intramolecular)- Pauson-Khand reaction, Volhardt reaction, Bergman cyclization, Nazarov cyclization, radical cyclization, Robinson annulation.
- 3.2 Inter-conversion of ring systems (contraction and expansion)- Demjénov reaction. Construction of macrocyclic rings - ring closing metathesis.
- 3.3 Formation of heterocyclic rings: Preparation and structure of the following heterocyclics- aziridine, oxirane, thirane, oxaziridine, azetidine and thietane, 5-membered ring heterocyclic compounds with one or more than 1 hetero atom like N, S or O- Pyrrole, furan, thiophene, imidazole, thiazole and oxazole.

**Unit4: Protecting Group Chemistry (9Hrs)**

- 4.1 Protection and deprotection of hydroxy, carboxyl, carbonyl, and amino groups. Chemo- and regioselective protection and deprotection. Illustration of protection and deprotection in synthesis.

- 4.2 Protection and deprotection in peptide synthesis: Common protecting groups used in peptide synthesis- Protecting groups used in solution phase and solid phase peptide synthesis (SPPS).
- 4.3 Role of trialkyl silyl group in organic synthesis.

**Unit5: Retrosynthetic Analysis (9Hrs.)**

- 5.1 Basic principles and terminology of retrosynthesis: synthesis of aromatic compounds- one group and two group C-X disconnections - one group C-C and two group C-C disconnections.
- 5.2 Amine and alkene synthesis: important strategies of retrosynthesis - functional group transposition - important functional group interconversions. Enantioselective synthesis of Corey lactone, longifolene and luciferin. Umpolung equivalence - Peterson olefination - enolate formation - Ireland method.

**Unit6: Molecular Recognition and Supramolecular Chemistry (9Hrs.)**

- 6.1 Concept of molecular recognition- host-guest complex formation- Forces involved in molecular recognition.
- 6.2 Molecular receptors: Cyclodextrins, crown ethers, cryptands, spherands, tweezers, carcerands, cyclophanes, calixarenes.
- 6.3 Importance of molecular recognition in nucleic acids and protein.
- 6.4 Applications of supramolecular complexes in medicine- targeted drug delivery.

**References**

1. M. B. Smith, *Organic Synthesis*, 3<sup>rd</sup> Edition, Wavefunctions Inc, 2011.
2. F.A. Cary and R. I. Sundberg, *Advanced Organic Chemistry*, Part A and B, 5th Edition, Springer, 2009.
3. S. Warren, *Organic Synthesis, The disconnection Approach*, John Wiley & Sons, 2004.
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7. J. Clayden, N. Greeves, S. Warren and P. Wothers, *Organic Chemistry*, Oxford University Press, 2001.
8. R. Noyori, *Asymmetric Catalysis in Organic Synthesis*, John Wiley & Sons, 1994.
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10. Solomons, T. W. G., *Organic Chemistry*, 6th ed, 1996.
11. R.O.C Norman, J.M.Coxon, *Principles of Organic Synthesis*, ELBS and Chapman and Hall, London, 1995.
12. V.K. Ahluwalia, L.S. Kumar, S. Kumar, *Chemistry of Natural Products*, Ane Books, New Delhi, 2009.
13. Joule, J.A. and Mills, K. *Heterocyclic Chemistry*, Fifth Edition, Wiley, 2010.
14. J.M. Lehn, *Supramolecular Chemistry: Concepts and Perspectives*, VCH, 1995.
15. F. Vogtle, *Supramolecular Chemistry: An Introduction*, John Wiley Sons, 1993.

**16P3CPHT11 PHYSICAL CHEMISTRY III****Credit 3****72hrs****UNIT 1 CHEMICAL KINETICS I (14 hours)**

**1.1 Theories of reaction rates:** Collision theory-steric factor, potential energy surfaces. Conventional transition state theory-Eyring equation, Comparison of the two theories. Thermodynamic formulation of the two theories. Thermodynamic formulation of the reaction rates. Significance of  $\Delta G^*$ ,  $\Delta H^*$  and  $\Delta S^*$ . Volume of activation. Effect of pressure and volume on velocity of gas reactions. **Introduction** to Molecular Reaction Dynamics

**1.2 Lindemann-Hinshelwood mechanism,** qualitative idea of RRKM theory, chain reactions, free radical and chain reactions, steady state treatment, kinetics of  $H_2-Cl_2$  and  $H_2-Br_2$  reactions, Rice-Herzfeld mechanism, Branching chains  $H_2-O_2$ , Semenov-Hinshelwood mechanism of explosive reactions.

**1.3 Kinetics of polymerization:** mechanism of step growth, ionic and addition polymerization, kinetics of anionic and cationic polymerization.

**1.4 Fast reactions:** relaxation, Flow and Shock methods, Flash photolysis. NMR and ESR as methods of studying fast reactions.

**UNIT 2: CHEMICAL KINETICS -II (14 Hrs.)**

**2.1 Reactions in solution:** factors determining reaction rates in solutions, effect of dielectric constant and ionic strength, cage effect, Bronsted-Bjerrum equation, primary and secondary kinetic salt effect, influence of solvent on reaction rates, significance of volume of activation, linear free energy relationship, kinetic isotope effect.

**2.2 Homogenous catalysis** -Acid-base catalysis: van't Hoff and Arrhenius intermediates for prototropic and protolytic mechanisms with examples specific and general catalysis, Skrabal diagram, Bronsted catalysis law, acidity function.

**2.3 Enzyme catalysis** and its mechanism, Michelis-Menten equation, effect of pH and temperature on enzyme catalysis.

**2.4 Heterogeneous catalysis** Mechanisms of: unimolecular and bimolecular surface reactions, Langmuir-Hinshelwood and Langmuir-Rideal mechanism-ARRT of surface reactions-mechanisms of catalyzed reactions like ammonia synthesis, hydrogenation of ethylene and catalytic cracking of hydrocarbons and related reactions.

**UNIT 3. ELECTROCHEMISTRY I****(12 hours)**

**3.1 Theories of ions in solution,** Ion activity, Ion-ion and ion-solvent interaction, Born's model, Debye-Huckel theory, Ionic atmosphere. The Debye-Huckel-Onsager conductance equation-its derivation and experimental verification- validity of DHO equation for aqueous and non-aqueous solutions. Deviations from DHO conductance equation. Extension of DHO equation to ion solvent interactions, Debye-Huckel Bjerrum model, Ion association, triple ions, triple ions and conductance minima. Ionic strength, Ionic activity coefficients of strong electrolytes- Derivation of Debye-Huckel limiting law.

**3.2 Conductance measurements,** results of conductance measurements, Factors affecting conductance, Debye Falkenhagen and Wien effects, Walden rule, abnormal ionic conductance.

**UNIT 4. SURFACE CHEMISTRY & COLLOIDS (18hrs)**

**4.1 Gas adsorption at solid surface** - influencing factors - bonding of adsorbate to solid - adsorption isotherms - Langmuir (derivation), BET (derivation) - determination of surface area.



**4.2 Spectroscopic techniques for probing solid surfaces** – Temperature programmed desorption (TPD), Reflection absorption infrared spectroscopy (RAIRS) High resolution electron energy loss spectroscopy (HREELS).

**4.3 Surface films** - film pressure - criteria for spreading of one liquid on another – surface pressure-structure of surface films - analogy between surface films and gases.

**4.4 Adsorption from solutions** - electrostatic adsorption - Gibbs adsorption isotherm (derivation) - verifications.

**4.5 Colloids & Micellar systems**–Types of colloids, electrical properties of colloids, electrical double layer, zeta potential- miscelles, and miscellisation - structure of miscelles - ionic miscelles.

**4.6 Electro kinetic effects** - electrophoresis, electro osmosis, streaming potential, sedimentation potential –Donnan membrane equilibrium.

## UNIT 5. PHOTOCHEMISTRY

(14 Hours)

**5.1 Laws of Photochemistry:** Grothus –Draper Law, Stark-Einstein's Law, Laws of light absorption, Quantum yield. Chemical actinometry, excimers and exciplexes, photosensitization, chemiluminescence, bioluminescence, thermo luminescence, pulse radiolysis, hydrated electrons, photo stationary state, dimerization of anthracene.

**5.2 Photo physical processes in electronically excited molecules,** Jablonsky diagram, Fluorescence and Phosphorescence. Quenching of fluorescence and its kinetics, Stern-Volmer equation, static and dynamic quenching. Concentration quenching, delayed fluorescence, E-type and P-type. Effect of temperature on emissions, two photon absorption spectroscopy,

**5.3 Photochemistry of environment,** greenhouse effect, principle of utilization of solar energy, solar cells and their working. Photochemistry of vision.

## References

1. J. Rajaram, J.C. Kuriakose, Kinetics and Mechanisms of Chemical Transformations, Macmillan India, 2000.
2. K.J. Laidler, Chemical kinetics, 3<sup>rd</sup>Edn. Harper & Row, 1987.
3. C. Kalidas, Chemical Kinetic Methods: Principles of Fast Reaction Techniques and Applications, New Age International, 2005.
4. J.W. Moore, R.G. Pearson, Kinetics and Mechanisms, John Wiley & Sons, 1981.
5. P.W. Atkins, Physical Chemistry, ELBS, 1994.
6. D.A. McQuarrie, J.D. Simon, Physical chemistry: A Molecular Approach, University Science Books, 1997
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9. G. Aruldas, Molecular structure and Spectroscopy, PHI Learning, 2007.
10. M.R Wright, An Introduction to Chemical Kinetics, John Interscience-2007
11. A.W & Sons, Adamson, A.P. Gast, Physical chemistry of surfaces, 6<sup>th</sup>Edn, John Wiley, 1997
12. D.O. Cowan, R.L. Drisko, Elements of Organic Photochemistry, Plenum Press, 1976

**16P3CHET12 SPECTROSCOPIC METHODS IN CHEMISTRY****Credit : 3****Contact Lecture Hours: 54****Unit1: Ultraviolet-Visible and Chiroptical Spectroscopy (9Hrs)**

- 1.1 Energy levels and selection rules- Woodward-Fieser and Fieser-Kuhn rules.
- 1.2 Solvent effect- Stereochemical effect-non-conjugated interactions. Applications.
- 1.3 Chiroptical properties- ORD, CD, octant rule, axial haloketone rule, Cotton effect.
- 1.4 Problems based on the above topics.

**Unit2: Infrared Spectroscopy (9Hrs)**

- 2.1 Fundamental vibrations - Characteristic regions of the spectrum (fingerprint and functional group regions).
- 2.2 Influence of substituents, ringsize, hydrogen bonding, vibrational coupling and field effect on frequency. Determination of stereochemistry by IR technique.
- 2.3 IR spectra of olefins and arenes, - C=C bonds and C=O bonds.
- 2.4 Problems-spectral interpretation with examples.

**Unit3: Nuclear Magnetic Resonance Spectroscopy (18 Hrs)**

- 3.1 A comparison of the NMR phenomena of  $^1\text{H}$  and  $^{13}\text{C}$  nuclei. Factors affecting chemical shift - relaxation processes, chemical and magnetic non-equivalence - local diamagnetic shielding and magnetic anisotropy. Proton and  $^{13}\text{C}$  NMR scales.
- 3.2 Spin-spin splitting: AX, AX<sub>2</sub>, AX<sub>3</sub>, A<sub>2</sub>X<sub>3</sub>, AB, ABC, AMX type coupling - First order and non-first order spectra - Pascal's triangle - coupling constant - mechanism of coupling, heteronuclear couplings-Karplus curve - quadrupole broadening and decoupling - diastereomeric protons - virtual coupling - long range coupling-epi, peri, bay effects. NOE - NOE and cross polarization.
- 3.3 Simplification non-first order spectra: shift reagents-mechanism, spin decoupling-double resonance and off resonance decoupling.
- 3.4 2D NMR, HOMOCOSY and HETEROCOSY
- 3.5 Polarization transfer. Selective Population Inversion - DEPT, INEPT and RINEPT-sensitivity enhancement and spectral editing- MRI.
- 3.6 Problems-Spectral interpretation with examples.

**Unit4: Mass Spectrometry (9Hrs.)**

- 4.1 Molecular ion: ion production methods (EI). Soft ionization methods: SIMS, FAB, CI, MALDI, Electrospray ionization.
- 4.2 Mass Analysis- Magnetic and electric fields, Quadrupole TOF and ion trap mass analysers.
- 4.3 Fragmentation patterns in EI MS,- nitrogen and ring rules-
- 4.4 McLafferty rearrangement - applications.
- 4.5 HRMS, MS-MS, MIKES, CAD, FTMS
- 4.6 LC-MS, GC-MS.
- 4.7 Problems-Spectral interpretation with examples.

**Unit5: Structural Elucidation Using Spectroscopic Techniques (9Hrs.)**

- 5.1 Identification of structures of unknown organic molecules based on the data from IR,  $^1\text{H}$ NMR and  $^{13}\text{C}$ NMR spectroscopy and mass spectroscopy (HRMS data or Molar mass or molecular formula may be given).
- 5.2 Interpretation of the given UV-Vis, IR, NMR and mass spectra.

### References

1. D.L. Pavia, G.M. Lampman, G.S.Kriz, *Introduction to Spectroscopy: A Guide for Students of Organic Chemistry* (3<sup>rd</sup> Ed.), Thomson. 2004.
2. W. Kemp, *Organic Spectroscopy*, 2nd edition, ELBS-Macmillan, 1987.
3. D. Nasipuri, *Stereochemistry of Organic Compounds: Principles and Applications*, Third Edition, New Age Publications, New Delhi, 2010.
4. D.F.Taber, *Organic Spectroscopic Structure Determination: A Problem Based Learning Approach*, Oxford University Press, 2009.
5. R. M. Silverstein, G.C. Bassler, T. C. Morrill, *Spectroscopic Identification of Organic Compounds*, John Wiley, 1991.
6. D. H. Williams, I. Fleming, *Spectroscopic Methods in Organic Chemistry*, Tata McGraw Hill, 1988.
7. F. Bernath, *Spectra of Atoms and Molecules*, 2nd Edition, Oxford University Press, 2005.
8. E. B. Wilson, Jr., J. C. Decius, P. C. Cross, *Molecular Vibrations: The Theory of Infrared and Raman Spectra*, Dover Publications, 1980.
9. Atta-Ur-Rahman, M.I. Choudhary, *Solving Problems with NMR Spectroscopy*, Academic Press, New York, 1996.
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11. Online spectroscopy problems and solutions like  
[www.orgchem.collarado.edu/Spectroscopy/Problems](http://www.orgchem.collarado.edu/Spectroscopy/Problems)  
[www.chem.ucla.edu/webSpectra](http://www.chem.ucla.edu/webSpectra)

## Semester 4

### Pharmaceutical Chemistry – II 16P4CPHT13EL BIOCHEMISTRY AND BACTERIOLOGY

Credit: 4

Hours: 90

#### Unit. I. (9 Hrs)

Biomolecules an over view- carbohydrates, proteins, glycoprotein and Lipids and their relevance in Pharmaceutical chemistry. Structure of cell membrane.

#### Unit: II. **AminoAcidsandProteins (12 Hrs)**

Structural and functional classification of proteins. Structure, Physicochemical properties, configuration and optional properties of amino acids, Purification of proteins and amino acids, sequence determination. Primary, Secondary Tertiary and Quaternary structure of Proteins. Protein folding, three dimensional structure of proteins. Solid phase peptide synthesis.

#### Unit: III (20 Hrs)

**1 Enzymes** Classification, Mechanism of enzymatic reactions, kinetics of enzymatic reactions, MichaelisMenton model, Measurement of significance of  $K_{max}$  and  $V_{max}$  perfect enzymes. Inhibition of enzymetic reactions. Kinetics of competitive and non-competitive Inhibition. Allosteric enzymes Mechanism of enzymatic catalysis by Lysozyme and carboxypeptidase, Zymogens.

**2. Coenzymes** Classification, Structure and Function of Nicotinamide adenine dinucleotides (NAD and NADP), Riboflavin Nucleotides (FMN and FAD), Biological oxidation and reduction, Lipoic acid, Cytochromes, Pyridoxal phosphate, Nucleoside diphosphates. Tetrahydrofolic acid conjugates, Biotinyl coenzyme. Coenzyme - A, and Thiamine pyrophosphate.

**3. Biotechnological Application of Enzymes** Large scale production and purification of enzymes, Techniques and method of immobilization of enzymes, effect of immobilization on enzyme activity, Application of immobilized enzymes, use of enzymes as targets for drug design. Clinical uses of enzyme therapy, Enzymes and recombinant DNA technology. Genomic Library.

#### Unit: IV (18 Hrs)

**1. Nucleic acids:** Nucleic acid bases, Nucleosides, nucleotides, structure of DNA, RNA and its classifications, Replication of DNA, transcription, translation and Protein Biosynthesis. Restriction enzymes. DNA finger printing Techniques, Introduction to Recombinant DNA technology. Genetic code, gene therapy (basic concept only), PCR. Chemical Synthesis of Nucleotides, Restriction enzymes. Chemistry of ATP, ADP and AMP.

**2. Hormones:** Functions and mode of action of hormones, Pituitary, thyroid, parathyroid, adrenal and adrenocorticoid and pancreatic hormones. Male and female sex hormones. Anti-hormones.

#### Unit V **Biological oxidation and metabolism: (18 Hrs)**

**1. Carbohydrate metabolism**-Carbohydrate the source of energy, glycolysis, glycogenesis, pentose pathway, citric acid and Cori cycle. Regulation of carbohydrate metabolism, Hormonal regulation of carbohydrate metabolism. Fructose and Galactose metabolism. Diabetes-Type I&II.

**2.Lipid metabolism:** Oxidation of fatty acid, biosynthesis of fatty acids, Prostaglandins-classification , structure and biosynthesis and biological role.

**3. Protein and amino acid metabolism:** Oxidative deamination and trans amination reactions, Urea formation- ornithine cycle.

**Unit VI: Buffer systems (9 Hrs)**

Buffer in pharmaceutical and biological system, pH, the buffer equation (Henderson Hesselbach), Buffer calculations, three important buffer systems in human body, buffer capacity, osmotic pressure and tonicity, pharmaceutical buffers, preparations of pharmaceutical buffer solutions.

**UNIT VII: Microbiology and Immunology (18 Hrs)**

**1 Microbial Drug Development** - Introduction to Microbiology and classification of Microbes. Characterization and Screening of Microbes:, Microbia1growth, kinetics, Isolation and Improvement of Individual micro- organism,; Fermentation technology:Design, operation and characteristics of fermentation processes. Staining of bacteria, theories of staining. General principles of microbial control- sterilization and disinfection.

**2 Immunochemistry in pharmaceutical applications.** Overview of the immune system and its role, Adaptive and innate Immunity. Immunoglobulins-classification and structure, their biological role. Immune response and the underlying mechanisms, Regulation of immune response. Hypersensitivity, immunodeficiency, Autoimmunity, Immunization, Immunosuppresants, Immunomodulators, Immunological techniques

Referances:All the referances given in this paper

Introduction to Microbiogy- IldnEdn Ingraham and Ingraham (Thomson Books)

2 Microbiogy-Stanies, 3 Microbiology-Pleczar.

4 Immunology-RoittBostolf,Malc (2001) Mosby

5. Industrial Microbiology-Cassida

**16P4CPHT14EL Pharmaceutical Chemistry III**  
**ADVANCES IN PHARMACEUTICAL OPERATIONS**

**Credit 4****Contact lecture Hours 90****UNIT 1: Pharmaceutical Dosage forms and Drug delivery Systems: 10 hrs.**

**1.1.** An over view of different dosage forms drug delivery systems- liposomes and nanoparticle drug delivery system, biodegradable drug delivery system, controlled release system, targeted drug delivery systems, hydrogel bases drug delivery systems,

**UNIT 2: Formulation and Development of solid dosage forms: 18 hrs.**

**2.1.** New materials, excipients science - diluents, disintegrants, super disintegrants. Evaluation of functional properties of excipients, co-processed materials, methods of preparation and evaluation. Coating, coating machines, coating techniques advanced coating technologies in tablet technology for product development

Specialized tablets: Formulation and evaluation of effervescent, or dispersible and chewable tablets. Formulation and manufacture of powder dosage forms for internal use. Soft and hard gelatine capsules advances in capsule manufacture, machines, processing and control. Filling equipment and filling operations, formulations, finishing, special techniques.

**2.2. Disintegration:** Disintegration, Disintegration time, factors affecting disintegration, disintegration testing of tablets.

**2.3. Dissolution:** Theories of Dissolution, dissolution models, Factors affecting dissolution rates, dissolution of different dosage forms- solids, suspensions, suppositories, controlled drug release systems.

**2.4. Micrometrics-** Introduction, Pharmaceutical importance, particle size distribution, surface area and particle volume derived properties of powder, flow properties of powder and application in pharmacy, Different methods in particle size determination.

**UNIT 3: Preformulation studies and Stability Testing 10 hrs.**

**3.1.** Preformulation studies: Factors affecting dissolution, bioavailability and drug absorption – pH, pka values, Partition coefficient, particle size, solubility etc. Methods to increase solubility of poorly soluble drugs. Drug release mechanisms.

**3.2.** Stability testing- drugs and dosage forms: Solid state drug stability, dosage form stability, accelerated stability testing, shelf life calculations, strategies for prolonging shelf life. Effect of packaging materials on dosage form stability. photostability testing and oxidative stability, role of containers in stability testing.

**UNIT-4: Colloids 10 hrs**

**4.1.:** Pharmaceutical application of colloids, brief introduction to properties of colloids. Coarse dispersions: Physical stability of suspension and emulsions, types of suspension, controlled flocculation-flocculated suspension, types of emulsion, theories of emulsification, emulsifying agents mechanism of action, factors to improve physical stability of emulsions.

**UNIT 5: Forensic pharmacy 14 hrs**

**5.1.** Getting the drug to the market- Preclinical studies of toxicology, drug metabolism pharmacology, formulation and stability tests and Clinical trials

**5.2. IPR: Patents:** Conditions for patentable inventions, Patentable inventions under the patent Act 1970, Types of inventions not patentable in India, Term of patent in Indian

System, Essential patent documents to be submitted, Provisional specification and complete specification, Criteria for naming inventors patent

**5.3.** Copyright Entitlement to copyright, works protected by copyright, Rights granted by copyright, Geographical indication

**5.4:** BP, IP, USP, Limits Tests

**UNIT 6: Chromatography**

**14 hrs**

**6.1.** - Applications of chromatography as an analytical and diagnostic tool in pharmaceutical chemistry-over view of plate and rate theories, different classification of chromatography,- adsorption, partition, size exclusion (GPC), Affinity, Ion exchange. Applications of PC, TLC, GC& different detectors, GCMS, Column chromatography, HPLC. Normal and reverse phase, chiral Columns, LCMS and its applications in pharmaceutical chemistry.

**UNIT 7: Modern Techniques of Extraction and Radio Pharmaceuticals**

**14 hrs**

**7.1.** Radio Pharmaceuticals and their applications in diagnosis and treatment, Diagnostics techniques- ELISA, RIA, PET, SPET .

**7.2.** Principles and methods of Industrial extraction, evaporation and distillation, ultracentrifugation, electrophoresis.

**References:**

1. Pharmaceutical drug Dosage Forms and Drug Delivery System: Mahanto R I and Narang, CRC Press Second Edition
2. Remington's Science and Practice of pharmacy, Edited by Allen, Loyd V., Jr 22<sup>nd</sup> edition, 2012
3. N.K. Jain, A Text Book of Forensic Pharmacy, 6<sup>th</sup> Edn., Vallabh Prakashan, 2003.
4. P. Ganguli, Intellectual Property Rights: Unleashing the Knowledge Economy, Tata McGraw Hill, 2001.
5. D.M. Vasudevan, S. Sreekumari, V. Kannan, Textbook of Biochemistry for Medical Students, 6<sup>th</sup> Edn., JP Medical, 2010.

**Pharmaceutical Chemistry IV**  
**16P4CPHT15EL DRUG DESIGN**

Credit 4

Contact Hours 90 hours

**UNIT 1.DRUG DESIGN and DEVELOPMENT :( 14 Hours)**

- 1.1. Development of new drugs, procedures followed in drug design.
- 1.2. Concept of lead compounds and lead modification & lead optimization- phytochemicals as lead compounds.
- 1.3. Prodrugs and soft drugs. Functions and properties of prodrugs and its effect and significance with relation to pharmacological activity.
- 1.4. Endogenous compounds as drugs- neurotransmitters, natural hormones.
- 1.5. Peptidomimetics in drug design.
- 1.6. SAR, factors affecting bioavailability, resonance and inductive effects, isosterism, bioisosterism.

**UNIT.2. QSAR: (12 Hours)**

- 2.1. Introduction and perspectives and parameters involved in studies of QSAR
- 2.2. Types of QSAR models
- 2.3. Classification of parameters utilized in QSAR studies
- 2.4. Statistical concept of QSAR
- 2.5. Hansch model of QSAR
- 2.6. De Novo model of QSAR
- 2.7. Hammett and Taft model of QSAR equations
- 2.8. Applications of QSAR in drug design

**UNIT.3. COMPUTER AIDED DRUG DESIGN (CADD): (10 Hours)**

- 3.1. Virtual screening- concept, drug likeness screening, focused screening libraries for lead identification, pharmacophore screening, and structure based virtual screening and application,
- 3.2. Molecular modeling- introduction, molecular methods, Molecular mechanics, modeling ligands for known and unknown receptors. Docking studies.

**UNIT.4. Combinatorial Chemistry: (10Hours)**

- 4.1. Introduction
- 4.2. Combinatorial approaches
- 4.3. Peptide and small molecule libraries
- 4.4. Applications, methodology
- 4.5. Combinatorial Organic Synthesis



4.6. Assays and Screening of Combinatorial libraries

4.7. Introduction to High Throughputs Screening (HTS)

**UNIT.5. ANTNEOPLASTIC DRUGS: (12Hours)**

5.1. Cancer chemotherapy,

5.2. Role of alkylating agents, antimetabolites and folate antagonists in the treatment of cancer. Carcinolytic antibiotics and mitotic inhibitors.

5.3. Plant derived drugs- vincristine, taxol,

5.4. Hormones and their antagonists.

5.5. Recent developments in cancer chemotherapy-immunological interventions

5.6. Synthesis of :5-fluouracil, 6-mercaptopurine, methotrexate, tamoxifen.

**Unit, 6. Drugs acting on ANS (14 Hrs)**

6.1. Introduction to autonomic nervous system and classification. Mechanism of action and uses of the following classes of drugs:

6.2 Adrenergicagonists : Clonidine, oxymetazoline, salbutamol. 3.2 Adrenergic blockers:  $\alpha$  and  $\beta$ adrenoreceptor antagonists-ergot alkaloids-Pronethalol , propranolol, atenolol, metoprolol, pindolo.

6.3 Cholinergic stimulants: nicotinic and muscarinic receptors, acetyl choline ,pilocarpine, and carbachol.

6.4 Cholinergic blockers: atropine, hyoscine

6.5. Nicotinic antagonists :Decamethonium and suxamethonium

6.6 Anticholinesterases: Competitive inhibitors-physostigmine and neostigmine. Organo phosphorous compounds and nerve gases.

6.7 Synthesis of :Salbutamol, methoxamine, Clonidine, terbutaline, Phentolamine, Phenoxybenzamine, Metoprolol , butoxamine, carbachol, nicotine, atropine

**Unit.7. Drugs acting on CNS: pharmacology of the following classes of drugs ( 18 hours)**

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7.1. Hypnotics, sedatives and anxiolytic agents.

7.2. Anxiolytic agents-benzodiazepines, buspirone and meprobamate.

7.3. Anticonvulsants: convulsions, types of epilepsy, barbiturates-hydantoins, oxazolidinediones, succinimides and benzodiazepines.

7.4. Analeptics: xanthines, amphetamines, nikethamide and ethamivan.

7.5. Centrally acting muscle relaxants: glyceryl ethers-mephenesin, alkane diol derivatives-meprobamate, benzodiazepines-librium, diazepam and baclofen.

- 7.6. Antiparkinson's agents: dopamine agonists, dopamine releasing agents and synthetic anticholinergics.
- 7.7. Drugs for Alzheimer's disease: cholinergic agonists and acetylcholine esterase inhibitors.
- 7.8. Synthesis and uses of the following drugs - Enflurane, Etomidate, Phenobarbital, Diazepam, Chlordiazepoxide, Meprobamate, Nikethamide, Ethamivan, Ethosuximide, Denzimidol, Topiramate, Levodopa, and Tacrine. Diphenhydramine

References:

1. Essentials of Pharmaceutical Chemistry, Donald Carins; pharmaceutical Press, 3 Edn.
2. Principles of Medicinal Chemistry, William Foye, Lippincott 5 Edn
3. Text Book of Medicinal and Pharmaceutical Chemistry, Wilson & Gisvold Lippincott, 10 Edn.
4. Medicinal Chemistry & Drug Discovery, Alfred Burger, John Wiley 6 Edn, 2007
5. Fundamentals of Medicinal Chemistry, G. Thomas. Wiley Publications 2006
6. An Introduction to Medicinal Chemistry, Graham L Patrick, Oxford University Press 2006
7. Organic Chemistry Vol:II, I.L. FINAR
8. Natural Products Chemistry, NR Krishnaswami, Oxford University Press, 2008
9. Recent Progress in Medicinal Plants Vol.I, Singh, Govil, Tec. Publications LLC, USA, 2002.
10. Computer aided Drug design, T.J. PERUNJIL Propst, Marcel & Dekker, 2007.
11. Introduction to Principles of Drug Design, Smith HJ, Willims H Edn. Wright Boston
12. Computer Aided Drug Design, Pope & Perruns, Academic Press, NY.
13. Heterocyclic Chemistry in Drug Discovery, Edn, JIE Jack Li, Wiley.
14. Organic Chemistry of Drug Design and Drug Action Richard B Silverman Academic Press
15. Computational Medicinal Chemistry for Drug Discovery, P Bultinck, P DeVinter.
16. Medicinal Chemistry, Alex Gringauz, Wiley India.

## 16P4CPHT16EL ANALYTICAL CHEMISTRY

Credit: 4

Contact Lecture Hours: 90

### Unit 1: Instrumental Methods (36 Hrs)

1.1 Electrical and nonelectrical data domains-transducers and sensors, detectors, examples for piezoelectric, pyroelectric, photoelectric, pneumatic and thermal transducers. Criteria for selecting instrumental methods - precision, sensitivity, selectivity, and detection limits.

1.2 Signals and noise: sources of noise, S/N ratio, methods of enhancing S/N ratio—hardware and software methods.

1.3 Electronics: transistors, FET, MOSFET, ICs, OPAMs. Application of OPAM in amplification and measurement of transducer signals.

1.4 UV-Vis spectroscopic instrumentation: types of optical instruments, components of optical instruments—sources, monochromators, detectors. Sample preparations. Instrumental noises. Applications in qualitative and quantitative analysis.

1.5 Molecular fluorescence and fluorometers: photoluminescence and concentration electron

transition in photoluminescence, factors affecting fluorescence, instrumentation details. Fluorometric standards and reagents. Introduction to photoacoustic spectroscopy.

1.6 IR spectrometry: Instrumentation designs-various types of sources, monochromators, sample cell considerations, different methods of sample preparations, detectors of IR-NDIR instruments. FTIR instruments. MidIR absorption spectrometry. Determination of path length. Application in qualitative and quantitative analysis.

1.7 Raman Spectrometric Instrumentation: sources, sample illumination systems. Application of Raman Spectroscopy in inorganic, organic, biological and quantitative analysis.

1.8 NMR Spectrometry-magnets, shim coils, sample spinning, sample probes ( $^1\text{H}$ ,  $^{13}\text{C}$ ,  $^{32}\text{P}$ ). Principle of MRI.

### Unit 2: Sampling (18 hrs)

2.1 The basis and procedure of sampling, sampling statistics, sampling and the physical state, crushing and grinding, the gross sampling, size of the gross sample, sampling liquids, gas, and solids (metals and alloys), preparation of a laboratory sample, moisture in samples-essential and non-essential water, absorbed and occluded water, determination of water (direct and indirect methods).

2.2 Decomposition and dissolution, source of error, reagents for decomposition and dissolution like HCl,  $\text{H}_2\text{SO}_4$ ,  $\text{HNO}_3$ ,  $\text{HClO}_4$ , HF, microwave decompositions, combustion methods, use of fluxes like  $\text{Na}_2\text{CO}_3$ ,  $\text{Na}_2\text{O}_2$ ,  $\text{KNO}_3$ , NaOH,  $\text{K}_2\text{S}_2\text{O}_7$ ,  $\text{B}_2\text{O}_3$  and lithium metaborate. Elimination of interference from samples-separation by precipitation, electrolytic precipitation, extraction and ion exchange. Distribution ratio and completeness of multiple extractions. Types of extraction procedures.

### Unit 3: Applied Analysis (9 hrs)

3.1 Analytical procedures involved in environmental monitoring. Water quality—BOD, COD, DO, nitrite, nitrate, iron, fluoride.

3.2 Soil- moisture, salinity, colloids, cation and anion exchange capacity.

3.3 Air pollution monitoring sampling, collection of air pollutants-SO<sub>2</sub>, NO<sub>2</sub>, NH<sub>3</sub>, O<sub>3</sub> and SPM.

3.4 Analysis of metals, alloys and minerals. Analysis of brass and steel. Analysis of limestone. Corrosion analysis.

#### **Unit 4: Capillary Electrophoresis and Capillary Electro-chromatography (9 Hrs)**

4.1 Capillary electrophoresis—migration rates and plate heights, instrumentation, sample introduction, detection(indirect)-fluorescence, absorbance, electrochemical, mass spectrometric, applications. Capillary gel electrophoresis. Capillary isotachopheresis. Isoelectric focusing.

4.2 Capillary electro chromatography—packed columns. Micellar electro kinetic chromatography.

#### **Unit 5: Process instrumentation (9 Hrs)**

5.1 Automatic and automated systems, flow injection systems, special requirements of process instruments, sampling problems, typical examples of C, H and N analysers.

#### **Unit 6: Aquatic Resources (9 Hrs)**

6.1 Aquatic resources: renewable and non-renewable resources, estimation, primary productivity – factors affecting it, regional variations.

6.2 Desalination: principles and applications of desalination—distillation, solar evaporation, freezing, electrodialysis, reverse osmosis, ion-exchange and hydrate formation methods. Relative advantages and limitations. Scale formation and its prevention in distillation process.

6.3 Non-renewable resources: inorganic chemicals from the sea – extraction and recovery of chemicals, salt from solar evaporation.

#### **References**

01. J.M. Mermet, M. Otto, R. Kellner, Analytical Chemistry, Wiley-VCH, 2004.
02. D.A. Skoog, D.M. West, F.J. Holler, S.R. Crouch, Fundamentals of Analytical Chemistry, 8th Edn., Saunders College Publ., 2007.
03. R.D. Brown, Introduction to Instrumental Analysis, McGraw-Hill, 1958.
04. H.H. Willard, L.L. Merritt, J.A. Dean, Instrumental Methods of Analysis, Van Nostrand, 1974.
05. G.D. Christian, J.E. O'Reilly, Instrumental Analysis, Allyn & Bacon, 1986.
06. J.H. Kennedy, Analytical Chemistry: Principles, Saunders College, 1990.
07. J.G. Dick, Analytical Chemistry, R.E. Krieger, 1978.
08. E.D. Howe, Fundamentals of Water Desalination, Marcel Dekker, 1974.
09. H.G. Heitmann, Saline Water Processing, VCH, 1990

**SEMESTERS 3 and 4**  
**Pharmaceutical Practical 1**  
**16P4CPHP04 PHARMACEUTICAL ANALYSIS PRACTICAL**

**Credit: 3**

**Contact Lab Hours: 54+54=108**

1. **Preparation, assay including limit tests** prescribed in the IP/BP of the following drugs: sodium salicylate, calcium lactate, yellow mercuric oxide, ferrous fumarate, ferric ammonium citrate, potassium antimony citrate, boric acid, light magnesium carbonate, and sodium citrate. Expectorants and emetics ((NH<sub>4</sub>Cl, antimony potassium tartarate), Respiratory Stimulants (NH<sub>4</sub>)<sub>2</sub>CO<sub>3</sub>, Dental products (Dicalcium Phosphate, Sodium Fluoride) Gastrointestinal agents: MgSO<sub>4</sub>
2. Assay, test for identity and purity of the following synthetic drugs: Aspirin, Paracetamol, Ibuprofen, hexamine, Boric acid, Ferrous Fumarate, Isoniacid, Calcium lactate, Calcium gluconate.
3. Analysis of official drugs using common analytical techniques (separation of excipients from tablets and Assay using spectrophotometer).
4. Assay of Antibiotics.
5. Assay of Vitamins: ascorbic acid, acetomenaphthone, niacinamide, pyridoxine and thiamine.
6. Determination of pKa valued of drug molecules.
7. Determination of pKa values at different pH conditions.

**References**

1. A.O. Bentley, J.E. Driver, Bentley and Driver's Textbook of Pharmaceutical Chemistry, 7<sup>th</sup> Edn., Oxford University Press, 1960.
2. G.L. Genkins, A.M. Knevel, F.E. DiGangi, Quantitative Pharmaceutical Chemistry, 7<sup>th</sup> Edn., McGraw Hill, 1977.
3. K.A. Connors, A Textbook of Pharmaceutical Analysis, John Wiley & Sons, 2007.
4. Indian Ministry of Health and Family Welfare, Indian Pharmacopoeia 1996, Controller of Publication, 2000.
5. Vogl's Text Book of Practical Organic Chemistry- Brian Furniss, Antony Hannaford, Peter Smith, Austrin (Eds), 5th edition, ELBS Publication, Singapore, 1997.
6. Experimental Pharmaceutical Organic Chemistry, A Becnchttop Manual by K. S. Jain, P. B. Miniyar & T. S. Chitre, 2nd Edition Carrier publications,.
7. Organic Chemistry, G. Marc Loudon, 4th Ed., Oxford University Press, 2004.
8. British Pharmacopoeia Commission, British Pharmacopoeia:2012 Edition, Bernan Assoc, 2011

**Pharmaceutical Practical 2**  
**16P4CPHP05 DRUG SYNTHESIS AND ANALYSIS PRACTICAL**

Credit: 3

Contact Lab Hours: 54+54=108

1. Synthesis of some typical organic medicinal compounds, spectral illustration of the intermediates and products formed: paracetamol, sulphanilamide, hippuran, benzocaine, clofibrate, mercurochrome, phenytoin, dapsone, sulphasalazin, antipyrine, aminacrine and phenobarbitone.

2. Preparation of some specified crude plant extracts and qualitative analysis by TLC of crude plant extracts/ products to detect the presence of phytochemicals

3. Isolation of phytochemicals from their natural sources.

Examples Caffeine from Tea

Nicotine from tobacco

Cucumin from turmeric

Tannins from Gallnuts

Lycopene from tomato

4. Qualitative analysis of barbiturates, lactates, tartarates and alkaloids

5. Limit tests

References

1. A.O. Bentley, J.E. Driver, Bentley and Driver's Textbook of Pharmaceutical Chemistry, 7th Edn., Oxford University Press, 1960.
2. K.A. Connors, A Textbook of Pharmaceutical Analysis, John Wiley & Sons, 2007.
3. J.W. Cooper, C. Gunn, Cooper and Gunn's Dispensing for Pharmaceutical Students, Pitman Medical, 1967.
4. A. Kar, Advanced Practical Medicinal Chemistry, New Age International, 2007.

**Pharmaceutical Practical 3**  
**16P4CPHP06 BIOCHEMISTRY AND BACTERIOLOGY PRACTICAL**  
**Credit: 3 Contact Lab Hours: 72+72 =144**

A. Biochemistry

01. Blood Analysis

- a. Determination of blood group and Rh factor.
- b. Enumeration of RBC, WBC and differential leucocyte count.
- c. Determination of ESR.
- d. Estimation of urea, uric acid, cholesterol, creatinine, haemoglobin and calcium.

02. Urine Analysis

- a. Qualitative analysis of urine for the common pathological constituents-sugar, albumin, ketone bodies, bile.
- b. Estimation of albumin, ketone bodies, sugar and urea.

03. Quantitative Estimation of Aminoacids by formol titration and direct titration.

04. Identification of Aminoacids and peptides by PC and TLC and Colour reactions

05. Separation of serum proteins by paper electrophoresis.

B. Bacteriology

01. Preparation of some typical nutrient media for collection and isolation of bacteria.

- a. Nutrient Agar, Endo's Agar, Chapman's Agar, Tergitol-7 Agar and McConkey Agar.

02. Staining and the study of the morphology of the bacteria.

- a. Simple stain
- b. Gram stain (Huker method)
- c. Capsule stain
- d. Acid fast stain (Ziehl- Neelson)
- e. Negative stain (India ink method)

03. Identification of some common pathogenic organisms.

04. Enumeration of bacteria in milk-the reductase test.

05. Evaluation of germicides-Riedel Walker test.

06. Antibiotic sensitivity tests.

### **16P4CPHCV - Comprehensive Viva Voce**

There will be a comprehensive viva at the end of the programme. The viva board consists of two external examiners preferably same as the practical examiners for the respective subject and one internal examiner (Class teacher).



### **16P4CPHPJ – Project**

Each student should submit a project report for evaluation. A minimum of 3 months period shall be given to each student for the project and this may be after the end semester examination of semester 4. Students can do their project in the department or any other reputed research institution in and outside the state. After completing the project the report should be submitted to the department for internal and external evaluation. The external evaluation will be done by the project viva board, which consists of two examiners preferably same as the practical examiners.