ST. ALBERT'S COLLEGE (AUTONOMOUS),

ERNAKULAM

Affiliated to Mahatma Gandhi University, Kottayam, Kerala

SYLLABUS FOR UNDERGRADUATE PROGRAMME

BACHELOR OF SCIENCE IN INDUSTRIAL CHEMISTRY

UNDER CHOICE BASED CREDIT SYSTEM

(WITH EFFECT FROM 2019 ADMISSION)

Syllabus of B.Sc. Industrial Chemistry

Proposed by the Board of Studies on 26th February 2019

Dr. M. A. Solomon

Chairman Board of Studies

Approved bythe Academic Councilon 28th February 2019

Dr. M. L. Joseph, Principal

Chairman, Academic Council

Adopted by the Governing Council on 4th May 2019

Fr. Antony Arackal

Chairman, Governing Council

Board of Studies

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16	Dr. Jolly V. Antony	Assistant Professor, Dept. of Chemistry, Maharaja's College, Ernakulam

Acknowledgement

Learning is a continuous process and it is important to update the syllabus as per the emergence of new knowledge as well as the need of the present day society. I am grateful to many who have helped in the smooth revision of this Under Graduate (UG) syllabus of both B. Sc. Chemistry Model I and Model II. I express my sincere gratitude to Rev. Fr. Antony Arackal, the Chairman and Manager of the college for his moral support. We also express our sincere gratitude to Dr. M. L. Joseph, the Principal of the college for his constant encouragement in the process of revision of the syllabus. The department and its board of studies conducted a Workshop on Syllabus Revision on 28th November 2018 and I am very thankful to Dr. Rajagopalan M. G and Dr.Ananthapadmanabhan P. (Associate Professors of Chemistry (Retd.), Maharaja's College, Ernakulam), Dr.Kochu Baby Manjooran S. (Senior Manager, Kochi Refineries Ltd), Dr. CibiKomalan (Associate Professor, S. N. M. College, Maliankara), Dr. Jude Martin Mendez, Associate Professor, St. Albert's College (Autonomous), Ernakulam for being served as the resource persons for the workshop. I would like to express my sincere gratitude to Dr. Paulson Mathew, Associate Professor, St. Thomas College (Autonomous), Thrissur for valuable suggestions and amendment. I express my sincere gratitude to all the faculty members for organizing the workshop and also for their hard work in formulating the syllabi. I also thank the non-teaching staff of the department of chemistry for their help one or other way. I am grateful to the Mahatma Gandhi University, Kottayam, its board of studies in chemistry, Dean, Faculty of science who has made their efforts in bringing in the present syllabi of under graduate programmes in 2017.

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Preface

Science is pivotal to the development of any modern society. However, the creation of a scientific temper in society necessitates proper education and guidance. An effective science education can be imparted at the undergraduate level only by revamping the present curriculum. To achieve this goal, the curriculum should be restructured, giving emphasis to various aspects such as the creativity of students, knowledge of current developments in the discipline, awareness of environmental impacts due to the development of science and technology, and the skills essential for handling equipment and instruments in laboratories and industries.

The Higher Education Council has taken the initiative to reformulate the undergraduate syllabi by introducing choice based credit and semester system. This is to cope with the internationally followed curricula and mode of evaluation. This approach has necessitated the revision of the present curriculum.

This curriculum is prepared to give sound knowledge and understanding of chemistry to undergraduate students. The goal of the syllabus is to make the study of chemistry stimulating, relevant and interesting. The syllabus is prepared with a view to equipping the students with the potential to contribute to academic and industrial environments. This curriculum will expose students to various fields in chemistry and develop interest in related disciplines. Chemistry, being a border science to biology, physics and engineering, has a key role to play in learning these disciplines. The new and updated syllabus is based on an interdisciplinary approach with vigour and depth. Care has been given to ensure that the syllabus is not very heavy while remaining compatible to the syllabi of other universities at the same level. Chemistry being an experimental science, sufficient emphasis is given in the syllabus for training in laboratory skills and instrumentation.

The syllabus has been prepared in a participatory manner, after discussions with a number of faculty members in the subject and also after evaluating the existing syllabi of B. Sc. Part- III, the new syllabi of XI& XII standards and U.G.C. model curriculum and the syllabi of other Universities. The units of the syllabus are well defined and the scope of each is given in detail. The number of contact hours required for each unit is also given. A list of reference books is provided at the end of each course.

Programme Outcomes

B. Sc. Chemistry Model II

- **Critical Thinking**

  Take informed actions after identifying the assumptions that frame our thinking and actions, checking out the degree to which these assumptions are accurate and valid, and looking at our ideas and decisions (intellectual, organizational, and personal) from different perspectives.

- **Problem Solving**

  Solve problems from the discipline of science using the knowledge, skills and attitude acquired from science.

- **Environment and Sustainability**

  Understand the issues of environmental contexts and sustainable development.

- **Self Directed and Life Long Learning**

  Acquire the ability to engage in independent and life-long learning in the broadest context socio-technological changes.

Programme Specific Outcomes

B. Sc. CHEMISTRY MODEL II

- Acquire knowledge in chemistry through theory and practicals.
- Clear competitive exam for admission to master programmes in chemistry conducted by IITs, IISc and IISERs and other reputed institutes or universities India and abroad.
- Be competitive to work in chemical/pharma production plants, petroleum refineries, material, plastic and food industries in both private and public sector.
- Be concerned and practice environmental protection and participate in sustainable development.

Regulations

1. TITLE

1.1 These regulations shall be called "ST.ALBERT'S COLLEGE (AUTONOMOUS), ERNAKULAM - REGULATIONS FOR UNDERGRADUATE PROGRAMMES UNDER CHOICE BASED CREDIT SYSTEM 2019"

2. SCOPE

2.1 Applicable to all regular B.A./ B.Sc. /B.Com /B.BA courses conducted by the College with effect from 2019 admissions.

2.2 Medium of instruction is English except in the case of language courses other than English unless otherwise stated therein.

2.3 The provisions supersede all the existing regulations for the Regular Undergraduate programmes to the extent herein prescribed.

3. DEFINITIONS

3.1. 'Academic Week' is a unit of five working days in which the distribution of work is organized from day-one to day-five, with five contact hours of one hour duration on each day.

3.2. 'Choice Based Course' means a course that enables the students to familiarize the advanced areas of core course.

3.3. 'Common Course I' means a course that comes under the category of courses for English

3.4. 'Common Course II' means additional language.

3.5. 'Complementary Course' means a course which would enrich the study of core courses.

3.6. 'Core Course' means a course in the subject of specialization within a degree programme. It includes a course on environmental studies and human rights.

3.7. 'Course' means a portion of a subject to be taught and evaluated in a semester (similar to a paper under annual scheme).

3.8. 'Credit' is the numerical value assigned to a paper according to the relative importance of the syllabus of the programme.'Department' means any teaching department in a college.

3.9. 'Examination Coordinator' is a teacher nominated by a Department Council to coordinate the continuous evaluation undertaken in that department.

3.10. 'Department Council' means the body of all teachers of a department in a college.

3.11. 'Class Tutor' means a teacher from the department nominated by the Department Council, who will advise the student on academic matters.

3.12. Grace Marks shall be awarded to candidates as per the Orders issued from the college from time to time at par with the affiliating University.

3.13. 'Grade' means a letter symbol (A, B, C, etc.), which indicates the broad level of performance of a student in a Paper/Course/ Semester/Programme.

3.14. 'Grade Point' (GP) is the numerical indicator of the percentage of marks awarded to a student in a course.

3.15. 'Institutional Average (IA)' means average mark secured (Internal + external) for a course at the college level.

3.16. 'Open Course' means an optional course which the student is free to take at his/her will. Open course shall be a non-major elective course offered by the Departments other than the parent Department.

3.17. 'Parent Department' means the department which offers core course/courses within an undergraduate programme.

3.18. 'Programme' means a three-year programme of study and examinations spread over six semesters, the successful completion of which would lead to the award of a degree.

3.19. 'Semester' means a term consisting of a minimum 90 working days, inclusive of tutorials, examination days and other academic activities within a period of five months.

3.20. 'Vocational Course' (Skill Enhancement Course) means a course that enables the students to enhance their practical skills and ability to pursue a vocation in their subject of specialization.

3.21. Words and expressions used and not defined in this regulation shall have the same meaning assigned to them in the Act and Statutes of the affiliating University.

4. ELIGIBILITY FOR ADMISSION AND RESERVATION OF SEATS

4.1. Eligibility for admissions and reservation of seats for various Undergraduate Programmes shall be according to the rules framed by the College in this regard, from time to time.

5. DURATION

5.1. The duration of U.G. programmes shall be 6 semesters.

5.2. There shall be two Semesters in an academic year, the "ODD" semester commences in June and on completion, the "EVEN" Semester commences. There shall be two month's vacation during April/May.

6. REGISTRATION

6.1. The strength of students for each programme shall be as per the existing orders issued by the college and as approved by the affiliating University.

7. SCHEME AND SYLLABUS

7.1. The U.G. programmes shall include (a) Common Courses I and II, (b) Core Course(s), (c) Complementary/Vocational Courses, and (d) OpenCourse.

7.2. Here shall be one Choice Based course (Elective Course) in the sixth semester. In the case of B.ComProgramme there shall be an elective stream from third semester onwards.

7.3. Credit Transfer and Accumulation system can be adopted in the programme. Transfer of Credit consists of acknowledging, recognizing and accepting credits by an institution for programmes or courses completed at another institution. The Credit Transfer Scheme shall allow students pursuing a programme in one University to continue their education in another University without break.

7.4. A separate minimum of 30% marks each for internal and external (for both theory and practical) and aggregate minimum of 35% are required for a pass for a course. The practical examinations (external/internal) will be conducted only at the end of each semesters for all programmes.

7.5. Students who complete the programme with minimum "D" grade will have one betterment chance within 12 months, immediately after the publication of the result of the whole programme. In such cases they should appear for all the papers in a particular semester.

8. PROGRAMME STRUCTURE

Model II B.A/B.Sc

a	Programme Duration	6 Semesters
b	Total Credits required for successful completion of the Programme	120
c	Credits required from Common Course I	16
d	Credits required from Common Course II	8
e	Credits required from Core + Complementary + Vocational Courses including Project	93
f	Open Course	3
g	Minimum attendance required	75%

9. EXAMINATION

9.1. The evaluation of each paper shall contain two parts:

- Internal or In-Semester Assessment(ISA)
- External or End-Semester Assessment(ESA)

9.2 The internal to external assessment ratio shall be1:4.

Both internal and external marks are to be rounded to the next integer.

All papers (theory and practical), grades are given on a 7-point scale based on the total percentage of marks, *(ISA+ESA)* as given below:

Percentage of Marks	Grade	Grade Point
95 and above	S Outstanding	10
85 to below 95	A^+ Excellent	9
75 to below 85	A Very Good	8
65 to below 75	B^+ Good	7
55 to below 65	B Above Average	6
45 to below 55	C Satisfactory	5
35 to below 45	D Pass	4
Below 35	F Failure	0
	Ab Absent	0

10. CREDIT POINT AND CREDIT POINT AVERAGE

Credit Point (CP) of a paper is calculated using the formula:

CP = C × GP, where C is the Credit and GP is the Grade point.

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

SGPA = TCP/TC, where TCP is the Total Credit Point of that semester.

Cumulative Grade Point Average (CGPA) is calculated using the formula:

CGPA = TCP/TC, where TCP is the Total Credit Point of that programme.

Grade Point Average (GPA) of different category of courses viz. Common Course I, Common Course II, Complementary Course I, Complementary Course II, Vocational course, Core Course is calculated using the formula:

GPA = TCP/TC, where TCP is the Total Credit Point of a category of course.

TC is the total credit of that category of course

Grades for the different courses, semesters and overall programme are given based on the corresponding CPA as shown below:

GPA	Grade	
9.5 and above	S	Outstanding
8.5 to below 9.5	A+	Excellent
7.5 to below 8.5	A	Very Good
6.5 to below 7.5	B+	Good
5.5 to below 6.5	B	Above Average
4.5 to below 5.5	C	Satisfactory
3.5 to below 4.5	D	Pass
Below 3.5	F	Failure

11. MARKS DISTRIBUTION FOR EXTERNAL AND INTERNAL EVALUATIONS

The external theory examination of all semesters shall be conducted by the college at the end of each semester. Internal evaluation is to be done by continuous assessment. For all courses without practical total marks of external examination is 80 and total marks of internal evaluation is 20. Marks distribution for external and internal assessments and the components for internal evaluation with their marks are shown below.

11.1. For all courses without practical

Marks of external Examination : 80

Marks of internal evaluation : 20

Components of Internal Evaluation of theory	Marks
Attendance	5
Assignment /Seminar/Viva	5
Test papers (2x5=10)	10
Total	20

For all courses with practical total marks for external evaluation is 60 and total marks for internal evaluation is15.

11.2. For all courses with practical

Marks of external Examination : 60

Marks of internal evaluation : 15

Components of Internal Evaluation	Marks
Attendance	5
Assignment /Seminar/Viva	2
Test papers (2 x 4)	8
Total	15

For practical examinations total marks for external evaluation is 40 for internal evaluation is 10

Components Internal evaluation of Practical	Marks
Attendance	2
Test paper (1 x 4)	4
Record*	4
Total	10

**Marks awarded for Record should be related to number of experiments recorded and duly signed by the teacher concerned in charge.*

All three components of internal assessments are mandatory.

11.3. For projects

Marks of external evaluation : 80

Marks of internal evaluation : 20

Components of External Evaluation of Project	Marks
Dissertation (External)	50
Viva-Voce (External)	30
Total	80

*****Marks for dissertation may include study tour report if proposed in the syllabus.*

Components of internal Evaluation of Project	Marks
Punctuality	5
Experimentation/data collection	5
Knowledge	5
Report	5
Total	20

Attendance Evaluation for all papers

Percentage of attendance	Marks
90 and above	5
85 – 89	4
80-84	3
76-79	2
75	1

(Decimals are to be rounded to the next higher whole number)

12. ASSIGNMENTS

Assignments are to be done from 1st to 4th Semesters. At least two assignments should be done in each semester for all courses.

13. SEMINAR/VIVA

A student shall present a seminar in every semester for each paper and appear for Viva-voce in the 6th semester for each course.

14. INTERNAL ASSESSMENT / TESTPAPERS

At-least two test papers are to be conducted in each semester for each course.

15. Grievances regarding internal evaluation

There is provision for grievance redressal regarding internal evaluation which operates at four levels. Complaints regarding the internal evaluation shall be brought to the notice of the teacher concerned in the first instance. If the student is not satisfied with the decision of the teacher concerned, he may appeal to the Departmental Grievance Redressal Committee which shall have the Head of the department, the class Tutor and the teacher against whom the complaint is made, as members. The student will also have the freedom to make further appeal to the College Level Grievance Redressal Committee which shall have the Principal, the COE and the concerned Head of the department, as members. If the student is not satisfied, he may appeal to the Governing Council.

15.1. The COE shall make arrangements for giving awareness of the internal evaluation components to students immediately after commencement of I semester.

15.2. The internal evaluation marks/grades in the prescribed format should reach the office of Controller of Examinations, St. Albert's College before the commencement of study leave in each semester.

15.3. Students can register for end semester examination only if they pass internal evaluation.

16. EXTERNAL EXAMINATION (END SEMESTER EXAMINATION)

The external examination of all semesters shall be conducted by the College at the end of each semester.

16.1 Students having a minimum of 75% average attendance for all the courses only can register for the examination. Condonation of shortage of attendance to a maximum of10 days in a semester subject to a maximum of 2 times during the whole period of the programme may be granted by the college on valid grounds. This condonation shall not be counted for internal assessment. Benefit of attendance may be granted to students attending University/College union/Co-curricular activities by treating them as present for the days of absence, on production of participation/attendance certificates, within one week, from competent authorities and endorsed by the Head of the Department. This is limited to a maximum of 10 days per semester and this benefit shall be considered for internal assessment also. Those students who are not eligible even with condonation of shortage of attendance will not be readmitted.

16.2 All students are to do a project in the area of core course. This project can be done individually or in groups (not more than five students) for all subjects which may be carried out in or outside the campus. The projects are to be identified during the II semester of the programme with the help of the supervising teacher. The report of the project in duplicate is to be submitted to the department at the sixth semester and are to be produced before the examiners appointed by the college. External Project evaluation and Viva / Presentation are compulsory for all subjects and will be conducted at the end of the programme.

16.3 There shall be supplementary exams only for fifth semester. For reappearance improvement for other semesters the students can appear along with the next batch.

16.4 A student who registers his/her name for the external exam for a semester will be eligible for promotion to the next semester.

16.5 All courses shall have unique alphanumeric code.

17. 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. She/he shall also upload a detailed scheme of answer type, short essay type /problem solving

type and long essay type questions and to be generated from the question bank. A question paper shall be a judicious mix of short answer type, short essay type/problem solving type and long essay type questions and to be generated from the question bank.

17.1 Pattern of Questions Papers

17.1.1 Without practical

Sl. No	Pattern	Marks	Choice of questions	Total marks
1	Short Answer/problem type	2	10/12	20
2	Short essay/problem	5	6/9	30
3	Essay/problem	15	2/4	30
Total				80

17.1.2 With practical

Sl. No	Pattern	Marks	Choice of questions	Total marks
1	Short Answer/problem type	1	10/12	10
2	Short essay/problem	5	6/9	30
3	Essay/problem	10	2/4	20
Total				60

Each Board of Studies shall specify the length of the answers in terms of number of words. Pattern of questions for external examination of practical papers will be decided by the concerned Board of Studies/Expert Committees.

18. MARK CUM GRADE CARD

The College under its seal shall issue to the students a MARK CUM GRADE CARD on completion of each programme, which shall contain the following information:

a. Name of the College

b. Title and Model of the Undergraduate Programme

c. Name of the Semester

d. Name and Register Number of the student

e. Date of publication of result

f. Code, Title, Credits and Maximum Marks (Internal, External and Total) of each course opted in the semester.

g. Internal, External and Total Marks awarded, Grade, Grade point and Credit point in each course opted in the semester.

h. The total credits and total credit points in the semester.

i. Semester Grade Point Average (SGPA) and corresponding Grade.

j. Cumulative Grade Point Average (CGPA), GPA corresponding to Common Courses I and II, Core Course, Complementary Courses, Vocational Courses and Open Course.

k. The final Mark cum Grade Card issued at the end of the final semester shall contain the details of all courses taken during the final semester examination and shall include the final Grade(SGPA) scored by the candidate from 1st to 5th semesters, and the overall Grade for the total programme.

19. RANK CERTIFICATE

The college publishes rank list of top 10 candidates for each programme after the publication of 6th semester results. Rank certificate shall be issued to candidates who secure positions from 1st to 3rd in the rank list. Candidates who secure positions from fourth to tenth in the rank list shall be issued position certificate indicating their position in the rank list. Candidates shall be ranked in the order of merit based on the CGPA scored by them. Grace marks awarded to the students should not be counted fixing the rank/position. Rank certificate and position certificate shall be signed by the Controller of Examinations.

20. There shall be 3 level monitoring committees for the successful conduct of the scheme. They are -

20.1. Department Level Monitoring Committee (DLMC), comprising HOD and two senior most teachers as members.

20.2. College Level Monitoring Committee (CLMC), comprising Principal, Controller of Examinations and A.O/Superintendent as members.

20.3. Governing Council.

21. TRANSITORY PROVISION

Notwithstanding anything contained in these regulations, the Governing Council shall, for a period of one 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.

22. The Governing Council is authorized to make necessary criteria for eligibility for higher education in the grading scheme, if necessary, in consultation with affiliating University and other Universities. The Governing Council is also authorized to issue orders for the perfect realization of the Regulations.

Annexure I: Model Mark Cum Grade Card

St. Albert's College (Autonomous)
Ernakulam-682 018, Kerala, India.
edited by National Assessment and Accreditation Council (NAAC)at A Grade
ISO 9001: 2015 Certified
Affiliated to Mahatma Gandhi University, Kottayam, Kerala

GRADE CARD

Name of the candidate													Student Photo
Permanent register number (prn):													
Degree													
Programme													
Stream													
Name of the examination													
Date of issue													
Course code	**Course title**	**Credits**	**Marks**						**Grade**	**Gp**	**Cgp**	**Result**	
			INTERNAL		**EXTERNAL**		**TOTAL**						
			AWARDED	**MAXIMUM**	**AWARDED**	**MAXIMUM**	**AWARDED**	**MAXIMUM**					
Common Course - I													
Common Course - II													
Core Course													
Complimentary Course													
Total													
Semester result		**SCPA :**							**SG :**				

Controller of Examinations Principal

Annexure II: Model Mark Cum Grade Card

St. Albert's College (Autonomous)

Ernakulam-682 018, Kerala, India.

edited by National Assessment and Accreditation Council (NAAC)at A Grade

ISO 9001: 2015 Certified

Affiliated to Mahatma Gandhi University, Kottayam, Kerala

CONSOLIDATED MARK CUM GRADE CARD

Name of the candidate	
Permanent register number (prn)	
Degree	
Programme	
Stream	
Date of birth	
Date of eligibility	

Student Photo

SEMESTER RESULTS

Semester	Marks awarded	Maximum marks	Credits	Scpa	Grade	Month and year of passing	Result
Semester 1							
Semester 2							
Semester 3							
Semester 4							
Semester 5							
Semester 6							
Total							

Programme part results

Programme part	Marks awarded	Maximum marks	Credit points	Credits	Ccpa	Grade
Common course i:						
Core course:						
Complementary course:						
Open course:						
Total						

Final result														
Credits			Ccpa			Grade			Result					
Course code	**Course title**	Credits	**Marks**											
			Internal		**External**		**Total**							
			Awarded	Maximum	Awarded	Maximum	Awarded	Maximum	Gp	Grade	Ccp	Ia	Result	
SEMESTER 1														
Common Course - I														
Core Course														
Complementary Course														
SEMESTER RESULT					SCPA:				SG:					
SEMESTER 2														
Common Course - I														
Core Course														
Complementary Course														
SEMESTER RESULT					SCPA:				SG:					
SEMESTER 3														
Common Course - I														
Core Course														

Complementary Course		
SEMESTER RESULT	SCPA:	SG :
SEMESTER 4		
Common Course - I		
Core Course		
Complementary Course		
SEMESTER RESULT	SCPA:	SG:
SEMESTER 5		
Core Course		
Open Course		
SEMESTER RESULT	SCPA:	SG:
SEMESTER 6		
Core Course		
Project		
Choice Based Core Course		
SEMESTER RESULT	SCPA:	SG:

Controller of Examinations Principal

Annexure III: Reverse side of the mark cum Grade Card (Common to all Semesters)

DESCRIPTION OF EVALUATION PROCESS

Grade and Grade point

The evaluation of each course comprises Internal and External components with the ratiol:4 for all courses. Grade and grade points are given on 7-point scale based on the percentage of marks (internal + external) as given in table-I.

Decimals are corrected to next higher whole number

Table -1

% of Marks	Grade	Grade Point
95 and above	S — Outstanding	10
85 to below 95	A+ Excellent	9
75 to below 85	A — Very Good	8
65 to below 75	Good	7
55 to below 65	B — Above Average	6
45 to below 55	C — Satisfactory	5
35 to below 45	D- Pass	4
Below 35	F Failure	
	Ab Absent	

Credit Point and Credit Point Average

Credit Point (CP) of a course is calculated using the formula: — CP = C ^{x} GP, where C is the Credit and GP is the Grade point

Semester Credit Point Average (SCPA) or Cumulative Grade Point Average (CCPA) for a programme is calculated using the formula:- SCPA or CCPA = TCP/TC, where TCP is the Total Credit Point of that semester or programme , TC = Total Credit

GPA	Grade
9.5 and above	S — Outstanding
8.5 to below 9.5	A+ Excellent
7.5 to below 8.5	A Very Good
6.5 to below 7.5	B+ — Good
5.5 to below 6.5	B — Above Average
4.5 to below 5.5	C Satisfactory
3.5 to below 4.5	D - Pass
Below 3.5	F — Failure

Grade Point Average (GPA), of a course is calculated using the formula:- GPA = TCP/TC, where TCP is the Total Credit Point of a course, TC is the total credit of that course.

A separate minimum of 30% marks each for internal and external (for both theory and practical) and aggregate minimum of 35% are required for a pass for a course. For a pass in a programme, a separate minimum of Grade D is required for all the individual courses and an overall grade D or above is mandatory. If a candidate secures F Grade for any one of the courses offered in a Semester/Programme, only F grade will be awarded for that semester /programme until he/she improves this to **D Grade** or above within the permitted period.

Read By	
Verified By	

QR Code

Programme Design

1. B. Sc. CHEMISTRY PROGRAMME – (MODEL - II)

Semester	Course code	Course Title	Course Category	Hours Per week	Credits
I		English I	Common Course	5	4
		Second Language I	Common	5	4
	CHEICRT0119	General and Analytical Chemistry	Core Course	2	2
	CHE1CRP0119	Volumetric Analysis	Core Course	2	-
		Complementary Mathematics	Complementary Course	5	4
	CHE1CMT0219	Industrial Aspects of Inorganic and Organic Chemistry	Complementary Course	4	3
	CHE1CMP0219	Industrial Inorganic Chemistry Practical	Complementary Course	2	-
II		English I	Common Course	5	4
		Second Language I	Common Course	5	4
	CHE2CRT0119	Theoretical and Inorganic Chemistry	Core Course	2	2
	CHE2CRP0119	Volumetric Analysis	Core Course	2	2
		Complementary Mathematics	Complementary Course	5	4
	CHE2CMT0219	Chemical Industry and Industrial Applications of Physical Chemistry	Complementary Course	4	3
	CHE2CMP0219	Industrial Inorganic Chemistry	Complementary Course	2	2

III		English III	Common Course	5	4
	CHE3CRT0119	Organic Chemistry-I	Core Course	3	3
	CHE3CRP0119	Qualitative Organic Analysis	Core Course	2	-
		Complementary Mathematics	Complementary Course	5	4
	CHE3CMT0319	Unit Operations in Chemical Industry	Complementary Course	3	3
	CHE3CMT0419	Unit Processes in Organic Chemicals Manufacture	Complementary Course	3	3
	CHE3CMP0319	Industrial Organic Chemistry Practicals	Complementary Course	2	-
	CHE3CMP0419	Industrial Physical Chemistry Practicals	Complementary Course	2	-
IV		English IV	Common Course	5	4
	CHE4CRT0119	Organic Chemistry-II	Core Course	3	3
	CHE4CRP0119	Qualitative Organic Analysis	Core Course	2	2
		Complementary Mathematics	Complementary Course	5	4
	CHE4CMT0319	Instrumental Methods of Chemical Analysis-I	Complementary Course	3	3
	CHE4CMT0419	Instrumental Methods of Chemical Analysis-II	Complementary Course	3	3
	CHE4CMP0319	Industrial Organic Chemistry Practicals	Complementary Course	2	2
	CHE4CMP0419	Industrial Physical Chemistry Practicals	Complementary Course	2	2
V	CHE5CRT0119	Environment, Ecology and Human Rights	Core Course	4	4
	CHE5CRT0219	Organic Chemistry-III	Core Course	3	3
	CHE5CRT0319	Physical Chemistry - I	Core Course	2	2
	CHE5CRT0419	Physical Chemistry - II	Core Course	2	3

	CHE5COT0219	Open course	Open Course	4	3
	CHE5CRP0119	Qualitative Inorganic Analysis	Core Course	3	-
	CHE5CRP0219	CHE5CRP0219	Core Course	2	-
	CHE5CRP0319	Physical Chemistry Practical	Core Course	3	-
	CHE5CPR0119	Project	Core Course	2	-
VI	CHE6CRT0119	CHE6CRT0119 Inorganic Chemistry	Core Course	3	3
	CHE6CRT0219	CHE6CRT0219 Organic Chemistry-IV	Core Course	3	3
	CHE6CRT0319	CHE6CRT0319 Physical Chemistry - III	Core Course	3	3
	CHE6CRT0419	Physical Chemistry - IV	Core Course	3	3
	CHE6CBT0219	Choice Based Course	Core Course	3	3
	CHE6CRP0119	Qualitative Inorganic Analysis	Core Course	3	2
	CHE6CRP0219	Organic Preparations and Basic Laboratory Techniques	Core Course	2	2
	CHE6CRP0319	Physical Chemistry Practical	Core Course	3	2
	CHE6CRP0419	Gravimetric Analysis	Core Course	2	2
	CHE6CPR0119	Project, Industrial visit and comprehensive viva – voce	Project	-	2
	CHE6CPR0219 OJT	CHE6CPR0219 OJT	Core Course	-	2

On the Job Training All the students have to undergo on the job training in a chemicalindustry for a minimum period of 15 days and submit a project report. The period of 15 days need be at a single stretch. The vacation days may be utilized for this purpose. A report of the training should be submitted to the department during the sixth semester for internal evaluation.

Open Course

Sl. No.	Semester	Course Code	Course Title
1	V	CHE5COT0119	Chemistry in Every day life
2	V	CHE5COT0219	Nanoscience and Nanotechnology
3	V	CHE5COT0319	Forensic Science

Elective Course

Sl. No.	Semester	CourseCode	Course Title
1	VI	CHE6CBT0119	Polymer Chemistry
2	VI	CHE6CBT0219	Soil and agricultural chemistry
3	VI	CHE6CBT0319	Nanochemistry and Nanotechnology

Detailed Syllabus: Semester I

Core Course I: General and Analytical Chemistry (CHE1CRT0119)

36 Hours **2 Credits**

Course Outcome

After successful completion of the course, the students should be able to

- Summarize the methodology of scientific research
- Explain the structure of atoms
- Compare the general characteristics of elements in periodic table
- Recognize the importance of representation of data
- Illustrate the fundamental analytical concepts in chemistry

Module I: Methodology of Chemistry **(3 Hours)**

Definition of Science. Scientific methods- observation-posing a question-formulation of hypothesis-experiment– theory-law. Falsification of hypothesis - inductive and deductive reasoning-revision of scientific theories and laws.

Module II: Atomic Structure **(6 Hours)**

Introduction based on historical development- blackbody radiation-Planck's quantum hypothesis-photoelectric effect-generalization of quantum theory. Atomic spectra of hydrogen and hydrogen like atoms – Bohr theory of atom– Calculation of Bohr radius, velocity and energy of an electron-explanation of atomic spectra-limitations of Bohr theory- Sommer-field modification. Louis de Broglie's matter waves–wave-particle duality-electron diffraction-Heisenberg's uncertainty principle.

Schrödinger wave equation (derivation not expected), wave functions–significance of ψ and ψ^2 – atomic orbitals and concept of quantum numbers-shapes of orbitals (*s*, *p* and *d*)-Pauli's Exclusion principle-Hund's rule of maximum multiplicity- Aufbau principle–electronic configuration of atoms.

Module III: Periodic Table and Periodic Properties **(15 Hours)**

Modern periodic law –Long form periodic table. Diagonal relationship and anomalous behavior of first element in a group. Periodicity in properties: Atomic and ionic radii-ionization enthalpy-electron affinity (electron gain enthalpy)–electro-negativity. Electro-negativity scales: Pauling and

Mullikan scales. Effective nuclear charge– Slater rule and its applications–polarizing power.

Periodicity in s- and p-block elements with respect to electronic configuration, atomic and ionic size, ionization energy and electro-negativity. Inert pair effect.

Transition Metals: General characteristics: Metallic character, oxidation states, size, density, melting points, boiling points, ionization energy, colour, magnetic properties, reducing properties, catalytic properties, non-stoichiometric compounds, complex formation and alloy formation. Difference between first row and other two rows.

Lanthanides: Electronic configuration and general characteristics–Occurrence of lanthanides

Isolation of lanthanides from monazite sand - Separation by ion exchange method. Lanthanide contraction: Causes and consequences. Industrial importance of lanthanides.

Applications of radioactivity: Carbon dating and applications in agricultural and medical field.

Module IV: Evaluation of Analytical Data (5 Hours)

Units, significant digits, rounding, scientific and prefix notation, graphing of data. Precision and accuracy-types of errors–ways of expressing precision–ways to reduce systematic errors-reporting analytical data. Statistical treatment of analytical data–population and samples–Mean and standard deviation–distribution of random errors.

Module V: Principles of Analytical Methods in Chemistry (7 Hours)

Molecular mass-mole concept– molar volume. Oxidation and reduction– oxidation number and valency– variable valency-equivalent mass.

Titrimetric analysis- fundamental concepts. Methods of expressing concentration: Weight percentage, molality, molarity, normality, mole fraction, ppm and ppb. Primary and secondary standards, quantitative dilution–problems. Acid base titrations-titration curves –pH indicators. Redox titrations–titration curve–titrations involving MnO_4^- and $Cr_2O_7^{2-}$ redox indicators. Complexometric titrations–EDTA titrations-titration curves– metal ion indicators.

References

- Peter Pruzan, *Research Methodology: The Aims, Practices and Ethics of Science*, Springer; 1st ed., Switzerland, 2016.
- Tanmoy Chakraborty, Lalita Ledwani, Research Methodology in Chemical Sciences: Experimental and Theoretical Approach, Apple Academic Press, USA, 2016.
- R.Gopalan, *Inorganic Chemistry for Undergraduates*, Universities Press, Hyderabad, 2009
- B. R. Puri, L. R. Sharma and K. C. Kalia, *Principles of Inorganic Chemistry*, 31stEdition, Milestone Publisher sand Distributors, New Delhi, 2013.
- J. D. Lee, Concise Inorganic Chemistry, 5th edn. Blackwell Science, London, 2010.
- J. Elias, The Chemistry of the p-Block Elements - Syntheses, Reactions and Applications, Universities Press; First edition, Universities Press/Orient Black Swan, New Delhi, 2018.
- S. C. Gupta, Fundamentals of Statistics, Himalaya Publishing House Pvt. Ltd.; India, Seventh Edition edition 2016.
- S. Crouch, D. West, F. Holler, D. A. Skoog, Fundamentals of Analytical Chemistry, Brooks/Cole; 9th edition edition, USA, 2013.
- J. Mendham, R. C. Denney, J. D. Barnes, M. Thomas, *Vogel's Text Book of Quantitative Chemical Analysis*, 6th Edition, Pearson Education, Noida, 2013.

Detailed Syllabus: Semester II

Core Course II: Theoretical and Inorganic Chemistry (CHE2CRT0119)

36 Hours **2 Credits**

Course Outcomes

After successful completion of the course, the students should be able to

- Compare and analyze the common themes running through ionic, covalent and metallic descriptions of chemical bonding
- Illustrate the theories of chemical bonding and the secondary bonding interactions
- Outline the function of metal ions in the body and evaluate the transport of oxygen and nutrients to body.
- Explain the structure and properties of boranes, interhalogen compounds and noble gases
- Demonstrate the basic metallurgical process

Module I: Chemical Bonding – I **(10 Hours)**

Introduction – Octet rule and its limitations.

Types of bonds: Ionic bond –factors favouringthe formation of ionic bonds-lattice energy of ionic compounds-Born-Lande equation with derivation-solvation enthalpy and solubility of ionic compounds–Born-Haber cycle and its applications– properties of ionic compounds-polarisation of ions–Fajan's rule and its applications.

Covalent Bond: Valence Bond Theory and its limitations. Concept of resonance-resonance structures of borate, carbonate and nitrate ions. Hybridization: Definition and characteristics

Shape of molecules ($BeCl_2$, C_2H_2, BF_3, C_2H_4, CH_4, NH_3, H_2O, NH_4^+, H_3O^+, PCl_5, SF_6 and

IF_7). VSEPR theory: Postulates- applications-shapes of molecules CCl_4, NH_3, H_2O, ClF_3, XeF_2, SF_6, IF_5, XeF_4, IF_7 and XeF_6.

Properties of covalent compounds–polarity of bonds–percentage of ionic character–dipole moment and molecular structure.

Module II: Chemical Bonding – II **(10 Hours)**

Covalent Bond: Molecular Orbital Theory – LCAO - bonding and anti-bonding molecular orbitals – bond order and its significance. MO diagrams of homonuclear and heteronuclear diatomic molecules: H_2, He_2, Li_2, Be_2, B_2, C_2, N_2, O_2, F_2, CO and NO – comparison of bond length, magnetic behavior and bond energy of O_2, O_2^+, O_2^{2+}, O_2^- and O_2^{2-} . Metallic Bond: free electron theory, valence bond theory and band theory (qualitative treatment only) - explanation of metallic properties based on these theories.

Intermolecular forces: Hydrogen bond - intra and inter molecular hydrogen bonds – effect on physical properties. Van der Waals forces, ion-dipole, dipole-dipole, ion-induced dipole, dipole-induced dipole and induced dipole-induced dipole interactions

Module III: Bioinorganic Chemistry **(4 Hours)**

Essential and trace elements in biological systems–Structure and functions of haemoglobin and myoglobin, Vitamin B12 (structure not expected). Electron carriers–cytochromes. Chlorophyll and photosynthesis (mechanism not expected).

Role of alkali and alkaline earth metals in biological systems, Na/ K pump. Importance of Ca and Mg. Biological functions and toxicity of metals–Fe, Cu, Zn, Cr, Mn, Ni, Co, Cd, Hg and Pb. Metallo-enzymes of zinc and copper, nitrogenase.Treatment of metal toxicity by chelation therapy.

Module IV: Chemistry of p block elements **(7 Hours)**

Preparation, properties and structure of diborane, borazine, boricacid, boron nitride. Oxyacids of Phosphorus and Sulphur Silicates, silicones, Structure of oxides and oxyfluorides of Xenon.

Interhalogens-classification-general preparation-structures of AB, AB_3, AB_5 and AB_7 types. Reactivity (ClF, ICl_3, ClF_3, IF_5 and IF_7).Comparison of pseudohalogens with halogens. Electropositive character of iodine. Separation of noble gases (charcoal adsorption method).Compounds of noble gases.

Module V: Metallurgy **(5 Hours)**

Concepts of ores, refining of ores, electrolytic ion exchange, zone refining, vapour phase refining and oxidative refining, Ellingham diagram, Extractive metallurgy of Ti and U.

References

- J. D. Lee, Concise Inorganic Chemistry, 5th Edn. Blackwell Science, London, 2010.
- J. E. Huheey, E. A. Keitler and R. L. Keitler, Inorganic Chemistry Principles of Structure and Reactivity, 4th Edition, Pearson Education, NewDelhi, 2013.
- F. A. Cotton and G. Wilkinson, Advanced Inorganic Chemistry, 6th Edn. John Wiley & Sons, New York, 1999.
- A. J. Elias, The Chemistry of the p-Block Elements - Syntheses, Reactions and Applications, Universities Press; First edition, Universities Press/Orient BlackSwan, New Delhi, 2018.
- W. U. Malik, G. D. Tuli and R. D. Madan, Selected Topics in Inorganic Chemistry, S. Chand and Co., New Delhi, 2010(Reprint).
- M. Weller, T. Overton, J. Rourke, F. Armstrong, (Schriver and Artkins') Inorganic Chemistry 6 Edition, Oxford University Press; 6th edition, 2015.
- B. R. Puri, L. R. Sharma and K. C. Kalia, Principles of Inorganic Chemistry, 31st Edition, Milestone Publishers and Distributors, New Delhi, 2013.

Core Course III: Volumetric Analysis-Practical– (CHE2CRP0119)

Core Chemistry Practical - Semester I & II

72 Hours **2 Credits**

Course outcomes

After successful completion of the course, the students should be able to

- Apply the basics of volumetric titrations in estimation of acids, bases, metal ions and metal salts.
- Perform estimations of acids or bases by titrations and related calculations
- Perform estimations of inorganic complexes/metal ions by EDTA titrations and related calculations
- Quantify metal salts/ions using their redox properties
- Practice safe laboratory protocols through the use of appropriate personal protective equipment and appropriate handling of all chemicals, including proper disposal of waste.

A. Acidimetry and Alkalimetry

1. Strong acid-Strong base
2. Strong acid – Weak base
3. Strong base – Weak acid
4. Estimation of $Na_2CO_3$and $NaHCO_3$ in a mixture
5. Estimation of NaOH and Na_2CO_3 in a mixture
6. Estimation of ammonia in ammonium salts by direct and indirect methods

B. Complexometric Titrations Using EDTA

1. Estimation of Zn
2. Estimation of Mg
3. Estimation of Mg and Ca in a mixture

4. Estimation of Ni
5. Determination of hardness of water

C. Oxidation – Reduction Titrations

(i) Permanganometry

1. Estimation of ferrous iron
2. Estimation of oxalic acid
3. Estimation of sodium oxalate
4. Estimation of calcium

(ii) Dichrometry

1. Estimation of ferrous iron using internal indicator
2. Estimation of ferrous iron using external indicator
3. Estimation of ferric iron using internal indicator
4. Estimation of ferric iron using external indicator

(iii) Iodimetry and Iodometry

1. Estimation of copper
2. Estimation of arsenious oxide

References

- I. Vogel 'A Text Book of Quantitative Inorganic Analysis Including Elementary Instrumental Analysis': (Third Ed.) (ELBS)
- D.A.Skoog, D.M.West and S.R.crouch, Fundamentals of Analytical Chemistry, 8thEdn. Brooks/Cole Nelson.
- Vogels Textbook of Quantitative Chemical Analysis, 6thEdn. Pearson Education Ltd.

Detailed Syllabus: Semester III

Core Course IV: Organic Chemistry– I (CHE3CRT0119)

(Reaction mechanisms expected only wherever mentioned)

54 Hours **3 Credits**

Course Outcomes

After successful completion of the course, the students should be able to

- IIlustrate the basic concepts of organic reactions and their mechanisms.
- Distinguish aromatic and nonaromatic compounds and understand the chemical consequences of aromaticity
- Identify the chirality in organic compounds and to determine the absolute configuration
- Explain the stability of various conformers of organic compounds
- Apply the concepts studied in predicting the products of reactions and its mechanisms.

Module I: Basic Concepts of Reaction Mechanisms (18 Hours)

Classification and IUPAC system of nomenclature of common organic compounds (bothaliphaticandaromatic), fused ring systems and compounds containing more than one functional groups.

Line diagram drawing. Cleavage of bonds: Homolysis and heterolysis with suitable examples. Curly arrow rules, formal charges. Factors affecting reaction mechanism.

Nucleophiles, electrophiles and free radicals.

Carbocations, carbanions, free radicals and carbenes–types, shape and relative stability.

Inductive effect, electromeric effect, mesomeric effect, resonance and hyperconjugation. Steric effects.

Types of Reactions: Addition, elimination, substitution, rearrangement and redox reactions (definition and examples). S_N1, S_N2, S_Ni, E_1, E_2 mechanisms, Substitution v/s Elimination.

Module II: Aromaticity (18 Hours)

Aromaticity Concepts: Definition, Hückel's rule-application to benzenoid (benzene, naphthalene and anthracene) and non-benzenoid (cyclopropenylcation, cyclopentadienyl anion and tropylium cation) compounds. Anti aromatic compounds.

Aromatic electrophilic substitutions: nitration, halogenation, sulphonation and Friedel-Craft's reaction (alkylation and acylation) with their mechanism. Orientation of aromatic substitution. *ortho*, *para* and *meta* directing effects of groups. Ring activating and deactivating groups with examples.

Aromatic nucleophilic substitutions: bimolecular displacement mechanism, elimination-addition (benzyne intermediate) mechanism, S_N ar mechanism.

Polynuclear Hydrocarbons: Naphthalene and Anthracene: Molecular orbital picture and resonance energy. Preparation – Haworth synthesis. Reactions - Electrophilic substitutions (halogenation, nitration and sulphonation) of naphthalene.

Module III: Stereochemistry (18 Hours)

Stereo Isomerism: Definition, Classification, Fischer projection formulae, Wedge formula, Newman and Sawhorse projections and their inter-conversions.

Optical Isomerism: Optical activity, specific rotation, concept of chirality (upto two carbon atoms). Configuration. Enantiomerism, diastereomerism and mesocompounds. Racemic mixture and methods of resolution. Threo and erythro; *d* and *l* designations; Cahn-Ingold-Prelogrules: R – S notation (for up to 2 chiral carbon atoms).

Geometrical Isomerism: *cis* - *trans*, *syn* – *anti* and E/Z nomenclature (for up to two C=C systems) with C.I.P rules. Methods for distinguishing geometrical isomers.

Cycloalkanes: Origin of ring strain in cyclic systems. Baeyer's strain theory.

Conformational analysis: Conformational analysis with respect to ethane, butane and cyclohexane. Relative stability and energy diagrams. Chair, boat and twist boat forms of cyclohexane with energy diagrams. Conformation of methyl cyclohexane.

References

- Morrison, R.T., Boyd, R.N. &Bhattacharjee, S.K. *Organic Chemistry*, 7thed.,DorlingKindersley(India)Pvt. Ltd(PearsonEducation),2011.
- GrahamSolomon, T.W., Fryhle, C.B. & Snyder, S.A. *OrganicChemistry*, John Wiley & Sons, 2014.

- McMurry, J.Organic Chemistry, 7th ed.CengageLearning, 2013.
- Sykes, P.*A Guidebook to Mechanism in Organic Chemistry*, *Orient* Longman, 1988.
- Eliel, E.L. & Wilen,S.H. *StereochemistryofOrganicCompounds*,Wiley,1994.
- Finar, I.L. *Organic Chemistry* (Vol.1&2), Dorling Kindersley (India) Pvt. Ltd (PearsonEducation).
- Jain, M.K. &Sharma, S.C. *ModernOrganicChemistry*, Vishal Publishing Co.2010.
- Bahl, A. & Bahl, B.S. *AdvancedOrganicChemistry*, S.Chand,2010.
- Kalsi, P.S. *Stereochemistry- Conformation and Mechanism*; New AgeInternational, 2005.
- Pillai, C.N. *OrganicChemistry*, Universities Press, 2008.
- Gupta, S.S. *OrganicChemistry*, Oxford UniversityPress, 2014.

Detailed Syllabus: Semester IV

Core Course V: Organic Chemistry –II (CHE4CRT0119)

(Reaction mechanisms expected only wherever mentioned)

54 Hours **3 Credits**

Course Outcomes

After successful completion of the course, the students should be able to

- Describe the structure and identify the reaction mechanism of organic compounds such as alcohols, ethers and organometallic reagents
- Predict the products and identify the mechanisms of reactions of carbonyl compounds.
- Identify the structure, properties and reaction/ mechanisms of organic acids.
- Develop methods for synthesis and transformation of the most common functional groups using suitable synthetic reagents
- Propose a synthetic route for a target molecule starting from active methylene compounds.

Module I: Organometallics, Hydroxy Compounds and Ethers (18 Hours)

Organometallic Compounds: Preparation and properties of Grignard Reagents, Alkyl Lithium, Organo Zinc Compounds – Reformatsky reaction.

Hydroxy Compounds: *Alcohols* – Reactions - esterification, oxidation (with PCC, alkaline $KMnO_4$, OsO_4, acidic dichromate, conc. HNO_3). Oppenauer oxidation (with mechanism). Methods to distinguish 1˚, 2˚ and 3˚ alcohols. Ascent and decent of alcohol series – methanol to ethanol, ethanol to methanol.

Diols: Preparation - hydroxylation of alkenes, hydrolysis of epoxides. Reactions - oxidative cleavage of diols using lead tetraacetate and periodic acid. Pinacol - Pinacolone rearrangement (with mechanism).

Phenols: Preparation - cumene hydroperoxide method, from diazonium salts. Reactions - Electrophilic substitution - nitration, halogenation and sulphonation. Reimer- Tiemann reaction and Fries rearrangement (with mechanisms).

Preparation and uses of nitrophenols, picric acid, resorcinol and quinol.

Ethers and Epoxides: Preparation - ethers and epoxides - Williamson's ether synthesis. Reactions of ethers – cleavage with HI. Zeisel's method of estimation of alkoxy groups. Reactions of epoxides – with alcohols, ammonia derivatives and $LiAlH_4$.

Module II: Carbonyl Compounds (15 Hours)

Structure and Reactivity: Structure of the carbonyl group and acidity of α-hydrogen. Comparison of reactivity of aldehydes and ketones.

Nucleophilic Addition Reactions: With HCN, ROH, $NaHSO_3$, Grignard reagents and ammonia derivatives. Aldol, Claisen, Claisen-Schmidt, Knoevenagel and Benzoin condensations (with mechanisms). Michael addition (with mechanism)

Oxidation reactions: Tollen's and Fehling's tests, Haloform Reaction, Baeyer-Villiger oxidation (with mechanism).

Reduction reactions: Clemmensen, Wolff-Kishner, Meerwein-Pondorff-Verley, $LiAlH_4$, and $NaBH_4$ reductions (with mechanisms)

Rearrangement Reactions: Beckmann, and benzil-benzilic acid rearrangements (with mechanisms).

Module III: Organic Acids (14 Hours)

Carboxylic acids and Sulphonic acids:-

Monocarboxylic acids: Preparation - Oxidation of alcohols and aldehydes, hydrolysis of nitriles, side chain oxidation and carbonylation of Grignard reagents. Acidic and alkaline hydrolysis of esters.Reactions - structure of carboxylate ion, effect of substituents on acid strength. Ascent anddescent of acid series. Reduction and decarboxylation reactions. Reactions with PCl_5, $PCl_3$and $SOCl_2$. Reaction withammonia, esterification and halogentaion. Hell –Volhard –Zelinsky reaction (with mechanism).

Dicarboxylicacids, hydroxyl acids and unsaturated acids: Methods of formation, important reactions and uses of dicarboxylic acids, hydroxyl acids and unsaturated acidslike oxalic acid, malonic acid, adipic acid, phthalic acid, citric acid, salicylic acid, cinnamic acid, anthranilic acid, acrylic acid, maleic acid and fumaric acid.

Sulphonic acids and their derivatives*:* Preparation, reactions and uses of benzene sulphonic acid, benzene sulphonyl chloride and *ortho*-and *para*-toluene sulphonyl chlorides.

Derivatives of Carboxylic acids: Preparation-acid chlorides, anhydrides, esters and amides from acids.

Reactions-comparative study of nucleophilicity of acyl derivatives.Perkin condensation (with mechanism).

Module IV: Synthetic Reagents (3 Hours)

Fehling's Solution, Tollens' Reagent, Barfoed's Reagent, Borsche's Reagent.

NBS, SeO_2, DCC, DDQ.

Gilman's Reagent – applications in organic synthesis.

Module V: Active Methylene Compounds (4 Hours)

Preparation and Properties of ethyl acetoacetate, diethyl malonate and ethyl cyan acetate.

Synthetic uses of ethyl acetoacetate, diethyl malonate and ethyl cyan acetate (preparation of non-heteromolecules only).

References

- Morrison, R.T., Boyd, R.N. &Bhattacharjee, S.K., Organic Chemistry, 7th ed.,DorlingKindersley(India)Pvt. Ltd(PearsonEducation),2011.
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- Pillai, C.N. Organic Chemistry, UniversitiesPress, 2008.
- Gupta, S.S. Organic Chemistry, Oxford University Press.

Core Course VI: Qualitative Organic Analysis–Practical-(CHE4CRP0119)

Organic Chemistry Practical I: Semester III & IV

72 Hours **2 Credits**

Course Outcomes

After successful completion of the course, the students should be able to

- Perform preliminary laboratory techniques of organic chemistry.
- Obtain experimental skill and motivation to do research.
- Develop laboratory discipline and knowledge in maintaining laboratory equipments properly.
- Perform in the laboratory some of the organic reactions learnt in the class room.
- Practice safe laboratory protocols through the use of appropriate personal protective equipment and appropriate handling of all chemicals, including proper disposal of waste.

1. Determination of physical constants of solids and liquids – melting and boilingpoints.
2. Tests for elements: Nitrogen, Halogens andSulphur
3. Tests for unsaturation.
4. Tests for aromatic character.
5. Study of the reactions of the following functional groups: carboxylic acid, 1, 2- dicarboxylic acid, phenol, aldehyde, ketone, ester, reducing and nonreducing sugars, polynuclear hydrocarbon, primary, secondary and tertiary amines, amides, diamide, nitro and halogencompounds.
6. Systematic analysis and preparation of solid derivative of the following organic compounds: carboxylic acid, 1,2-dicarboxylic acid, unsaturated acids, phenol, hydroxy acids, aldehyde, ketone, ester, reducing and nonreducing sugars, polynuclear hydrocarbon, primary, secondary and tertiary amines, amide, diamide, nitro and halogencompounds.(Minimum twelve compounds to be analysed)

References

- Furniss, B.S.; Hannaford, A.J.; Rogers, V. Smith, P.W.G.; Tatchell, A.R. *Vogel's Textbook of Practical Organic Chemistry*, 5th ed., Pearson Education,2005.
- Mann, F.G.; Saunders, B.C. *Practical Organic Chemistry*, 4th ed., Pearson Education, 2009.
- Ahluwalia, V.K.; Dhingra, S. *Comprehensive Practical Organic Chemistry – Qualitative Analysis*, Universities Press, 2000.
- Vishnoi, N.K. *Advanced Practical Organic Chemistry*, 3rd ed., Vikas Publishing House, New Delhi,2010

Detailed Syllabus: Semester V

Core Course VII: Environment, Ecology and Human Rights – (CHE5CRT0119)

72 Hours **4 Credits**

Course Outcome

- Analyze the need for environmental protection.
- Evaluate how ecological balance is important.
- Explain and evaluate the legal, policy, philosophical and social issues relating protection of environment.
- Aalyze the various forms of pollutions, issues related with them and come up with solutions to reduce them.
- Recognize human rights and analyze it in the perspective of the under privileged sections of the society.

Environmental Chemistry (54 Hours)

Module I: Introduction to environmental studies: Natural resources (10 Hours)

Definition, scope and importance of environmental studies for sustainable development, need for public awareness.

Natural Resources: Classification of natural resources; renewable and non-renewable resources: Natural resources and associated problems;

1.1 Land resources: Land as a resource, land degradation, man induced landslides, soil erosion and desertification. Mineral resources: Use and exploitation, environmental effects of extracting and using mineral resources.

1.2 Water resources: Use and over-utilization of surface and ground water, floods, drought, conflicts over water, dams-benefits and problems.

1.3 Forest resources: Use and over-exploitation, deforestation, case studies. Timber extraction, mining, dams and their effects on forests and tribal people.

1.4 Food resources: World food problems, changes caused by agriculture and overgrazing, effects of modern agriculture, industrial farming of livestock and effects on global warming, fertilizer-pesticide problems, water logging, salinity. Energy resources: Growing energy needs, renewable and nonrenewable energy sources, use of alternate energy sources, mass production of biodiesel for energy needs and food security. Role of an individual in conservation of natural resources. Equitable use of resources for sustainable lifestyles.

Module II: Environment: Pollution and Social Issues (18 Hours)

Fundamental ideas of pollution and pollutant. Cause, effects and preventive measures of various types of pollutions including; air, water, soil, marine, noise and thermal pollutions. Nuclear energy as a source of energy and its hazards. Solid waste management; causes, effects and control mechanisms of urban and industrial wastes. Prevention of pollution: role of individual. Disaster management mechanisms; disaster management of; floods, earthquake, cyclone and landslides.

Movement from unsustainable to sustainable development. Urban crisis related to energy. Water conservation, rain water harvesting, watershed management, Environmental ethics: Issues and possible solutions. Introduction to important green house gases (GHGs), sources of the primary greenhouse gases in earth's atmosphere including water vapor, carbon dioxide, methane. The lesser GHGs- nitrous oxide, ozone and fluorinated gases. Carbon cycle, CO2 sources, Keeling curve and Natural 'sinks' for CO2. Green house effect, climate change, global warming, acid rain, ozone layer depletion, role of CFCs in ozone depletion, and its mechanism, nuclear accidents and holocaust. Wasteland reclamation. Consumerism and waste products. Environment Protection Act (EPA). Air (prevention and control of pollution) Act. Water (prevention and control of pollution) Act, Wildlife Protection Act, Forest Conservation Act. Issues involved in the enforcement of environmental legislation. Introduction to the concept of green chemistry, atom economy (with suitable examples) and the twelve principles of green chemistry.

Module III: Population and Environmental Issues (8 Hours)

Human population growth, Malthusian theory (basic idea) and theory of evolution by natural selection, Malthusian catastrophe. Global challenges, environmental problems of population growth, impacts on human health and welfare, variation among nations, population explosion and Family Welfare Programme. Socio- economic, and geo-political dimensions of poverty, absolute and relative poverty, poverty scale, variation among nations, international food crisis. Resettlement and rehabilitation of project affected population. Environmental movements in India: Chipko, Silent valley, Bishnois of Rajasthan etc.

Module IV: Ecological Chemistry (18 hours)

Definition and scope of ecological chemistry, ecological stress posed upon ecosystems by the presence of chemicals. Origin of chemical toxicants; natural sources, and man-made. Organization

of chemicals as xenobiotic, essential or nonessential substances. Release of chemicals in the environment, Transport Processes, Classification of transformation processes, biotic and abiotic. Structure- activity relationships in degradation and biodegradation of organic chemicals. Transformation processes including general, hydrolysis, oxidation, reduction, photochemical degradation, microbial degradation, and phytodegradation, environmental fate determining processes, bioavailability, exposure of species to (bio)available fractions, uptake (accumulation), metabolism, biomagnifications, distribution in organisms, and subsequent toxic effects. Risk assessment of chemicals-assessment of contaminated soils.

Persistent organic pollutants (POPs), natural and anthropogenic origin of POCs and characteristic properties; half-lives, Kow, Kaw and Koa. Adverse effects of persistent chemicals. Legislation on the use of POPs and twelve persistent organic pollutants. The sources, the uses, some of the physico-chemical properties, the half-lives in the environmental compartments of air, water and soil. Behaviour of the priority persistent organic pollutants identified by the United Nations Economic Commission for Europe (UNECE) including; polychlorinated biphenyls, dieldrin, aldrin, dichlorodiphenyltrichloroethane (DDT), Mirex, Heptachlor and Polychlorinated furans. Agency for Toxic Substances and Disease Registry (ATSDR) list, the ATSDR 2017 Substance Priority List, Restriction of Hazardous Substances (RoHS) directive, Material Safety Data Sheet (MSDN), Toxic Substances Control Act (TSCA) and banned/severely restricted chemicals list.

References

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- Lomborg, Cool It: The Skeptical Environmentalist's Guide to Global Warming, Alfred A. Knopf Publisher- New York, 2007.

Module V **(18 hours)**

V.I Human Rights

An Introduction to Human Rights, meaning, concept and development –History of Human Rights- Different Generations of Human Rights- Universality of Human Rights- Basic International Human Rights Documents - UDHR, ICCPR, ICESCR.-Value dimensions of Human Rights.

V-II Human Rights and United Nations

Human Rights co-ordination within UN system- Role of UN secretariat- The Economic and Social CouncilThe Commission (of) Human Rights?-The Security Council and Human rights- The Committee on the Elimination of Racial Discrimination- The Committee on the Elimination of Discrimination Against Women- the Committee on Economic, Social and Cultural Rights- The Human Rights Committee- Critical Appraisal of UN Human Rights Regime.

V-III Human Rights National Perspective

Human Rights in Indian Constitution – Fundamental Rights- The Constitutional Context of Human Rightsdirective Principles of State Policy and Human Rights- Human Rights of Women-children – minoritiesPrisoners- Science Technology and Human Rights- National Human Rights Commission- State Human Rights Commission- Human Rights Awareness in Education.

References

- H.O. Agarwal, Implementation of Human Rights Covenants with Special Reference to India.
- P. Alston, The United Nations and Human Rights, Clarendon Press, London, 1995.
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- M. Banton, International Action against Racial Discrimination Clarendon Press, Oxford, 1996.
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- N.Bava (ed.,) Human Rights and Criminal Justice Administration in India, Uppal Publishing House, New Delhi, 2000.
- UN Centre for Human Rights, Civil and Political Rights: The Human Rights Committee, World Campaign for Human Rights, Geneva, 1997.
- UN Centre for Human Rights, Discrimination against Women, World Campaign for Human Rights, Geneva, 1994.
- UN Centre for Human Rights, Minority Rights, World Campaign for Human Rights, Geneva, , 1998. UN Centre for Human Rights, Human Rights Machinery, World Campaign for Human Rights, Geneva, 1987.
- Ian Brownlie, Basic Documents Human Rights
- Jack Donelli, Universal Human Rights in Theory and practice
- Upendra Baxi, Future of Human Rights
- P Dhiman, Understanding Human Rights-An Overview
- D P Khanna, Reforming Human Rights
- Chiranjivi J Nirmal, Human Rights in India-Historical, social and political perspectives
- Human Rights in Post-Colonial India, Edited by Om Prakash Dwivedi and V G Julie Rajan.

Core Course VIII: Organic Chemistry–III (CHE5CRT0219)

54 Hours **3Credits**

Course Outcome

After successful completion of the course, the students should be able to

- Recognize various nitrogen containing compounds , their structure, preparation and reactions
- Interpretation of spectroscopic data of simple compounds and their structures
- Recognize fundamental organic photochemical and pericyclic reactions with their mechanisms
- Understand the structure and synthesis of organic polymers, Drugs, Dyes
- Summarize the fundamentals of green chemistry and apply in day today life

Module I: Compounds containing Nitrogen and Heterocyclics (18 Hours)

Nitro Compounds**:** Preparation: Methods of preparation of nitroalkanes and aromatic nitro compounds. *Reactions*: Tautomerism of nitroalkanes. Reduction products of nitro benzene in acidic, neutral and alkaline media and Electrolytic reduction. Selective reduction of poly nitro compounds. Formation of charge transfer complexes.

Amino Compounds**:** Reductive amination of aldehydes and ketones, Gabriel's phthalimide synthesis, Hofmann bromamide reaction (with mechanism).

Reactions- Hofmann elimination, Carbylamine test, Hinsberg test, with HNO_2. Separation of a mixture of 1°, 2° and 3° amines using Hinsberg reagent, Hoffmann's method.

Stereochemistry of amines. Structural features affecting basicity of aliphatic and aromatic amines. Comparative study of aliphatic and aromatic amines. Schotten–Baumann Reaction (with mechanism).

Electrophilic substitution reactions of aniline –Halogenation, nitration and sulphonation. Quaternary amine salts as phase-transfer catalysts.

Diazonium Salts*:* Preparation from aromatic primary amines–Reactions– Structure and stability of

benzene diazonium salts. Conversion to benzene, phenol, chloro, bromo, iodo and fluoro benzenes, nitrobenzene and azodyes. Mechanisms of Sandmeyer and Gatterman reactions. Schiemann and Gomberg reactions. Preparation, structure and uses of Phenyl hydrazine, Diazomethane and Diazoacetic ester. Arndt–Eistert synthesis–Mechanism of Wolff rearrangement.

Heterocyclic Compounds**:** Classification and nomenclature. Structure and aromaticity of 5 – numbered and 6- membered rings containing one heteroatom. Synthesis and reactions of: Furan, Thiophene, Pyrrole (Paal-Knorr synthesis and Knorr pyrrole synthesis), Pyridine (Hantzsch synthesis), Indole (Fischer's indole synthesis), Quinoline (Skraup synthesis and Friedlander's synthesis) and Isoquinoline (Bischler-Napieralski reaction).

Module II: Organic Spectroscopy (15 Hours)

UV Spectroscopy: Types of electronic transitions, λ max, Chromophores and Auxochromes, Bathochromic and Hypsochromic shifts, Intensity of absorption; Application of Woodward Rules for calculation of λ_{max} for the following systems:α,β-unsaturated aldehydes, ketones, carboxylic acids and esters; Conjugated dienes: alicyclic, homoannular and heteroannular; Extended conjugated systems (aldehydes, ketones and dienes); distinction between *cis* and *trans* isomers.

IR Spectroscopy*:* Fundamental and non-fundamental molecular vibrations; IR absorption positions of O and N containing functional groups; Effect of H-bonding, conjugation, resonance and ring size on IR absorptions; Finger print region and its significance; application in functional group analysis.

NMR Spectroscopy: Basic principles of Proton Magnetic Resonance, chemical shift and factors influencing it; Spin–Spin coupling and coupling constant; Anisotropic effects in alkene, alkyne, aldehydes and aromatics, Interpretation of NMR spectra of simple compounds.

Mass Spectrometry: Introduction. EI ionisation. Determination of molecular mass by MS (elementary idea only–fragmentation study not required).

Applications: Applications of IR, UV and NMR for identification of simple organic molecules.

Module III. Organic Photochemistry and Pericyclic Reactions *(9 Hours)*

Organic Photochemistry: Introduction. Photochemical versus Thermal reactions. Electronic excitation and fate of excited molecules. Jablonski diagram. Fluorescence and phosphorescence.

Photosensitisation. Photochemical reactions: Norrish typeI and II reactions of acyclic ketones, Paterno-Buchi reaction and Photo-Fries reaction (with mechanisms).

Pericyclic Reactions: Molecular Orbitals of Ethene and 1, 3 – Butadiene. Symmetry properties of molecular orbitals, Conservation of orbital symmetry, Woodward – Hoffmann Rule. Classification – electrocyclic reactions, cycloadditions and Sigmatropic Reactions with examples. – Diels-Alder reaction, Claisen rearrangement (with mechanisms).

Module IV. Applied Organic Chemistry (12 Hours)

Synthetic Polymers: Introduction and classification. Polymerisation reactions-Addition and condensation. Mechanism of cationic, anionic and free radical addition polymerization; Metallocene based Ziegler-Natta polymerization of alkenes. Preparation and applications of plastics – thermosetting (Polyurethane) and thermosoftening (Polythene, PVC); Fibres (acrylic, polyamide, polyester). Synthetic rubbers – SBR, Nitrile rubber and Neoprene.

Drugs: Classification of drugs. Structure, therapeutic uses and preliminary ideas of mode of action (synthesis not required) of Antibiotics: Ampicillin and Chloramphenicol, Sulphadrugs: Sulphanilamide, Antipyretics: Paracetamol, Analgesics: Aspirin and Ibuprofen, Antimalarials: Chloroquine, Antacids: Ranitidine, Anti-cancer drugs: Chlorambucil and Anti-HIVagents: Azidothymidine (Zidovudine). Psychotropic drugs: Tranquilizers, antidepressants and stimulants with examples.

Dyes: Theories of colour and chemical constitution. Classification of dyes–according to chemical constitution and method of application. Natural and synthetic dyes. Synthesis and applications of: Azodyes– Methylorange; Triphenyl methane dyes- Malachite green and Rosaniline; Phthalein dyes –Phenolphthalein and Fluorescein; Indigoid dyes-Indigotin; Anthraquinoid dyes– Alizarin. Edible dyes (Foodcolours) with examples.

Green Chemistry in Organic Reactions: Basic idea of Principles of Green Chemistry, Green Chemical reactions: Acetylation of Primary Amine using Zn and Acetic acid, Base catalyzed Aldol Condensation, Halogenation of C = C, Diels-Alder reaction between furan and maleic acid, Benzil-Benzilic acid rearrangement.

References

- Morrison, R.T., Boyd, R.N. & Bhattacharjee, S.K. *Organic Chemistry*, 7th ed.,Dorling Kindersley(India)Pvt. Ltd (PearsonEducation),2011.
- Graham Solomon, T.W., Fryhle,C.B.& Snyder,S.A.*Organic Chemistry*,Wiley,2014.
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- Finar, I.L. *Organic Chemistry* (Vol.1 &2), Dorling Kindersley (India) Pvt.Ltd (Pearson Education).
- Jain,M.K.&Sharma,S.C.*Modern Organic Chemistry*

Core Course IX: Physical Chemistry - I (CHE5CRT0319)

36 Hours **2 Credits**

Course Outcomes

After successful completion of the course, the students should be able to

- Explain the properties and characteristics of three states of matter.
- Develop a detailed understanding of different types of crystal systems.
- Understanding different interactions and bonding in three states of matter
- Acquainted with surface phenomena, their importance and properties of colloids.
- Solve numerical problems related to states of matter, adsorption etc.

Module I: Gaseous State (12 Hours)

Postulates of Kinetic Theory of Gases and derivation of the kinetic gas equation. Deviation of real gases from ideal behaviour, compressibility factor, causes ofdeviation. Van der Waals equation of state for real gases. Boyle temperature (derivation not required). Critical phenomena and Andrews experiments and isotherms of CO_2, critical constants and their calculation from van der Waals equation. Vander Waals equation under different conditions and significance of Vander Waals constants with units.

Maxwell Boltzmann distribution laws of molecular velocities and molecular energies (graphical representation – derivation not required) and their importance.Temperaturedependence of these distributions. Most probable, average and rootmean square velocities (no derivation), Relation between different velocities.

Collision properties: Collision cross section, collision number, collision frequency, collision diameter and mean free path of molecules. Relation between mean free path and coefficient of viscosity.

Module II: Liquid State (4 Hours)

Intermolecular forces in liquids (qualitative idea only), Types of liquids- Polar and non-polar- Examples.Physical properties of liquids- Surface Tension and Viscosity, Measurement of Surface tension by stalagmometer method, factors affecting Surface tension. Viscosity, Poisuelle's equation, Determination of viscosity by Ostwald's viscometer, Factors affecting Viscosity- Nature of liquid, temperature, molecular mass. Refractive index: Molar refraction – Lorenz equation.

Module III: Solid State (13 Hours)

Classification of solids- Crystalline and amorphous. Laws of Crystallography – Law of constancy angles, Law of rational indices, Weiss indices and Miller indices, Unit cells- Types of unit cells, Bravais lattices, Types of crystal systems, Identification of lattice planes. Calculation of no.of atoms per unit cell. X–Ray diffraction by crystals, Bragg's equation- Derivation- Simple problems based on Bragg's equation. Determination of solid structures- Using Bragg's method and Debye-Scherrer method. Analysis of powder diffraction patterns of NaCl and KCl, Density of cubic crystals- Mathematical relation and problem based on this equation.

Types of voids (Interstitious sites and coordination sites).Structure of simple ionic solids of the type AX (NaCl, CsCl, ZnS) and AX_2 (CaF_2) and A_2X (Na_2O)

Defects in crystals – stoichiometric (Schotky and Frenkel) and non-stoichiometric defects (Metal Excess and Metal Deficiency).

Liquid crystals and its thermographic behaviour. Classification, structure of smectic, nematic and cholestric phases.

Module IV: Surface Chemistry and Colloidal State (7 Hours)

Adsorption – types, adsorption of gases by solids – factors influencing adsorption –Adsorption isotherm – Freundlich andLangmuir. Derivation of Langmuir adsorption isotherm. The BET theory (no derivation) – use of BET equation for the determination of surface area.

Types of solutions – true, colloid and suspensions, Purification of colloids – Ultra filtration and electrodialysis, optical and electrical properties of colloids. Electrical double layer and zeta potential. Coagulation of colloids, Hardy-Schulz rule. Micelles and critical micelle concentration, sedimentation and streaming potential. Problems related to all topics should be covered.

References

- R P W Atkins, *"Physical Chemistry"*, Oxford University Press
- R J Silby and R AAlberty, *"Physical Chemistry"*, John Wiley & Sons
- F Daniels and AAlberty, *"Physical Chemistry"*, Wiley Eastern
- Puri, Sharma and Pathania, *"Principles of Physical Chemistry"*, Millennium Edition,
- Vishal Publishing Co
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- K. L. Kapoor, "*A Textbook of Physical chemistry"*, Volume 1, Macmillan India Ltd.,
- B. R. Puri, L. R. Sharma, M. S. Pathania, "*Elements of Physical chemistry"*, Vishal Pub. Co.,
- L V Azaroff, *"Introduction to Solids"*, McGraw Hill.
- N B Hannay, *"Solid State Chemistry"*, Prentice Hall.
- McQuarrie, J. D. Simon, *"Physical Chemistry – A molecular Approach"*, Viva Books Pvt. Ltd.
- Anthony R. West, *"Solid State Chemistry and its Applications"*, Wiley Eastern.

Core Course X: Physical Chemistry –II (CHE5CRT0419)

36 Hours **3 Credits**

Course Outcomes

After successful completion of the course, the students should be able to

- Recognize the importance of Schrödinger equation
- Explain the basic principles and the physical implications of quantum mechanics.
- Interpret and explain basic principles of microwave, IR, UV-Visible, ESR and mass spectroscopy.
- Predict the signals observed in the rotational, vibrational and electronic and NMR spectrum of various materials.
- Solve numerical problems related to different spectroscopic methods.

ModuleI: Quantum Mechanics (14 Hours)

Classical Mechanics: Basic concepts, Failures of Classical Mechanics- Black body radiation, Photoelectric effect, Compton effect and atomic spectra. Planck's Quantum theory and explanation of photoelectric effect,de Broglie hyothesis, dual nature of electrons- Davisson and Former's experiment. Heisenberg's uncertainty principle and its significance.

Postulates of quantum mechanics: Schrodinger wave equation-significance of Ψ, well behaved wave functions, Concept of operators - Operator algebra- Linear and Hermitian operators-Laplacian and Hamiltonian operators-Eigen functions and Eigen values of an operator.

Application of quantum mechanics to simple systems-Particle in a 1D box, normalization of wavefunction, 3D box- rectangular and cubic box-concept of degeneracy.

Introductory treatment of Schrodinger equation for hydrogen atom- The wave equation in spherical polar coordinates (derivation not required)-Separation of wave equation-Radial and angular functions (derivation not required) - Orbitals. Quantum numbers and their importance, hydrogen like wave functions- radial and angular wave functions, radial distribution curves.

Module II: Molecular Spectroscopy-I (12 Hours)

Introduction: electromagnetic radiation, regions of the spectrum, interaction of electromagnetic radiation with molecules, various types of molecular spectroscopic techniques, Born-Oppenheimer approximation.

Rotation spectroscopy: Introduction to rotational spectroscopy, Criteria for rotational spectra, Rotational energy levels, Selection rules and expression for rotational energy of a diatonic rig-id rotor, determination of bond length (derivation not required)

Vibrational spectroscopy: Introduction, Criteria for vibrational spectroscopy, simple harmonic oscillator,Hooke's law, Selection Rules, Classical equation of vibration, calculation of force constant, concept of anharmonicity, Morse potential, dissociation energies, fundamental freq-uencies, overtones, hot bands. Degrees of freedom for polyatomic molecules, modes of vibration (H_2O and CO_2 as examples), finger print region, Fermi resonance.

Raman spectroscopy: Introduction, Classical and quantum treatment of Raman effect, Qualita-tive treatment of Rotational Raman effect; Vibrational Raman spectra, Selection rules, Stokes and anti-Stokes lines: their intensity difference, rule of mutual exclusion.

Module III: Molecular Spectroscopy-II (10 Hours)

Electronic spectroscopy: Introduction, selection rule, Franck-Condon principle, electronic transitions, singlet and triplet states, dissociation and predissociation. Polyatomic molecules – qualitative description of σ, π and n- molecular orbitals, their energy levels and the respective transitions. Lambert-Beer's law (definition and mathematics statement only) and its applications.

Nuclear Magnetic Resonance (NMR) spectroscopy: Principles of NMR spectroscopy, Larmor precession, chemical shift - different scales. Spin-spin coupling and coupling constant.Low resolution spectra of simple molecules like pure ethanol containing water and ethanol, ethyl bromide, Acetaldehyde,

Electron Spin Resonance (ESR) spectroscopy: Principle, hyperfine structure, ESR of methyl radical.

Mass spectroscopy: Basic principle – ionization, fragmentation, separation of ions and representation of the spectrum, application in molecular mass determination.

References

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- Mc Quarrie, J. D. Simon, Physical Chemistry – A molecular Approach, Viva Books.
- N. Levine, Physical Chemistry, Tata McGraw Hill,
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- Manas Chanda, Atomic structure and Chemical bonding in Molecular Spectroscopy" Tata McGraw Hill.
- L. Pavia, G. M. Lampman, G. S. Kriz, Introduction to spectroscopy, 3rd edn,
- ThomsonBrooks/Cole, 2001.
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- D.N. Sathyanarayana, Introduction to Magnetic Resonance Spectroscopy ESR, NMR, NQR, IK International, 2009.
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- Gurdeep Raj, "Advanced Physical Chemistry", Goel Publishing House.

Open Course

Open Course I: Chemistry in Everyday Life (CHE5COT0119)

(Chemical structures are non-evaluative)

72 Hours **3 Credits**

Course Outcome

- Summarise different types of food additives used in our daily life.
- Illustrate the different cleansing agents and relate their clensing action.
- Explain the preparation and applications of various types of commodity plastics in daily life.
- Compare the various agricultural chemicals and their applications.
- Explain the importance of chemical drugs and their uses

Module I: Food Additives **(12 Hours)**

Food additives – definition. Preservatives, Food colours - permitted and non-permitted, Toxicology. Flavours - natural and synthetic. Artificial sweeteners, Emulsifying agents, Antioxidants, Leavening agents and Flavour enhancers. Importance of food additives. Soft drinks - formulation and health effects. Health drinks. Fast foods and junk foods and their health effects. Food adulteration. Food laws and standards. Food Safety and Standards Act, 2006.

Module II: Soaps and Detergents **(10 Hours)**

Soaps – Introduction. Types of soaps - Toilet soaps, washing soaps. Liquid soap. TFM and grades of soaps. Bathing bars. Cleansing action of soap.

Detergents - Introduction. Types of detergents - anionic, cationic, non-ionic and amphoteric detergents. Common detergent additives. Enzymes used in commercial detergents. Comparison between soaps and detergents. Environmental aspects.

Module III: Cosmetics **(10 Hours)**

Cosmetics - Introduction. General formulation of different types of cosmetics - Dental cosmetics, Shampoos, Hair dyes, Skin products (creams and lotions, lipstick, perfumes, deodorants and antiperspirants), Bath oil, Shaving cream and Talcum powder. Toxicology of cosmetics.

Module IV: Plastics, Paper and Dyes (12 Hours)

Plastics in everyday life. Plastics and Polymers. Classification of polymers. Brief idea of polymerization. Use of LDPE, HDPE, PP, PVC and PS. Environmental hazards of plastics. Biodegradable plastics. Recycling of plastics. Paper – Introduction. Paper manufacture (basic idea only). Weight and size of paper. Types of paper - News print paper, writing paper, paperboards, cardboards. Environmental impact of paper. International recycling codes, and symbols for identification of plastics. Natural and synthetic dyes with examples (elementary idea only).

Module V: Drugs (9 Hours)

Classification of drugs - Analgesics, Antipyretics, Antihistamines, Antacids, Antibiotics and Antifertility drugs with examples. Psychotropic drugs - Tranquilizers, Antidepressants and Stimulants with examples. Drug addiction and abuse. Prevention and treatment

Module VI: Chemistry and Agriculture (12 Hours)

Fertilizers – Introduction. Types of fertilizers - Natural, synthetic, mixed, NPK fertilizers. Excessive use of fertilizers and its impact on the environment. Bio-fertilizers. Plant growth hormones. Pesticides - Introduction. Classification - Insecticides, Fungicides, Herbicides. Excessive use of pesticides - Environmental hazards. Bio pesticides.

Module VII: Nanomaterials (7 Hours)

Terminology. Scales of nanosystems. Different types of nanoparticles. Applications of nanoparticles in biology and medicine – biological labels, drug and gene delivery, tissue engineering, tumour destruction. Other applications of nanoparticles – electronics, paints, food packaging. Toxicology of nanoparticles.

References

- B. Sreelakshmi, Food Science, New Age International, New Delhi, 2015.
- Shashi Chowla; Engineering Chemistry, Danpat RaiPublication.
- B.K. Sharma; Industrial Chemistry. Goel Publishing House, Meerut, 2003.
- C.N.R. Rao; Understanding Chemistry, UniversitiesPress.

- M.K. Jain and S.C. Sharma; Modern Organic Chemistry, Vishal Pub. Co., Jalandhar, 2009.
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- V.R.Gowariker; N.V. Viswanathan and J. Sreedhar; Polymer Science, 2nd edn., New Age, New Delhi,2015.
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- Singh, K., Chemistry in Daily Life; Prentice Hall of India, New Delhi,2008.

Open Course II: Nanoscience and Nanotechnology (CHE5COT0219)

72 Hours **3 Credits**

Course Outcomes

- Illustrate the scientific and technological concept of Nano technology and classification of prime materials in nanotechnology.
- Explain different strategies of preparation of nanoparticles.
- Outline the important methods for the characterization of nanomaterials.
- Summaries the application of science of small in various sectors.
- Interpret the practicability of nano materials in commercial products.

Module I: History of Nanotechnology (18 Hours)

Historical landmarks- terminology-scales. Top-down and bottom-up paths in nanoscience. Feynman's hypothesis-Moore's law -Types of nanomaterials: fullerene- its discovery- production-contribution to nanotechnology-unusual properties of fullerene. Nanotubes:carbon nanotubes-synthesis- properties and applications.

Module II: Nanoscience: Its Social, Economic and Ethical Perspectives(18 Hours)

Existing laws and regulations of nanotechnology- regulatory agencies- intellectual property policy of nanotechnology. Energy challenges-environmental impacts of nanotechnology - green nanotechnology- technology business: nano economics- entrepreneurs in the technological ecosystem- nanoethics - future ofnanotechnology.

Module III: Seeing the Nanoworld (18 Hours)

Fundamental particles-elctromagnetic radiation- its components- impact on matter-the Planck's equation- de Broglie relation- matter-wave concept of radiation- concept of colour and vision-Auxochromes and chromophores- spectroscopic methods and radiation- elementary ideas of UV-visible, XPES and UPES techniques, SEM, TEM, SPL, and SIMS - their use in the studies of nanosystems (theory is not expected).

Module IV: Applications of Nanotechnology (18 Hours)

Nanobiology and its applications- Nanomedicines- immuno targeted drug delivery-- nanoparticle drug systems for oral, nasal, and ocular administration- nanomaterials in medical diagnosis - therapeutic applications. Nanosensors- smart dusts. Destructive applications of nanotechnology.

References

- T. Pradeep, Nano: The Essentials, Mc Graw Hill Publishing Company, New Delhi (2007).
- V. S. Muraleedharan and A. Subramania, Nanosciece and nanotechnology, Ane Books Pvt. Ltd. New Delhi, 2009.
- N. R. Rao and A.Govindraj, Nanotubes and Nanowires, Royal Society of Chemistry (2005).
- J. M. M. Duart, R. J. M. Palma and F.A. Rueda,Nanotechnology and Microelectronics and optoelectronics, Elsevier(2002).
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- C. P. Poole Jr and F J Owens, Introduction to nanotechnology, Wiley IndiaPvt Ltd2009.
- L. E. Foster, Nanotechnology: Science, Innovation and Opportunity, Pearson Education (2008).

Open Course III: Forensic Science (CHE5COT0319)

72 Hours **3 Credits**

Course Outcomes

After successful completion of the course, the students should be able to

- Explain the various modes of poising and their identification from the perspective of forensic science.
- Get a fundamental idea with regard to explosives, bombs, toxic and corrosive materials.
- Explain and recognize forgery and counterfeiting.
- Summarize the forensic analysis of biological substances.
- Illustrate various aspects with regards to forensic chemical tests.

ModuleI: Poisons **(12 Hours)**

Poisons-types and classification-diagnosis of poisons in the living and the dead – clinical symptoms - postmortem appearances. Heavy metal contamination (Hg, Pb, Cd) of sea foods- use of neutron activation analysis in detecting Arsenic in human hair. Treatment in cases of poisoning - use of antidotes for common poisons.

Module II: Crime Detection **(12 Hours)**

Accidental explosion during manufacture of matches and fire works. Human bombs- possible explosives (gelatin sticks and RDX) - metal detector devices and other security measures for VVIP-composition of bullets and detecting powder burn. Analysis of incendiary and timed bombs - spill of toxic and corrosive chemicals from tankers.

Module III: Forgery and Counterfeiting **(12 Hours)**

Documents - different types of forged signatures-simulated and traced forgeries - inherent signs of forgery methods - writing deliberately modified - uses of ultraviolet rays - comparison of type written letters - checking silver line water mark in currency notes - alloy analysis using AAS to detect counterfeit coins - detection of gold purity in 22 carat ornaments - detecting gold plated jewels - authenticity ofdiamond.

Module IV: Tracks and Traces (18 Hours)

Tracks and traces - small tracks and police dogs-foot prints - casting of foot prints - residue prints, walking pattern or tyre marks - miscellaneous traces and tracks - glass fracture - tool markpaints – fibres. Analysis of biological substances - blood, saliva, urine and hair- Cranial analysis (head and teeth) DNA Finger printing for tissue identification in dismembered bodies -Detecting steroid consumption in athletes and racehorses.

Module V: Medical Aspects (18 Hours)

Aids - causes and prevention - misuse of scheduled drugs - burns and their treatment by plastic surgery. Metabolite analysis using mass spectrum – gas chromatography. Arson- natural fires and arson - burning characteristics and chemistry of combustible materials - nature of combustion. Ballistics - classification - internal and terminal ballistics - small arms - laboratory examination of barrel washing and detection of powder residue by chemical tests.

References

- T.H.James, Forensic Sciences, Stanley ThornesLtd.
- Richard, Criminalistics - An Introduction to Forensic Science (College Version),8th Edition, Sofestein, PrinticeHall.

Detailed Syllabus: Semester VI

Core Course XI: Inorganic Chemistry (CHE6CRT0119)

54 Hours

Course Outcomes **3 Credits**

After successful completion of the course, the students should be able to

- Explain the basic concepts in coordination chemistry
- Learn various theories associated with coordination chemistry and predict electronic spectra of coordination compounds
- Recognize various inorganic reaction mechanisms
- Explain the basics of organometallic chemistry
- Illustrate various analytical methods of inorganic compounds

ModuleI: Coordination Chemistry-I **(8 Hours)**

Introduction of coordination compounds, Types of ligands– Anionic, cationic and neutral –IUPAC Nomenclature, Isomerism incoordination compounds–Structural isomerism and stereoisomerism .Chelates, chelate effect-Stability of complexes, Inert and labile complexes

Factors influencing stability. Review of Werner's theory and Sidgwick's concept of coordination – EAN rule.

Module II: Coordination Chemistry -II **(14 Hours)**

Bonding theories: Valence bond theory – Geometries of coordination numbers 4 and 6–Inner orbital and outer orbital complexes-Limitations of VBT. Crystal filed theory- Splitting of *d*-orbitals in octahedral, tetrahedral, tetragonal and square planar complexes-Jahn Teller Effect–Jahn–Teller distortion in Cu (II) complexes. Factors affecting crystal field splitting-CFSE of low spin and highspin octahedral complexes. Spectrochemical series- Explanation of geometry, magnetism and spectral properties –Merits and demerits of Crystal field theory. Molecular orbital theory–evidence for metal ligand covalency-MO diagram for octahedral complexes (with sigma bonds only).

Module III: Cooridnation Chemistry III (8 Hours)

Spectral and magnetic properties of complexes–electronic absorption spectrum of $[Ti(H_2O)_6]^{3+}$,Calculation of magnetic moments–spin only formula. Reactivity of complexes - Ligand substitution reactions – S_N1 and S_N2 substitutionreactionsofsquareplananrcomplexs- Transeffect and its applications. Application of coordination chemistry in qualitative and quantitative analysis of metal ions such as Cu^{2+}, Zn^{2+}, $Ni^{2+}$and Mg^{2+}.

Module IV: Organometallic Compounds (12 Hours)

Definition– Classification based on the nature of metal-carbon bond and on the basis of hapticity. Naming of organometallic compounds.The18-electron rule and stability–Ferrocene: Preparation, properties and bonding (VBT only). Metal-alkene complexes- –Zeise's salt. Catalytic properties of organometallic compounds- Zeigler Natta catalyst in the polymerization of alkene and Wilkinson catalyst in the hydrogenation of alkene (mechanism not expected). Metal carbonyls-Preparation and structure of following carbonyls-Structures of $Mo(CO)_6$, $Fe(CO)_5$ and $Ni(CO)_4$. Polynuclear carbonyls, bridged carbonyls and bonding in carbonyls– $Mn_2(CO)_{10}$ and$Fe_2(CO)_9$. EAN of metals in metal carbonyls–indication of metal – metal bonding – Quadruple bond–structure of $Re_2Cl_8^{2-}$.

Module V: Applications of analytical methods (12 Hours)

Qualitative analysis: Applications of solubility product and common ion effect in the precipitation of cations. Principle of intergroup separation of cations. Interfering acid radicals and their elimination (oxalate, fluoride, borate and phosphate).

Gravimetric analysis: Unit operations in gravimetric analysis-illustrations using iron and barium estimation. Separation and purification techniques –crystallization and precipitation–fractional distillation, solvent extraction.

Chromatographic techniques: Classification of Chromatographic techniques. Column Chromatography, Principle, types of adsorbents, elution, recovery of substances and applications. Thin Layer Chromatography. Principle, choice of adsorbent and solvent, Rf-values, significance of Rf values. Ion exchange chromatography. Principle and experimental techniques. Gas

Chromatography, Principle and experimental techniques. High Performance Liquid Chromatography (HPLC), Principle and experimental techniques.

References

- J. E. Huheey, E. A. Keitler and R. L. Keitler, *Inorganic Chemistry Principles of Structure and Reactivity,* 4th Edition, Pearson Education, NewDelhi, 2013.
- F. A. Cotton and G. Wilkinson, Advanced Inorganic Chemistry, 6th Edn, John Wiley & Sons, New York, 1999.
- J. D. Lee, Concise Inorganic Chemistry, 5th edn. Blackwell Science, London, 2010.
- W. U. Malik, G. D. Tuli and R. D. Madan, Selected Topics in Inorganic Chemistry, S. Chand and Co., New Delhi, 2010(Reprint).
- A. J. Elias and B. D. Gupta, Basic Organometallic Chemistry, Universities Press; 2 edition, 2013.
- M. Weller, T. Overton, J. Rourke, F. Armstrong, (Schriver and Artkins') Inorganic Chemistry 6 Edition, Oxford University Press; 6th edition, 2015.
- B. R. Puri, L. R. Sharma and K. C. Kalia, Principles of Inorganic Chemistry, 31st Edition, Milestone Publishers and Distributors, New Delhi, 2013.
- D. J. Carswell, An Introduction to Nuclear Chemistry, Elsevier,1967.
- E. Heftmann, Chromatography 6th Edition, Elsevier, 2004.
- J. M. Miller, Chromatography: Concepts and Contrasts, Second Edition, Wiley, 2013.

- Learning Outcome
- To understand various ligands and analyze their various modes of coordination to the metal centers.
- To understand and analyze various theories of bonding in coordination compounds and predict their spectral and magnetic properties.
- To examine various reaction mechanisms associated with coordination complexes.
- To understand organometallic chemistry and its applications in hydrogenation reactions.
- To understand the preparation and structure of metal carbonyl compounds and their importance.
- To analyze cations and anions in a mixture of inorganic salts.
- To understand and apply various chromatographic techniques of purification and analysis

Core Course XII: Organic Chemistry–IV (CHE6CRT0219)

(Reaction mechanisms expected only wherever mentioned)

54 Hours **3 Credits**

Course Outcomes

After successful completion of the course, the students should be able to

- Explain the structure and perform classification, inter conversions and transformations of sugars
- Recognize and elucidate the structure of terpenoids, steroids, alkaloids, vitamins, lipids and their properties.
- Explain the basic structural aspects of amino acids and proteins
- Illustrate the structure and functions of nucleic acids
- Explain the basic structural aspects and functions of enzymes

Chemistry of Natural Products

Module I: Natural Products I **(18 Hours)**

Classification of carbohydrates. Reducing and non-reducing sugars. Properties of Glucose and Fructose Epimers, mutarotation and anomers.

Transformations in Monosaccharides:-Chain lengthening and chain shortening of aldoses-Kiliani Fischer synthesis and Wohl degradation. Interconversion of aldoses and ketoses.

Preparation, Properties, Open chain Structure and Cyclic structureof glucose and fructose.

General Determination of configuration of Glucose (Fischer proof).

Structure of the disaccharides sucrose, maltose and cellobiose (excluding their structure elucidation). Reactions and uses of sucrose.

Structure of the polysaccharides starch and cellulose (excluding their structure elucidation). Industrial applications of cellulose.

Artificial sugars (sweeteners) – Saccharin, Cyclamate, Aspartame, Sucralose.

Module II: Natural Products II (18 Hours)

Terpenoids: Classification. Isoprene rule. Structure elucidation and uses of citral and geraniol. Natural rubber-structure, latex processing methods, vulcanisation, rubber compounding, mastication and uses.

Steroids: Introduction. Diels' hydrocarbon. Structure and functions of cholesterol. Elementary idea of HDL and LDL.

Alkaloids: General methods for isolation. Classification, Physiological action and medicinal importance. Structure elucidation and synthesis of coniine, nicotine and piperine.

Vitamins– Classification. Structure, biological functions and deficiency diseases of vitamins A, B_1, B_2, B_3, B_5, B_6,C and D.

Lipids – Introduction to lipids. Classification. Oils and fats: Biological functions. Extraction and refining. Common fatty acids present in oils and fats. Omega fatty acids.Trans fats and their effect. Hydrogenation, Rancidity. Acidvalue, Saponification value, Iodine value and R M value. Biological functions of waxes, phospholipids and glycolipids.

Module III: Amino acids, Proteins, Nucleic Acids and Enzymes (18 Hours)

Amino acids and Peptides: Classification of aminoacids. Synthesis, ionic properties and reactions of α-aminoacids. Zwitter ion structure and Isoelectricpoint.

Synthesis of simple peptides (upto tripeptides) by N-protecting (benzyloxycarbonyland*t*-butyloxy carbonyl) &C-activating groups. DCC method. Merrifield's solid phase peptide synthesis.

Proteins: Classification of proteins. Overview of Primary, Secondary, Tertiary and Quaternary structure of proteins. Determination of primary structure of proteins. Determination of N- terminal aminoacid (by FDNB and Edman method) and C–terminal aminoacid (by hydrazinolysis and with carboxypeptidase enzyme). Helical and sheet structures. Denaturation of proteins.

Nucleic acids: Components of Nucleic acids: Adenine, guanine, cytosine, thymine and uracil (structure only), other components of nucleic acids. Nucleosides and nucleotides (nomenclature), Structure of polynucleotides; Structure of DNA (Watson-Crick Model) and RNA. Biological functions of DNA and RNA-Replication and protein biosynthesis. Transcription and Translation. Genetic code.

Enzymes: Introduction, classification and characteristics of enzymes. Salient features of active site of enzymes.Mechanism of enzyme action, factors affecting enzyme action, Coenzymes and cofactors and their role in biological reactions, Specificity of enzyme action (Including stereospecificity). Enzyme inhibitors andtheir importance. Uses of enzymes.

References

- Finar, I.L.OrganicChemistry (*Volume2)*, DorlingKindersley (India) Pvt.Ltd. (PearsonEducation).
- Morrison, R.T., Boyd, R.N. &Bhattacharjee, S.K. *Organic Chemistry*, 7th ed., DorlingKindersley(India)Pvt. Ltd(PearsonEducation),2011.
- Nelson, D.L. & Cox, M.M.Lehninger's Principles of Biochemistry, 7th ed., W. H.Freeman.
- Berg, J.M., Tymoczko, J.L. & Stryer, L. *Biochemistry*, W.H.Freeman, 2002.
- Bhat S.V. Nagasampagi, B.A. & SivakumarM. *Chemistry of Natural Products*, Narosa, 2005.
- Jain, M.K. &Sharma, S.C.ModernOrganicChemistry, VishalPublishingCo.2010.
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- Tewari, K.S. &Vishnoi, N.K.OrganicChemistry, VikasPublishing House, 2012.
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- Gupta, S.S. *OrganicChemistry*, OxfordUniversityPress, 2014.
- S.V. Bhat, B.A. Nagasampagi, M. Sivakumar, Chemistry of Natural Products,
- Narosa, 2005.
- V.K. Ahluwalia, L.S. Kumar, S. Kumar, Chemistry of Natural Products, CRS Press, 2007.
- Chatwal Gurudeep R. 1990. *Organic Chemistry of Natural products* Vol I and II. Himalaya Publishing House, Bombay.

Core Course XIII: Physical Chemistry – III (CHE6CRT0319)

54 Hours **3 Credits**

Course Outcomes

After successful completion of the course, the students should be able to

- Analyse different laws of thermodynamics
- Describe various thermodynamic properties such as entropy, enthalpy, and predict the feasibility of physical and chemical changes.
- Describe the significance of ΔG for physical and chemical changes.
- Explain the basic concept of phase rule and its applications, Interpret phase diagram of simple eutectic systems
- Derive rate laws and predict the factors affecting rate of a reaction and evaluate the effect of a catalyst on rate of reaction.

Module 1: Thermodynamics-I (15 Hours)

Basic concepts- system, surroundings, types of systems. Extensive and intensive properties, macroscopic properties. State functions and path functions. Types of Processes, Zeroth law of thermodynamics. Internal energy and enthalpy. Heat capacities at constant volume (C_v) and at constant pressure (C_p), relationship between C_p and C_v for an ideal gas, Kirchoff's equation.

First law of thermodynamics –Mathematical statement of first law. Reversible process and maximum work. Calculation of work, heat, internal energy change and enthalpy change for the expansion of an ideal gas under reversible isothermal and adiabatic condition, simple problems based on the above equation

The Joule-Thomson effect – derivation of the expression for Joule-Thomson coefficient. Sign and magnitude of Joule-Thomson coefficient, inversion temperature. Liquefaction of gases, problems based on inversion temperature.

Thermochemistry – standard states. Enthalpies of formation, combustion and neutralization. Integral and differential enthalpies of solution. Hess's law and its applications.

Module II: Thermodynamics-II (12 Hours)

Second law: Limitations of first law – Different statements of IInd law, Thermodynamic scale of temperature. Carnot cycle and its efficiency, Carnot theorem.

Concept of entropy – Definition and physical significance. Entropy as a function of volume and temperature, Entropy as a function of pressure and temperature. Entropy as a criteria of spontaneity and equilibrium. Third law of thermodynamics-statement and determination of absolute entropies of substances, Problems based on entropy

Gibbs and Helmholtz free energies and their significances- criteria of equilibrium and spontaneity. Gibbs-Helmholtz equation, dependence of Gibbs free energy change on temperature, volume and pressure.

Module III: Chemical Equilibria (3 Hours)

Law of mass action-equilibrium constant – Relation between Kp, Kc and Kx – Problems based on Kp, Kcand Kx. Thermodynamic treatment of the law of mass action – Vant Hoff reaction isotherm – Temperature dependence of the equilibrium constant – The Van'tHoffs equation –Pressure dependence of the equilibrium constant Kp.

Module IV: Ionic Equilibrium (8 Hours)

Introduction – Concepts of acids and bases, Arrhenius, Bronsted-Lowry and Lewis definitions, relative strength of conjugate acid-base pairs, influence of solvents, Dissociation constants – acids, bases, and polyprotic acids. Ostwald's dilution law.

Degree of ionization, factors affecting degree of ionization, ionization constant and ionic product of water-pH. Effects of solvents on ionic strength, Problems based on pH.

Buffer solutions – Mechanism of buffer action, Henderson equation. Hydrolysis of salts – degree of hydrolysis and hydrolysis constant, determination of degree of hydrolysis, pH of salt solutions, Problems based on Henderson equation.

Module V: Phase equilibria (6 Hours)

The phase rule-derivation, equilibrium between phases – conditions. Phase diagram -One component system – watersystem, sulphur system. Two component systems – solid-liquid

equilibrium – Simple Eutectic, Lead- Silver system, Formation of compounds with Congruent Melting Point; Ferric chloride–Water system, Formation of compounds with Incongruent Melting Point Sodium sulphate–Water system.

Module VI: Chemical Kinetics (10 Hours)

Rate of reaction, rate equation, order and molecularity of reactions, determination of order of a reaction.integrated rate expressions for first and second order reactions ($2A \rightarrow P$ and $A + B \rightarrow P$). Zero order reactions, pseudo, half-life.

Theories of chemical kinetics: Effect of temperature on the rate of reaction: Arrhenius equation, Problems based on Arrhenius equation, concept of activation energy, Collision theory, Transition state theory. Thermodynamic parameters for activation – Eyring equation (no derivation needed), enthalpy and entropy of activation. Theory of unimolecular reactions – Lindemann Theory.

Kinetics of complex (composite) reactions: Opposing reactions, consecutive reactions, and parallel (simultaneous) reactions. Chain reactions – steady state treatment, Hydrogen– Bromine reaction-derivation of rate expression.

Catalysis: Homogeneous catalysis, enzyme catalysis – Michaelis–Menten equation (no derivation needed). Heterogeneous catalysis – Surface catalysis, Elementary idea about Autocatalysis.

References

- R. P. Rastogi, R. R. Misra, An Introduction to Chemical Thermodynamics, 6th edn., Vikas Pub. Pvt. Ltd. (2003).
- P. Atkins and J Paula, The elements of Physical chemistry, 7th edn. Oxford University Press.
- K.K. Sharma, L.K. Sharma, A Textbook of Physical Chemistry, 4thedn, Vikas publishing House.
- B. R. Puri, L. R. Sharma, M. S. Pathania, Elements of Physical chemistry, Vishal Pub. Co. Jalandhar
- J. Rajaram and J. C. Kuriakose, Thermodynamics, ShobanLalNagin Chand & Co (1986).
- A. McQuarrie, J. D. Simon, Physical Chemistry – A molecular Approach, Viva Books Pvt. Ltd.

- A. Alberty and R. J .Silby, Physical Chemistry, John Wiley.
- F Daniels and R AAlberty, Physical Chemistry, Wiley Eastern.
- Gurdeep Raj, Advanced Physical Chemistry, Goel Publishing House.
- S. Glasstone, Thermodynamics for Chemists, Affiliated East West Publishers.
- G.S. Rush Brooke, Statistical Mechanics, Oxford University Press.
- K. L. Kapoor, A Textbook of Physical chemistry, Volumes 3, Macmillan India Ltd.
- Gurdeep Raj, Chemical Kinetics, Krishna's Educational Publishers (2014).
- K. J. Laidler, Chemical kinetics, 3rd edn, Pearson education, 2004.

Core Course XIV: Physical Chemistry – IV (CHE6CRT0419)

54 Hours **3 Credits**

Course Outcomes

After successful completion of the course, the students should be able to

- Develop ability in solving practical problem related to analytical chemistry of solutions
- Explain the concepts of electrochemistry and its applications
- Outline the principles of emf, its measurement and applications
- Explain the Principles and application of photochemistry
- Summarize the fundamentals group theory

Module I: Solutions (12 Hours)

Introduction – Binary liquid solutions – Raoult's law- ideal and non-ideal solutions– (ΔH_{mix}, ΔV_{mix}, and $\Delta S_{mix}$for ideal solutions). Vapour pressure – composition and temperature– composition curves of ideal and non-ideal binary liquid solutions. Fractional distillation of binary liquid-liquid solutions – distillation of miscible liquids, partially miscible liquid - liquid systems. Critical solution temperature (CST).

Solubility of gases in liquids – Henry's law. Distribution of a solute between two solvents– Nernst distribution law.

Partial molar quantities – Chemical potential – Gibbs–Duhem equation. Colligative properties of dilute solutions – vapour pressure lowering, Boiling point elevation and freezing point depression (thermodynamicderivation).Molar mass determination-related problems – Osmotic pressure –laws of osmotic pressure – Reverse osmosis – purification of sea water. Abnormal molecularmasses – Van't Hoff factor – Degree of association and Degree of dissociation. Problems based on colligative properties.

Module II: Electrical Conductance (12 Hours)

Introduction- Faraday's laws of electrolysis, electrochemical equivalent& chemical equivalent. Electrolytes - conductivity and molar conductivity – Variation of conductivity and molar conductivity with concentration. Kohlrausch's law – Applications.

Ionic mobility – relation with ionic conductivity, influence of temperature on ionic conductivity, ionic conductivity and viscosity – Walden's rule. Abnormal ionic conductivity of hydrogen and hydroxyl ions.

Transference number and its experimental determination using Hittorf and Moving boundary methods.

Debye-Hückel theory of strong electrolytes – the concept of ionic atmosphere, Asymmetry and electrophoretic effect, Debye- Hückel-Onsager equation (no derivation). Activity, mean ionic activity and mean ionic activity coefficients of electrolytes. Ionic strength of a solution, Debye-Hückel limiting law (no derivation).

Applications of conductance measurements – Determinations of degree of dissociation of weak electrolytes, determination of solubility and solubility products of sparingly soluble salts, conductometric titrations involving strong acid- strong base, weak acid- strong base, mixture of a strong acid and weak acid against strong base and precipitation titrations. Problems based on Faraday's laws of electrolysis, conductance, molar/equivalent conductance, Kohlrausch's law, degree of dissociation and solubility product.

Module III: Electromotive Force (15 Hours)

Introduction –Electrochemical cells and electrolytic cells, Galvanic cells, characteristics of reversible cells. Reversible electrodes – Different types, Reference electrodes – Standard Hydrogen Electrode, Calomel electrode, Electrode potential – Electrochemical series. Representation of electrochemical cells, Electrode reactions and cell reactions Derivation of Nernst equation for electrode potential and cell potential, Gibb's Helmholtz equation and EMF of a cell, calculation of ΔG, ΔH and ΔS from EMF data. Calculation of equilibrium constant from EMF data. Problems based on Nernst equations.

Concentration cells – Electrode concentration cell and electrolyte concentration cells. Types of

electrolyte concentration cells – with transference and without transference, liquid junction potential and salt bridge. Fuel cells – the hydrogen-oxygen fuel cell.

Applications of emf measurements – determination of solubility product, determinationof pH using hydrogen electrode, quinhydrone electrode and glass electrode. Problems based on determination of pH and Ksp

Potentiometric titrations of acid-base and redox reaction, oxidation reduction indicators.Irreversible electrode processes – overvoltage.

Corrosion of metals – forms of corrosion, electrochemical theory of corrosion and rusting methods and prevention methods.

Module IV: Photochemistry (6 Hours)

Laws of photochemistry-Grothus-Draper law, Stark-Einstein law. Jablonsky diagram -qualitative description of fluorescence, phosphorescence, non-radiative processes (internal conversion, intersystem crossing). Quenching of fluorescence. Problems based on Stark-Einstein law.

Quantum yield, examples of low and high quantum yields, Problems based on quantum yields, photochemical reactions (decomposition of HBr, isomerisation of maleic acid to fumaric acid), photosensitised reactions (photosynthesis, isomerization of 2-butene), chemiluminescence, bioluminescence..

Module V: Group Theory (9 Hours)

Symmetry elements and symmetry operations. Elements of symmetry – Proper and improper axis of symmetry, plane of symmetry, centre of symmetry and identity element. Combination of symmetry operations, Group multiplication table of C_2V, Schoenflies symbol, Point groups, C_{2V}, C_{3V} and D_{3h}, Point groups of simple molecules like H_2O, NH_3 and BF_3.

References

- B. R. Puri, L. R. Sharma, M. S. Pathania, Elements of Physical chemistry, Vishal Pub. Co. Jalandhar.
- K. L. Kapoor, A Textbook of Physical chemistry, Volume 4, Macmillan India Ltd.
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- S. H. Marron and J. B. Lando, Fundamentals of Physical Chemistry, MacmillanLtd.
- G. K. Vemulapalli, Physical Chemistry, Prentice-Hall of India Pvt. Ltd. (1997)
- V Ramakrishnan and M S Gopinathan, "Group Theory in Chemistry", Vishal
- Publishing.

Core Course XV: Qualitative Inorganic Analysis – Practical (CHE6CRP0119)

108 Hours **3 Credits**

Course Outcomes

After successful completion of the course, the students should be able to

- Adequate understanding of reactions of cationic and anionic radicals with a view to their identification and confirmation.
- Acquire the Skill to analyze qualitatively the mixtures containing acid and basic radicals.
- Attain competency to systematically analyze mixtures of acid and basic radicals containing one interfering radical by Semi-micro method.
- Identify the presence of metal salts in environmental samples
- Acquire practical skill in detecting ions in solutions

1. Study of the reactions of the following radicals with a view to their identification and confirmation. Ag^{+} , Hg^{2+}, Pb^{2+}, Cu^{2+}, Bi^{2+}, Cd^{2+}, As^{3+}, Sn^{2+}, Sb^{3+}, Fe^{2+}, Fe^{3+}, Al^{3+}, Cr^{3+},Zn^{2+},Mn^{2+},Co^{2+},Ni^{2+},Ca^{2+},Sr^{2+},Ba^{2+},Mg^{2+},Li^{+},Na^{+},K^{+},NH_4^{+}.CO_3^{2-},S_2^{-}, SO_4^{2-}, NO_3^{-}, F^{-}, Cl^{-}, Br^{-} , BO_2^{-} , $C_2O_4^{2-}$, $C_4H_4O_6^{2-}$, CH_3COO^{-} , PO_4^{3-} , AsO_3^{3-} ,AsO_4^{3-} and CrO_4^{2}-
2. Systematic qualitative analysis of mixtures containing two acid and two basic radicals from the above list without interfering radical and with one interfering radical bySemi- micro method only. (Minimum of 10 mixtures to beanalysed)

References

- Vogel 'A Text Book of Quantitative Inorganic Analysis Including Elementary Instrumental Analysis': (Third Ed.)(ELBS)
- G. Svehla, Text Book of Vogel's Macro and Semi-micro Inorganic Analysis, revised, OrientLongman.
- V. V. Ramanujam, 'Inorganic Semi micro Qualitative Analysis', The National Publishing Co.,Chennai,
- W. G. Palmer 'Experimental Inorganic Chemistry', Cambridge.

Core Course XVI: Organic Preparations & Laboratory Techniques-Practical- (CHE6CRP0219)

72 Hours **2 Credits**

Course Outcomes

After successful completion of the course, students should be able to

- Acquire ample expertise in basic laboratory techniques such as crystallisation, distillation, solvent extraction, separation and purification
- Competent enough to perform organic reactions involving Oxidation, Hydrolysis, Nitration, Halogenation, Acylation, Esterification, Side chain oxidation, condensation etc.
- Acquire skill in preparation of simple organic compounds
- Trained to perform separation and identification of organic compounds using TLC and Column Chromatography.
- Acquire knowledge on Rf value

A. Basic LaboratoryTechniques

1. Crystallisation – Any four compounds using ethyl acetate, ethanol, and water - Record the yield ofrecovery.
2. Distillation - Purification of water and ethyl acetate-Record the yield ofrecovery.
3. Solvent extraction – aniline from water - methyl benzoate from water - usingether-
4. Record the yield of recovery. (Any two experiments shall bedone).

B. OrganicPreparations

Organic preparations involving:

1. Oxidation (benzaldehyde to benzoicacid).
2. Hydrolysis (methyl salicylate or ethyl benzoate to theacid).
3. Nitration (m-dinitrobenzene and picricacid).

4. Halogenation (p-bromoacetanilide fromacetanilide).
5. Acylation (Benzoylation of aniline, phenol, β-naphthol).
6. Esterification (benzoic acidester).
7. Iodoform from acetone or ethyl methylketone.
8. Side chain oxidation (benzyl chloride to benzoicacid).
9. Claisen – Schmidt reaction: Dibenzal acetone frombenzaldyde.

C. Chromatography

1. TLC - Separation and identification- Determination of Rf value of o-andp-nitroanilines,o- and p-chloroanilines, p-chlorophenol and p-nitrophenol, p-chloroaniline and p–nitroaniline, benzil and o-nitroaniline or any two amino acids.
2. Column Chromatography – Purification of o-nitro aniline, o-nitrophenol, benzil, m- dinitro benzene, benzene azo –β-naphthol (non–evaluative).

References

- Furniss, B.S.; Hannaford, A.J.; Rogers, V. Smith, P.W.G.; Tatchell, A.R.*Vogel's Textbook of Practical Organic Chemistry*, 5th ed., Pearson Education,2005.
- Mann, F.G.; Saunders, B.C. *Practical Organic Chemistry*, 4th ed., PearsonEducation, 2009.
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- *Preparation and Quantitative Analysis*, Universities Press, 2000.
- Vishnoi, N.K. *Advanced Practical Organic Chemistry*, 3rd ed., Vikas Publishing House, New Delhi,2010.

Core Course XVII: Physical Chemistry Practical - (CHE6CRP0319)

108 Hours **3 Credits**

Course Outcomes

After successful completion of the course, students should be able to

- A firm foundation in the fundamentals and application of current chemical and scientific theories in physical chemistry
- Able to explore new areas of research in both chemistry and allied fields of science and technology.
- Acquire knowledge on electrochemical cells using conductometric and potentiometric titrations and able to measure the concentration of an unknown sample.
- Understand chemical kinetics and able to determine the order of chemical reactions.
- Able to handle viscometer in order to measure the viscosity of an unknown solution

Viscosity– percentage composition of a mixture.

1. Heat of solution – KNO3,NH4Cl
2. Heat ofneutralization
3. Determination of equivalent conductance of anelectrolyte
4. Conductometric titration – strong acid vs. strong base, weak acid-strongbase
5. Transition temperature of salt hydrates. (Sodium thiosulphate, sodiumacetate)
6. Determination of the surface tension of a liquid(Drop number method or Dropweight method)
7. Critical solution temperature of phenol-watersystem.
8. Effect of electrolytes on the CST of phenol-watersystem.
9. Molecular weight determination by Rast's method. (using naphthalene, camphor or biphenyl as solvent and acetanilide, p-dichlorobenzene etc. assolute.)

10. Kinetics of simple reactions eg. Acid hydrolysis of methylacetate.
11. Potentiometric titration – Fe2+vs. Cr2O72–, I-vs.MnO4–
12. Data analysis of kinetic experiments using spreadsheet program (determination of rate constant)
13. Determination of equivalence point of potentiometric and conductometric titrations using spread sheet program.

References

- W. G. Palmer: 'Experimental physical chemistry', Cambridge UniversityPress.
- J.B. Yadav: Advanced Practical Physical Chemistry Goel PublishingHouse.
- R.C. Das and B. Behra; 'Experiments in Physical Chemistry' , Tata McGrawhill.
- K.K. Sharma : 'An Introduction of Practical Chemistry': Vikas PublishingHouse, NewDelhi
- Khosla, B. D.; Garg, V. C. &Gulati, A. Senior Practical Physical Chemistry,R.Chand & Co.: New Delhi(2011).

Core Course XVIII: Gravimetric Analysis -Practical-(CHE6CRP0419)

36 Hours **2 Credits**

Course Outcomes

After the successful completion of the course, students should be able to

- Competent enough to perform the quantitative estimation of the metals such as Nickel, Copper, Iron , Barium and radicals such as sulphate gravimetrically
- Able to do analysis quite precisely
- Able to determine the atomic masses of many elements to six figure accuracy
- Able to determine the quality of an analyte
- Able to do ore analysis
    1. Estimation of Barium as barium sulphate
    2. Estimation of iron as Fe_2O_3
    3. Estimation of sulphate as bariumsulphate
    4. Estimation of copper as cuprousthiocynate
    5. Estimation of nickel as nickel dimethylglyoxime.

References

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- D.A. Skoog, D.M. West, F.J. Holler and S.R. Crouch, Fundamentals of Analytical Chemistry, 8th Edition, Brooks/Cole, Thomson Learning, Inc., USA,2004.
- G. D. Christian, Analytical Chemistry, JohnWiley andSons.
- R. D. Day, A. L. Uderwood, Quantitativeanalysis.

Elective Courses

Elective Course I: Polymer Chemistry (CHE6CBT0119)

54 Hours **3 Credits**

Course outcomes

After successful completion of the course, the students should be able to

- Recognize the history of polymers, terminology and different schemes of classification of polymers.
- Explain different polymerization techniques and mechanisms
- Recognize the structure-property relationships of polymers
- Realize the environmental impacts of polymers and practice its use accordingly
- Explain different speciality polymers and recognize their applications

Module I: Introduction and History of Polymeric Materials (4 Hours)

History of Polymers. Terminology. Different schemes of classification of polymers. Polymer nomenclature.

Module II: Mechanisms of Polymerization (6 Hours)

Classification of polymerization processes. Mechanism of step growth, radical chain growth, ionic chain (both cationic and anionic) and coordination polymerizations. Mechanism of copolymerization. Mechanism of ring opening and group transferpolymerisations.

Module III: Polymerisation Techniques (4 Hours)

Polymerisation techniques: Bulk, solution, suspension and emulsion polymerisations. Melt, solution and interfacial polycondensation techniques.

Module IV: Physical Properties of Polymers (14 Hours)

Structure-Property relationships of polymers.

Crystallization and Crystallinity*:* Determination of crystalline melting point and degree of crystallinity, Morphology of crystalline polymers, Factors affecting crystalline melting point.

Molecular weight of polymers: Determination of Molecular Weight of Polymers (M_n, M_w, etc) by end group analysis, viscometry, light scattering and osmotic pressure methods. Molecular weight distribution and its significance. Polydispersity index.

Glass Transition Temperature *(T_g):* Definition. Factors influencing glass transition temperature (T_g). T_g and molecular weight. T_g and melting point. Importance of T_g.

Module V: Reactions of Polymers (4 Hours)

Hydrolysis, hydrogenation, addition, substitution, crosslinking, vulcanisation and cyclisation reactions.

Module VI: Polymer Degradation (4 Hours)

Types of degradation. Thermal, mechanical, photo and oxidative degradations of polymers.

Module VII: Polymer Processing (4 Hours)

Polymer processing techniques: Compression moulding, Injection moulding, Blow moulding, Extrusion moulding, Thermoforming, Die casting, Film casting, Rotational casting, Calendering and Spinning.

Module VIII: Chemistry of Commercial Polymers (8 Hours)

Brief introduction to the preparation, structure, properties and applications of the following polymers: polyolefins (LDPE, HDPE and PP), poly(vinyl chloride), polystyrene, poly(vinyl acetate), acrylic polymers (PAN and PMMA), fluoro polymers (PTFE), aliphatic polyamides (Nylon 6,6 and Nylon 6), aromatic polyamides (Kevlar), polyesters (PET), formaldehyde resins (PF, UF and MF), polyurethanes, polycarbonates, epoxyresins.

Module IX: Specialty Polymers (6 Hours)

High temperature resistant and flame retardant polymers. Biomedical applications of polymers. Controlled drug delivery systems. Conducting polymers - polyacetylene, polyaniline, poly (p-phenylene sulphide), polypyrrole, polythiophene. Conduction mechanism and applications. Carbon nanotubes. Synthesis and applications (elementary idea only).

References

- Carraher, C.E. Seymour/Carraher's Polymer Chemistry, 6th ed., Marcel Dekker, New York, 2003.
- Odian, G. Principles of Polymerization, 4th ed., Wiley, 2004.
- Billmeyer, F.W. Textbook of Polymer Science, 3rd ed., Wiley-Blackwell, 1984.
- Gowariker, V.R., Viswanathan, N.V.; Sreedhar J. Polymer Science, 2nd ed., New Age, 2015.
- Ghosh, P. Polymer Science & Technology, 2nd ed., Tata McGraw-Hill, New Delhi, 2002.
- Lenz, R.W. Organic Chemistry of Synthetic High Polymers. IntersciencePublishers, New York,1967.
- Bahadur, R., Sastry, N.V. Principles of Polymer Science, Narosa, New Delhi,2003.

Elective Course II: Soil and Agricultural Chemistry (CHE6CBT0219)

54 Hours **3 Credits**

Course Outcomes

After successful completion of the course, the students should be able to

- Explain the origin and various components of soil.
- Summarize the various properties of soil.
- Explain the various chemical and biological processes associated with soil.
- Illustrate various chemical and biological fertilizers as plant nutrients.
- Explain various pesticides, fungicides and herbicides used in agriculture along with their mechanism of action.

Module I: Origin of Soil (9 Hours)

Definition of soil - origin - igneous - metamorphic and sedimentary rocks - rock systems – weathering of rocks and minerals - main components of soil- organic, inorganic, liquid and gaseous phase - minerals of importance with respect to industries and agriculture - Soil formation - physical, chemical and biological factors responsible for soil formation-soil forming processes - Major soil groups of Kerala- methods of soil survey - remote sensing and soil mapping - soil resource management - use of satellite data for source inventory.

Module II: Physical Properties of Soil (9 Hours)

Physical properties of soil - soil texture and textural classification - pore space - bulk density, particle density - soil structure and soil colour - surface area - soil colloids - plasticity, shrinkage - flocculation and deflocculation - soil air, soil temperature, their importance in plant growth – soil reaction - Ion exchange reaction- cation exchange - anion exchange - Buffering capacity – hydrogen ion concentration - determination of pH values - Factors affecting soil pH - Soil pH and nutrient availability - Soil degradation - causes.

Module I

II: Chemistry Aspects of Soil (9 Hours)

Origin of problem soils, their properties- acid, alkali and saline soils - diagnosis - remediation of acid and salt affected soils - Methods of reclamation and after care - Quality of irrigation water – causes for poor quality waters for irrigation, their effects in soils and crops. Soil testing - concept, objectives and basis - soil sampling, collection processing, despatch of soil and water samples. soil organic matter - its decomposition and effect on soil fertility - source of organic matter in soil - maintenance and distribution - soil organism - their role - nitrification - denitrification, nitrogen fixation in soils - biological nitrogen fixation - microbial interrelationship in soil - microbes in pest and disease management - Bio- conversion of agricultural wastes.

Module IV: Plant Nutrients (18 Hours)

Plant nutrients - macro and micro nutrients - their role in plant growth - sources- forms of nutrient absorbed by plants - factors affecting nutrient absorption - deficiency symptoms in plants - corrective measures - chemicals used for correcting nutritional deficiencies - nutrient requirement of crops, their availability, fixation and release of nutrients. Fertilizers - classification of NPK fertilizers - sources - natural and synthetic - straight – complex - liquid fertilizers, their properties, use and relative efficiency - micro nutrient fertilizers - mixed fertilizers - principle of fertilizers use - the efficient use of various fertilizers - integrated nutrient management - biofertilizers - rhizobium, azospirillum, azetobacter - Blue green algae and azolla - production and quality control of bio-fertilizers.

Module V: Pesticides, Fungicides and Herbicides (9 Hours)

Pesticides: Definition – Classification – organic and inorganic pesticides – mechanism of action – Characteristics – Safe handling of pesticides – impact of pesticides on soil, plants and environment – Acts and Laws concerning the pesticides. Fungicides: definition – classification – mechanism of action – sulfur, copper, mercury compounds, dithanes, dithiocarbamates. Herbicides: definition – classification – mechanism of action – Arsenic and boron compounds – nitro compounds, chloro compounds, triazines, propionic acid derivatives, urea compounds. Acaricides – rodenticides – attractants – repellants – fumigants, defoliants.

References

- Biswas, T. D. and Mukeherjee, S. K. Textbook of Soil Science,1987
- Daji, A.J. A Textbook of Soil Science, Asia Publishing House, Madras,1970
- Tisdale, S.L., Nelson, W.L. and Beaton, J. D. Soil Fertility and Fertilizers, Macmillian Publishing Company, New York,1990
- Hesse,P.R. A Textbook of Soil Chemical Analysis, John Murray, New York,1971.
- Buchel, K.H. Chemistry of Pesticides, John Wiley & Sons, New York,1983
- SreeRamula, U. S. Chemistry of Insecticides and Fungicides, Oxford and IBH Publishing Co., NewDelhi.

Elective Course III: Nanochemistry and Nanotechnology (CHE6CBT0319)

54 Hours **3 Credits**

Course Outcomes

After successful completion of the course, the students should be able to

- Understand the concept of Nano and classification of nanomaterials
- Understandd the important methods for the characterization of nanomaterials
- Unerstand electrical and optical properties of carbon nanotubes
- Understand the Applications of Nanomaterials as Nanocatalysis – nanomedicine
- Able to understand different preparation strategies of nanoparticles

Module I: Introduction to Nanomaterials (15 Hours)

History-Feynman's hypothesis- scales of nanosystems- Moore's law-Classification of nanomaterials based on dimensions -quantum dots-. Different types of nanomaterials. Synthesis, properties and applications of fullerenes, carbon nanotubes and quantum dots. Various approaches in nanoparticle synthesis: CVD, Laser ablation and Arc discharge - self- assembled monolayers, monolayer protected metalnanoparticles.

Module II: Characterization of Nanomaterials (15 Hours)

Important methods for the characterization of nanomaterials – electron microscopy (SEM), transmission electron microscopy (TEM), scanning tunneling electron microscopy (STEM), environmental transmission electron microscopy (ETEM), scanning probe electron microscopy (SPL), secondary ion mass spectrometry (SIMS)-photoelectron spectroscopy (UPES and XPES).

Module III: Electrical and Optical Properties of Nanomaterials (12 Hours)

Electrical and optical properties of metal nanoparticles- electrical and optical properties of carbon nanotubes. Nanocrystals, nanolithography- optoelectronic devices-photodetectors.

Module IV: Applications of Nanomaterials (12 Hours)

Nanocatalysis – nanomedicines - immunogold labeling- applications in medical diagnosis- nanobased drug delivery. Applications in biotechnology -nanosensors- self-assebly, nanosensor based on quantum size effects- nanobiosensors- destructive applications of nanomaterials.

References

- T. Pradeep, Nano: The Essentials, Mc Graw Hill Publishing Company, New Delhi (2007).
- V. S. Muraleedharan and A. Subramania, Nanosciece and Nanotechnology, Ane Books Pvt. Ltd. New Delhi, 2009.
- N. R. Rao and A.Govindraj, Nanotubes and Nanowires, Royal Society of Chemistry (2005).
- J. M. M. Duart, R. J. M. Palma and F.A. Rueda, Nanotechnology and microelectronics and optoelectronics, Elsevier (2002).
- R. Booker and E. Boysen, Nanotechnology, Wiley India Pvt Ltd,2008.
- K. J. Klabunde, Nanoscale materials in chemistry, John Wiley andSons.
- P. Poole Jr and F J Owens, Introduction to nanotechnology, Wiley IndiaPvt Ltd 2009.
- G.L. Hornyak, J.Dutta, H.F Tibbals, A.K Rao, Introduction to Nanoscience, CRC Press.

Vocational / Complementary Courses

Industrial Aspects of Inorganic and Organic Chemistry (CHE1CMT0219)

72 Hours **4 Credits**

Course outcomes

After successful completion of the course, the students should be able to

- Explain the basic properties of fuels
- Illustrate the properties of various food components and principles behind analytical techniques associated with food.
- Recognize the various metals and alloys that are industrially applied
- Able to recognize appropriate type of materials present in various conducting devices
- Explain the behaviour of a metallic material to a certain application

Module I: Fuels and Petroleum **(26 Hours)**

Fuels: Introduction –Solid, liquid and gaseous fuels –Characteristics of a good fuel-calorific value: GCV, NCV, Bomb calorimeter, Calorific values of different fuels.

*Petroleum:*Introduction- Petroleum- origin- exploration- drilling- recovery– transportation- composition of crude oils-Natural gas- composition-distillation: atmospheric and vaccum distillation-cracking: thermal cracking –catalytic cracking-Reforming-Isomerisation-Petroleum products: LPG, Naphtha, Kerosene, MS, HSD, ATF, Furnace oil and Bitumen. Quality of petroleum products: API Gravity, RVP, Flash point, Fire point, cloud and pour point, viscosity, ashes and carbon residue, octane number, cetane number, Bulk storage of petroleum products. Petroleum Refineries in India.

Coal: Origin- analysis of coal- valuation and selection of coal- role of sulphur in coal-role of ash in coal- classification of coal- types of coals- Indian Coal-carbonization of coal- Manufacture of coke-Conversion of coal into liquid fuels: Fischer-tropsch method-Bergius process- Coal tar distillation. Major coal related industries in India.

Alternate fuels: LPG LNG, CNG, Biogas, Biodiesel, Ethanol mixed petrol, Hydrogen.

Other gaseous fuels: Producer gas, Water gas, coal gas, oil gas.

Module II: Food Chemistry (14 Hours)

Food quality tests-Colour, Texture, natural toxicants, microbial toxins, bacterial food poisoning, contaminants-Reasons for food deterioration- Methods of preservation and processing.

Food adulteration.Food additives-anti-oxidants-chelating agents-coloring agents-curing agents-emulsions-flavours and flavor enhancers-flour improvers-humectants and anticaking agents-Leavening agents-Nutrient supplements-Non-nutritive sweeteners-pH control agents-preservatives: sodium chloride-sugar-sulphur dioxide-nitrate and nitrite-sorbic acid-acetic acid-propionic acid-benzoic acid-parabens-epoxides-antibiotics-diethyl pyrocarbonate; Stabilisers and thickners. Tastemakers–MSG and vinegar

Module III: Metallurgy (15 Hours)

Introduction -general metallurgical operations-crushing-grinding of the ore-concentration of the ore-pulverisation-calcination-roasting-refining of metals-Extraction of iron, copper, silver, aluminium, uranium and titanium. Necessity of making alloys-classification of alloys-Brass-Bronze-Duralumin-Magnalumin.Alloys of lead and tin.Classification of steel- Plain-carbon steels-Alloy steels-heat treatment of steel.Comparison of cast iron, wrought iron and steel

Corrosion and its control: Corrosion-cause of corrosion-effects of corrosion-types and mechanism of corrosion-chemical or dry corrosion-electrochemical or wet corrosion-underground or soil corrosion-microbiological corrosion-other forms of corrosion-passivation-galvanic series-Factors influencing corrosion-nature of the metal-nature of the corroding environment-Protective measures against corrosion-Modification of the environment-modification of the properties of the metal-use of protective coatings-cathodic protection-prevention of corrosion by material selection and design-other corrosion prevention methods-chemical conversion-phosphating-chromising-hot dipping-inhibitors-metal polishes-Major steel industries in India

Module IV: Industrial Important Inorganic Materials (9 Hours)

Silicates: Introduction-classification of silicates-Application of silicates- Soluble silicates, Silica industries.

Ceramics- Clays- Feldspars – Methods for fabrication of ceramic ware-Ceramic products-Earthenwares- Glazes.

Glasses: Glass, Manufacture of Glass –Properties –Types of glasses.

Refractories: Requisites of a good refractory-Classification of Refractories-properties of Refractories-Raw materials of Refractories-Manufacture of Refractories- Types of Refractory products.

Abrasives: Properties of abrasive materials- classification of abrasives-Application of abrasives.

Chlor-alkali compounds: Chlorine, Caustic soda, soda ash, lime.

Module V: Insulators, Semiconductors & Superconductor (8 Hours)

Conductors- Semi-conductors and insulators- Intrinsic semiconductor- Extrinsic semiconductor-Mobility and conductivity-preparation of semiconductors-semiconductor devices-Junction diode and transistor-photodiode and photovoltaic cell – Rectifiers. Superconductors – properties- Type I and Type II superconductors-high temperature superconductors-structure-applications of superconductivity.

References

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- E.J. Hoffmann,Coalconversion- theEnergonCo.Lavamic,Wyoming USA (1978)

- L.F. Hath, S. Matarm ,From Agro Carbons to petrochemicals,Gulf publishing Co.,Houston
- Steiner,Introduction to petroleum chemicals,Pergamonpress, New York (1978)
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- Fillipoy,Theory of metallurgical process, MIRPublications
- Pchlke,Unit processes of extractive metallurgy, Elsevier publication
- R. Gopalan, D. Venkappaya, S. Nagarajan; Engineering Chemistry;Vikas Publications, NewDelhi. (2006)
- JayashreeGhosh, Fundamental Conceptsof AppliedChemistry, (2010)
- B.Sreelakshmi, FoodScience, Chandand Co.17., NewAge International publishers. (1997)

Chemical Industries and Industrial Aspects of Physical Chemistry (CHE2CMT0219)

72 Hours **4 Credits**

Course outcomes

After successful completion of the course, the students should be able to

- Explain the polymer properties , processing and uses
- Bother about water pollution and familiarize with water purification tests
- Recognize the importance of catalytic methods in industry and summarize their preparation and characterization
- Recognize various energy storage systems related to industry
- Recognize the raw materials used for cement manufacturing

Module I: Surface Chemistry (14 Hours)

Colloids, Gels and its applications:

Colloids: Introduction, Different types.Preparation. General Properties

Stability of sols- Protective action of sols– protective colloids–gold number- determination of molecular weights of macromolecules.

Application of colloids in environmental chemistry- analytical chemistry; agriculture-chemical industry-pharmaceutical industry-and in food industry.

Gels- types of gels- elastic and non-elastic gels, properties of gels-hydration, swelling, syneresis, thixotropy, emulsions-types of emulsions factors determining the types of emulsions Methods for distinction of two types of emulsions–dye solubility method, dilution method, fluorescence method, wetting of filter paper method, conductivity method – microemulsions (Elementary idea only)-micelles CMC and Kraft temperature-,hydrotropes. Aerosols- classification of aerosols.

Module II: Industrial Catalysts (9Hours)

Catalysis: Introduction-types-homogeneous and heterogeneous-–basic principles–mechanism-factors affecting the performance. Catalytic promoters or activators; catalytic poisons; acid-base catalysis; auto catalysis Introduction to phase transfer catalysis.

Enzyme Catalyzed reactions–rate–model–examples of industrially important enzyme catalyzed reactions.

Applications of catalysts in industries (production of NH_3, H_2SO_4 and Polymers), Cracking-catalyst supports three way catalysts

Module III: Hydrochemistry (12 Hours)

Characteristics of water, hardness of water–unit of hardness; water softening methods-Clark's process- limesoda process, modified limesoda process, permutit or zeolite process-Water purification-potability of water, clarification, coagulation- contact and electrochemical coagulation-sterilization and disinfections of water, precipitation– aeration–ozonisation-chlorination.-Drinking water characteristics,(ISO)-purification of water for domestic purpose.-Domestic water purifiers-Muncipal water purifier systems.

WHO standards- Dissolved oxygen- free chlorine; chlorides- sulphates; dissolved carbon dioxide; Total dissolved solids (TDS).

Waste Water treatment: Preliminary treatment-settling process- Biological treatment process-Activated sludge process- Clarification in clarifiers.Desalination of brackish water.

Module IV: Polymer Chemistry (12 Hours)

Introduction- polymers and their classification- polymerization techniques-addition polymerization-condensation polymerization- step growth polymerization- chain growth polymerization-condensation polymersisation – copolymerization. Molecular weights of polymers- Number average molecular weight and weight-average molecular weight – structure-property relationship in polymers- degradation of polymers- additives for polymers – Biopolymers.

Characteristics of polymers: Tg, Tensile strength, Tear resistance, Abrasion resistance.

Processing techniques Extrusion, injection moulding, compression moulding, transfer moulding, blow moulding

Plastics: Introduction- Commercially important thermoplastics and thermosets- PE, PP, PVC, PVA, PS. – Conducting polymers- Manufacture of plastic articles-.

Elastomers: Introduction- Structural requirement of an elastomer- Natural Rubber- Processing of

natural rubber- drawbacks- vulcanization- compounding of rubber. Synthetic rubbers- Styrene Rubber, Poly Urethane, Nitrile Rubber, Neoprene, Butyl rubber. Adhesives (NR)

Reclaimed rubber, Foam rubber and Sponge Rubber.

Fibres PET, Aramids (Preparation Properties and Application)

Module V: Lubricants (9Hours)

Classification of lubricants- lubricating oils (conductingandnon-conducting),-solid and semisolid lubricants-synthetic lubricants- Properties of lubricants (viscosity index, cloud point, pourpoint, aniline point, flash point)

Module VI: Cement Industry (7Hours)

Raw materials used for cement manufacturing- dry process- wet process, semi wet process-Special cement, chemistry involved in hydration of cement- Setting of cement, setting time-Chemical composition of portland cement- Physical properties of portland cement- ISI Specifications of Cement- decay of cement.

Module VII: Batteries (9 Hours)

Introduction- Theoretical principles- Primary cells: Simple voltaic cell-Daniel Cell - Weston-Cadmium Cell- Secondary cells: Lead Acid Accumulator – Rechargeable alkaline storage batteries-Nickel hydrogen batteries – Reserve batteries: Silver chloride cell- Fuel Cells – Solar cells.

References

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- B.Delmon, G.Janner, Catalysis-Heterogeneousandhomogeneous.
- J.Anderson,Catalysisscienceandtechnology
- J.Fendler,E.Fendler,Catalysis in micellar and macromolecular systems
- K.Rideal,H.S.Taylor,Catalysis in theory andpractice
- Starles,Phase transfer catalysis, Principles and techniques
- J.J.Bikermann,Surface chemistry, Academic press

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- R.Gopalan, D.Venkappayya, S.Nagarajan: Engineering Chemistry, VikasPublications,NewDelhi
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- B.K.Sharma: Engineering Chemistry, Goel PublishingHouse, Meerut.
- Baron,PaulA.,andKlausWilleke.AerosolMeasurement:Principles,Techniques,andApplications.2nded.Hoboken,NJ:Wiley-Interscience,
- Friedlander, S.K. Smoke, DustandHaze: Fundamentals of Aerosol Behavior. NewYork: JohnWiley&Sons.
- John O.M.Bockris and AKN Reddy, Modern Electrochemistry 2B, 2nd Edition, KluwerAcademicPublishers

Industrial Inorganic Chemistry- Practical (CHE2CMP0219)

72 Hours **2 Credits**

Course outcomes

After successful completion of the course, the students should be able to

- Design, carry out and analyze the various experiments in industrial inorganic and organic chemistry
- Perform the basic purification and separation experiments like distillation chromatography etc
- Carry out hands on training in water analysis, ore analysis and alloy analysis
- Identify the components present in various cement samples
- Find out the percentage of acetic acid in vinegar and Iron in Mohrs Salt.

1. Simple Laboratory techniques: Crystallisation and distillation.
2. Estimation of copper in brass
3. Water Analysis
   (i) Estimation of dissolved oxygen by Winklers method
   (ii) Estimation of chloride in water
   (iii) Determination of total, temporary and permanent hardness using EDTA.
   (iv) Determine hydroxide alkalinity, carbonate alkalinity and bicarbonate alkalinity of the given water sample volumetrically.
   (v) Determination of Chemical Oxygen Demand (COD) of the given water sample.
4. Ore Analysis
   (i) To analyse the amount of calcium present in a given sample of limestone.
   (ii) Quantitative analysis of calcium and magnesium in dolomite by complexometric titration.

(iii) Estimation of MnO_2 in pyrolusite.

(iv) Estimation of Iron in iron ore.

5. Alloy Analysis

(i) Estimation of copper in brass

(ii) Estimation of zinc in brass

6. To determine the percentage of $NaHCO_3$ in a mixture of $NaHCO_3$ and NaCl.
7. Determination of weight percent of acetic acid in vinegar.
8. Determination of percentage of iron in Mohr's salt.
9. Determination of percentage of silica, calcium, magnesium and iron in the given cement sample.
10. Identification of cations in the mixture by paper chromatography.

References

- A. Skoog, D. M. West, and S. R. Crouch, Fundamentals of Analytical Chemistry 8th edn, Brooks/Cole Nelson
- Vogel's Textbook of Quantitative Chemical Analysis 6th edn, Pearsons Education Ltd.
- R. D Day, A.L. Uderwood, Quantitative analysis,6th Edn.,Prentice Hall of India Pvt. Ltd.
- Vogel's Qualitative Inorganic Analysis, 7th edn., Pearson Education Ltd.7. A text book on experiments and calculation Engg. S.S. Dara., S. Chand & Company Ltd., Delhi.
- Laboratory Manual on Engineering Chemistry, Dr. Subdharani ,Dhanpat Rai Publishing.
- Gurdeep Raj, Advanced Practical Inorganic Chemistry, Goel Publishing House.

Unit Operations in Chemical Industry (CHE3CMT0319)

54 Hours **3 Credits**

Course outcome

After successful completion of the course, the students should be able to

- Explain basic concepts of process of various unit operations in chemical industry
- Perform distillation, crystallization etc.
- Design columns for separation purposes.
- Purify materials through distillation, crystallization, filtration etc.
- Separate and identify solid and liquid samples

Module I: Distillation and Absorption **(18 Hours)**

Introduction- Boiling point diagrams, distillation methods: equilibrium distillation, differential distillation, rectification, construction of rectifying column, types of down comers, types of columns: Plate columns and packed columns, entrainment.

Absorption: Introduction, selection criteria for Solvent, Gas absorption Equipments: mechanically agitated vessels, packed and platecolumns, types of towerpacking, HETP, Liquid distributiondevices.

Module II: Evaporation **(12 Hours)**

Introduction- Equipment short tube (standard) evaporator, forced circulation evaporators.Fallingfilm evaporators. Climbingfilm (upwardflow) evaporators, wiped (agitated) film evaporators.

Module III: Filtration: **(12 Hours)**

Introduction-Filter media and filter aids, Equipment plate and frame filter press, nutch filter, rotary drum filter, sparkler filter, candle filter, bag filter, centrifuge Drying: Introduction: free moisture, bound moisture, drying curve, Equipment tray dryer, rotary dryer, flash dryer, fluid bed dryer,drum dryer, spray dryer.

Module IV: Crystallisation **(12 Hours)**

Introduction- solubility, super saturation, nucleation, crystal growth, techniques to increase crystal size, crystallization from melt.

Equipment- tank crystallizer, agitated crystallizer, evaporator crystallizer, draft tube crystallizer, MSMPR crystallizer.

References

- W.L.BadgerandJ.T.Bachero,IntroductiontoChemicalEngineering,TataMcGrawHill,U.S.A
- W.L.McCabe andJ.C.Smith,UnitoperationsinChemicalEngineering,TataMcGrawHillN.Y
- J.H.Perry, ChemicalEngineeringHandBook, McGrawHill, N.Y.
- D.D.Kale,UnitOperations–1and2,PuneVidyarthiGrihaPrakashan,Pune
- K.A.Gavhane, Unit Operations-IIHeatandMasstransfer, Nirali Prakashan.
- J.D.Seader, Ernest J. Henley and D.KeithRoper, Separation Process Principles, John Wiley & Sons, Inc.
- J.F.Richardson, J.H.Harker, J.R.Backhurst, Particle Technology and Separation Processes, Butterworth-Heinemann.

Unit Processes in Organic Chemicals Manufacture (CHE3CMT0419)

54 Hours **3 Credits**

Course Outcomes

After successful completion of the course, the students should be able to

- Understand the basic idea of various unit operations
- Identify the appropriate unit processes involved in the manufacture of various materials
- Identify suitable unit processes in chemical industries.
- Apply the basic concepts for the development of different industrially important materials.
- Use the most appropriate process for manufacture of chemicals

Module I: **(8 Hours)**

Nitration: Introduction: Nitrating agents, mechanism of nitration processes such as nitration of (a) Paraffinic hydrocarbons (b) Benzene orthonitrobenzene and meta-dinitrobenzene (c) Chlorobenzene ortho - and p –nitrochlorobenzene (d) Toluene. Continuous and Batch Nitration Process Case studies: Nitro benzene, TNT

Module II **(12 Hours)**

Halogenation: Introduction: mechanism of halogenation reactions, reagents for halogenation, Halogenation of aromatics-side chain and nuclear halogenations.Chloral, mono chloroaceticacid and dichlorofluoromethane, D.D.T, B.H.C

Sulphonation: Introduction: Sulphonating agents, chemical and physical factors in sulphonation. Mechanism of sulphonation reaction. Commercial sulphonationof benzene and naphthalene.

Module III **(6 Hours)**

Oxidation: Introduction–types of oxidation reactions. Oxidizing agents. Mechanism ofoxidation of Organic compounds, Liquid phase oxidation, Vapour phase oxidation. Commercial manufacture of benzoic acid, acetic acid, Phthalic anhydride, Acrolein.

Module IV **(9 Hours)**

Hydrogenation: Introduction- Catalysts for hydrogenation reactions, Hydrogenation of vegetable oil, Manufacture of methanol from carbon monoxide and hydrogen, hydrogenation of acids and esters to alcohols, catalytic reforming.

Module V **(8 Hours)**

Esterification*:* Introduction, esterification by organic acids, by addition of unsaturated compounds, esterification of carboxylic acid derivatives, commercial manufacture and uses of ethyl acetate, dioctyl phthalate, vinyl acetate, cellulose acetate.

Hydrolysis*:* Definition and types of hydrolysis, Hydrolyzing agents, mechanism of hydrolysis, Industrial Hydrolysis of carbohydrates –starch to dextrose.

Module VI **(6 Hours)**

Amination: By reduction: Introduction, Methods of reduction- metal and acid, catalytic, sulphide, electrolytic, metal hydrides, sodium metal, concentrated caustic oxidation, reduction. Commercial manufacture of aniline and meta-nitro aniline. Amination by Ammonolysis-Different types of ammonolysis reactions, Aminating agents, factors affecting ammonolysis process.

Module VII **(5Hours)**

Alkylation: Introduction: Types of Alkylation, Alkylating agents, manufacture of alkyl benzene (for detergent manufacture), N-alkyl anilines (mono and di-methyl and ethyl anilines)

References

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- P.L.Soni:Organicchemistry,S.ChandCo.,NewDelhi

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- K.Weissermal, H.J.Arpe, WileyVCH.Industrial organicChemistry.
- JamesG.Speight,Mcgraw-Hill,Chemicalandprocessdesignhandbook
- AndreasJess, Peter Wasserscheid,.ChemicalTechnology.Wiley-VCHVerlag&Co.
- KGaA, Robert A.Smiley, HaroldL.Jackson, Chemistry and the Chemical industry. CRC PRESSBocaRaton LondonNewYork Washington,D.C.
- Mohammad Farhat Ali, BassamM. El Ali, James G.Speight,. Hand book of Industrial Chemistry.

Instrumental Methods of Chemical Analysis – I (CHE4CMT0319)

54 Hours **3 Credits**

Course Outcomes

After successful completion of the course, the students should be able to

- Acquire a working knowledge of analytical instruments like UV-Visible spectroscopy, AAS, HPLC, GC etc.
- Demonstrate knowledge of sampling methods for all states of matter.
- Integrate a fundamental understanding of the underlining physics principles as they relate to specific instrumentation used for atomic, molecular, and mass spectrometry, and chromatography
- Explain the theory and operational principles of analytical instruments.
- Distinguish between qualitative and quantitative measurements and be able to effectively compare and critically select methods for elemental and molecular analysis.

Module I: Principles of Instrumentation (14 Hours)

Characteristics of measurement system: introduction- Functional units - Classification (automatic/ manual type, self-operated/ power operated, analogue/ digital) - Performance characteristics (Static/ dynamic characteristics) – Zero order instrument and first order instrument Signal and noise-types of noises-chemical noise-instrumental noise-thermal-shot – flicker and environmental noise-S/N ratio and its significance.

Transducers–characteristics of transducers, sensitivity and transfer function-some typical examples. Photoemissive-photoconductive and photovoltaic systems –photomultiplier and photodiode.

Module II: Typical Analytical Instruments 1 (9 Hours)

UV-Visible spectrometry: Origin of absorption spectra, components of typical instrument–Source-Tungsten filament lamp, Hydrogen and Deuterium discharge lamps.Wavelength selectors- filters, prisms and grating –Sample cell-Detectors Single and double beam spectrophotometers.

I.R spectrophotometry: classification of the types -Sources–Nernst glower, globar, Nichrome wire-Wavelength selectors- Sample cell–characteristics-sample preparation-solvent selection-Detectors–thermal, pneumatic and pyroelectric –NDIR instruments.

Module III: Typical Analytical Instruments -2 (12 Hours)

Molecular Fluorescence: Spectrofluorimetry–factors affecting fluorescence–typical instrumentation

Atomicspectroscopy: (1) AAS : Principle-typical instrumentation–Flames, Nebulisers- burner system- Non flame techniques- Resonant line source–HCL and EDL –source modulation- sample preparation- Interference in measurements (2) AES: Excitation techniques- arc, spark and ICP

Sampling: Basis of sampling-sampling procedure-Importance of representative sampling-sample preparations of solid, liquid and gaseous analytes- Hazards in sampling.

Module IV: Electro Analytical Instrumentation (12 Hours)

Potentiometricmethods: Principle-technique and detection limit

Non-Potentiometric methods: (a)Conductometry (b) Polarography (c) Amperometry (d) Anodic stripping analysis (e) coulometry (primary and secondary)

Module V: Chromatographic instrumentation (7Hours)

Basic principles, instrumentation and applications of ion exchange and size exclusion chromatography (gel-permeation and gel-filtration).

HPLC: Instrumentation, methods of detection and industrialapplications.

GC: Instrumentation, Temperature programming, Detectors: TCD, FID and ECD, PID. GC-MS and GC-IR.

References

- Jeffry, Basset, Mendhem,R.C Denwy, Vogel's Text Book of Quantitative Inorganic Analysis, 4^{th}& 5^{th}Edition.
- Skoog and Leary, Principles of Instrumental analysis, 4^{th} Edition, Sanders College Publishing.

- D.Patranabis, Principles of Industrial Instrumentation, 2nd Edition, TataMcGraw HillCompany, Delhi.
- JamesW.Robinson, Eileen M. Skelly Frame and George M. Frame II , Undergraduate Instrumental analysis, 6th Edition, Marcel Dekker, New York.
- Francis Rouessac and Annick Rouessac, Chemical Analysis: Modern Instrumentation
- MethodsandTechniques, 2nd Edition, John Wiley &Sons.
- FrankA.Settle, Hand book of Instrumental Techniques for Analytical Chemistry, Prentice Hall PTR.
- Skoog and West ,Fundamentals of Analytical Chemistry,9th edition,SandersCollege
- Publishing.
- John Kenkel.Analytical Chemistry forTechnicians, 4th Edition,CRC Press.

Instrumental Methods of Chemical Analysis-II (CHE4CMT0419)

54 Hours **3 Credits**

Course Outcomes

After successful completion of the course, the students should be able to

- To provide the basic practical knowledge relevant to the analysis
- To develop an understanding of the range and theories of instrumental methods available in analytical chemistry.
- To develop knowledge pertaining to the appropriate selection of instruments for the successful analysis of complex mixtures.
- To develop an understanding of the role of the chemist in measurement and problem solving in chemical analysis.
- To provide an understanding of and skills in advanced methods of separation and analysis.

1. To provide working knowledge of analytical instrumentation like Surface analysis, thermogravimetric analysis, SFC, POLARIMETRY etc
2. To provide the student with an appreciation of the relative strengths and limitations of different instrumental based analysis methods.
3. To provide the basic practical knowledge relevant to the analysis
4. To develop an understanding of the range and theories of instrumental methods available in analytical chemistry
5. To develop knowledge pertaining to the appropriate selection of instruments for the successful analysis of complex mixtures
6. To develop an understanding of the role of the chemist in measurement and problem solving in chemical analysis
7. To provide an understanding of and skills in advanced methods of separation and analysis
8. To provide practical experience in selected instrumental methods of analysis

Module I: Process Instrumentation (12Hours)

Difference between Process Instrumentation and Laboratory Instrumentation-concept of measurement and accuracy

Principle, construction and working of following measurements

(1) Temperature: Glass thermometers- bimetallic thermometers-pressure spring thermometers- vapour filled thermometers- resistance thermometers- radiation pyrometers

(2) Pressure: Manometers- barometers- Bourdon pressure gauge- bellow and diaphragm type gauges -McCleod gauge - Pirani gauge, Electrical pressure transducer (Linear Variable Differential Transformer type)

Module II: Microprocessor Based Instruments (9 Hours)

Telemetry: Pneumatic- electrical (voltage telemetering) -frequency telemetering, multiplexing- Modulation of digital data- transmission channels- fibre optics.

Module III: Surface Analysis and Microscopic techniques (10 Hours)

Theory, instrumentation and applications of the following techniques: ESCA, XPES and UPES techniques. Auger-electronspectros copy. X-ray techniques. SEM, TEM, STM, SPL, AFM and SIMS.

Module IV: Optical Methods (7 Hours)

Polarimetry: Principle, instrumentation and applications of polarimetry. Refractometry: Principle, instruments and application of refractometry.

Nephelometry: Principle, instruments, factors affecting intensity of scattered radiations and application of nephelometry.

Module V: Thermo analytical techniques (8 Hours)

Thermal gravimetricanalysis (TGA), differential thermal analysis (DTA), differential scanning calorimetric (DSC) and their industrial applications.TMA and DMA

Module VI: SFC and Electrophoresis (8 Hours)

Super critical Fluid Chromatography (SFC): Basic Principles, Instrumentation, mobile phases,

stationary phases, detectors, and comparison with other column chromatographic methods. Applications.

Electrophoresis: capillaryzone electrophoresis (CZE) – sample injection and detection, Modes of CE, Applications

References

- P.Eckman,IndustrialInstrumentation,JohnWiley&Sons
- Patranabis, Principles of Industrial Instrumentation, 2nd Edition, Tata McGraw-Hill Company, Delhi.
- Skoog and Leary, Principles of Instrumental analysis, 4thEdition, Sanders College
- Publishing.
- Willard, Merrit, Dean &Settle- Instrumental Methods of Analysis, C.B.S Publishers, 4th Edition 2. J.G.Dick,Analytical Chemistry, McGrawHill
- JamesW.Robinson, Eileen M. Skelly FrameandGeorgeM.FrameII, Undergraduate Instrumental analysis, 6th Edition, MarcelDekker, NewYork.
- Francis Rouessac and Annick Rouessac, Chemical Analysis: Modern Instrumentation Methods andTechniques, 2nd Edition, John Wiley & Sons.
- Frank A.Settle, Hand book of Instrumental Techniques forAnalytical Chemistry,Prentice HallPTR.
- Skoog and West, Fundamentals of Analytical Chemistry, 9th edition, Sanders College Publishing.
- John Kenkel. Analytical Chemistry for Technicians, 4th Edition,CRC Press.
- C.RichardBrundle,Charles K Evans,Jr., and Shaun Wilson, Encyclopedia of Material Characterization, Butterworth-Heinemann.
- Narendra Kumar, Sunita Kumbhat, Essentials in Nanoscience and Nanotechnology, JohnWiley&Sons.
- Tattamangalam R. Padmanabhan, Industrial Instrumentation Principles and Design, Springer.
- WilliamC.Dunn, Fundamentals of Industrial Instrumentation and Process Control, McGraw-Hill.

Industrial Organic Chemistry Practical (CHE4CMP0319)

72 Hours **2 Credits**

Course outcome

After successful completion of the course, the students should be able to

- Be able to design and carryout various unit processes involving Nitration, Sulphonation, Hydrolysis, Oxidation and Halogenation.
- To synthesise different polymers.
- To determine the acid value, saponification value and iodine value of different oils.
- To carry out hands-on training in the synthesis of soap.
- To get hands-on training in the analysis of adulterants present in turmeric powder, milk and mustard oil.

1. Unit Process:

   One or two examples for each of the following unit process:

   (i) Nitration: Preparation of p-nitroacetanilide from acetanilide

   (ii) Sulphonation: Syntheis of 2,5-dimethylbenzene sulphonic acid from p-xylene

   (iii) Hydrolysis : Hydrolysis of methyl salicylate, ethyl benzoate and triglycerides

   (iv) Oxidation: Oxidation of cane sugar to oxalic acid, Preparation of p-nitro benzoic acid from p-nitro aniline.

   (v) Halogenation : 2,4,6-tribromoaniline

   (vi) Reduction: Preparation of m-nitroaniline from m-dinitrobenzene

   (vii) Polymerisation: Preparation phenol-formaldehyde resin and urea-formaldehyde resin

2. Determination of acid value, saponification value, and iodine value of oil.
3. Study of number of components in the organic mixture by TLC.
4. Synthesis of soap

2. Extraction of a known mixture: Separation of a mixture of aspirin, ù-naphthol and naphthalene (or any other similar mixture) from one another and recrystallization of each component after separation.
3. Fractional distillation of a mixture of hexane and toluene.
4. Estimation of aspirin in the given tablet.
5. To determine the percentage purity of given sample of formaldehyde.
6. Separation of component from their mixture by fractional crystallization (acetanilide-urea, Benzoic acid-oxalic acid).
7. Testing of turmeric powder, milk and mustard oil for adulterants.
8. Purification of an organic compound by column chromatography.

References

- R. Gopalan, D. Venkappayya, S. Nagarajan: Engineering Chemistry, Vikas Publications, New Delhi.
- B. K. Sharma: Engineering Chemistry, Goel Publishing House, Meerut.
- Vogel's Text Book of Practical Organic Chemistry, Longman.
- Steven F. Pedersen, and Arlyn M. Myers, Understanding the Principles of Organic Chemistry a Laboratory Course, Brooks/Cole.
- V K Ahluwalia, SunitaDhingra, Adarsh Gulati, Practical Chemistry, Universities Press.
- John Leonard, Barry Lygo and Garry Procter, Advanced Practical Organic Chemistry, CRC Press.
- Zeba N. Siddiqui, Practical Industrial Chemistry, Anmol Publisher.

Industrial Physical Chemistry Practical (CHE4CMP0419)

72 Hours **2 Credits**

Course outcome

After successful completion of the course, the students should be able to

- Acquire the foundation in the fundamentals and applications of Physical Chemistry.
- Explore the fundamentals of colorimetry.
- Perform conductometric and potentiometric titration.
- Find out the flash and fire point of an oil
- Perform viscosity measurement with the help of Ostwald viscometer.

1. Colorimetry:
   (i) Estimation of Iron in water colorimetically.
   (ii) Determination of molar absorptivity of Fe^{3+}.
   (iii) Verification of Beer Lambert's law and determination of strength of unknown solution.
2. Flame photometric estimation of Na^{+} in the given solution.
3. Determination of dissociation constant of weak acid using pH-meter.
4. To determine the concentrations of strong acid and weak acid in a mixture by conductometric titration using a strong base.
5. Determination of flash point and fire point of oil by Pensky Martin apparatus.
6. Polarimetry:
   (i) Determine the specific and molecular rotation of an optically active substance like cane sugar at a number of concentrations.
   (ii) Determine the concentration of a given solution of an optically active substance by polarimetric measurement.

7. Viscosity Measurements:

To determine the coefficient of viscosity of a given liquid with the help of Ostwald's viscometer.

To determine the molecular weight of a polymer by viscosity measurements.

8. Surface Tension:

   (i) To determine the surface tension of the given liquid by drop-number method.

   (ii) To determine the surface tension of the given liquid by drop-weight method.

9. Refractive index measurements:

10. Determine the refractive index of given liquid by Abbe's refractometer and find the specific and molar refraction.

    (i) Determination of concentration of given KCl solution by refractive index measurements.

    (ii) Determination of dissociation constant of a weak acid potentiometrically.

11. Determination of molecular weight of a non-volatile solute by elevation of boiling point using water as a solvent (solute: urea, glucose, sucrose).

12. Study of adsorption of oxalic acid from solution on activated charcoal.

References

- Advanced Practical Physical Chemistry : J. B. Yadav, Goel Publishing House
- P. S. Sindhu, Practicals in Physical Chemistry, Macmillan.
- B. Viswanathan, P. S. Raghavan, Practical Physical Chemistry, Viva Books Private Limited.
- R. Mukhopadhyay and P. Chatterjee, Advanced Practical Chemistry, Books and Allied (P) Ltd. Jahagirdar D V, Experiments in Chemistry, Himalaya Publishing House

Gist of Changes

Inorganic Chemistry

Semester	Paper	Unit	Changes	
			Existing	**Modified**
I	GENERALAND ANALYTICAL CHEMISTRY (36 Hours) (There is no change for total credits and workload)	Unit 1	Methodology of Chemistry (7 Hours)	Second paragraph of unit I removed. (Evolution of science, nanotechnology, biotechnology, chemistry as central to other branches of science)Unit shortened(3Hours)
		Unit 2	Periodic Table and Periodic Properties (5 Hours)	Moved to unit 3 along with similar topics from Sem II. Included Atomic Structure (From Unit 1, Sem II)(6 Hours)
		Unit 3	Analytical Methods in Chemistry (12 Hours)	Moved to Unit 5. Included Periodic Table and Periodic Properties (From unit 3 and Sem II, Units 4 &5)(15 Hours)
		Unit 4	Chromatographic Methods (7 Hours)	Moved to Sem VI, Unit 5. Included Evaluation of Analytical Data (From Unit 5)(5Hours)
		Unit 5	Evaluation of Analytical Data (5 Hours)	Moved to Unit 4, Included analytical Methods in Chemistry(From Unit 3) (7 Hours)
II	THEORETICAL AND INORGANIC	Unit I	Atomic Structure (6 Hours)	Moved to Sem I, unit I Included Chemical Bonding –I(From Sem VI, Unit2) (10 Hours)
			Chemical Bonding – I	Moved to Unit 1, Included Chemical

	CHEMISTRY (36 Hours) (There is no change for total credits and workload)	Unit 2	(9 Hours)	Bonding –II (From Sem II, Unit 3) (10 Hours)
		Unit 3	Chemical Bonding – II (9 Hours)	Moved to Unit 2. Included Bioinorganic Chemistry(From Sem VI, Unit 5)(4 Hours)
		Unit 4	Chemistry of s and p Block Elements (3 Hours)	Moved to Sem I, Unit 3.Chemistry of p block elements elaborated by adopting from Sem VI, Unit6 &7(9Hours)
		Unit 5	Chemistry of d and f Block Elements (9 Hours)	Moved to Sem I, Unit 3,New topics of Metallurgy added.(5 Hours)
VI	INORGANIC CHEMISTRY (54 Hours) (There is no change for total credits and workload)	Unit 1	Coordination Chemistry - I (7 Hours)	No change in content. (7 Hours)
		Unit 2	Coordination Chemistry - II (14Hours)	No change in content (14 Hours)
		Unit 3	Cooridnation Chemistry III (6 Hours)	No change in content. (6 Hours)
		Unit 4	Organometallic Compounds (12 Hours)	No change in content. (12 Hours)
		Unit 5	Bioinorganic Chemistry (6 Hours)	Moved to Sem II, Unit 3, included applications of analytical methods (From Sem I, Units 3 & 4) (12 Hours)
		Unit 6	Boron Compounds (3 Hours)	Moved to Sem II, Unit 4 (3 Hours)
		Unit 7	Inter-halogen and Noble Gas Compounds (6 Hours)	Moved to Sem II, Unit 4 (6 Hours)

Semester	Paper	Unit	Changes	
			Existing	**Mod ified**
III	SEMESTER III ORGANIC CHEMISTRY – I (Reaction Mechanisms, aromaticity and stereochemistry) 54 Hours	1 8 Hours	Fundamental of organic chemistry: All content retained in the unit 1 of new syllabus	Contents from the unit 3 of existing syllabus are added to unit 1 of the modified syllabus. Concept of S_Ni is added Unit 1: 18 Hours
		2 15 Hours	Stereochemistry- this unit has been changed to unit 3 without significant changes	Unit 4 of the old syllabus has been modified and included in the unit 2. Topic on preparation of benzene has been deleted. Unit 2: 18 Hours
		3 12 Hours	Aliphatic Hydrocarbons and Alkyl Halides Topics in the unit 3 of existing syllabus will be discussed in unit 1 of modified syllabus. Topic on Grignard reactions is deleted and will be discussed in sem IV	unit 2 of existing syllabus is moved to the unit 3 in modified syllabus without changeUnit 3: 18 Hours
		4 15 Hours	Aromatic Hydrocarbons and Aryl Halides (contents moved to unit 2 of modified syllabus)	-
		5 4 Hours	Pericyclic Reactions (has been removed and added in 5th semester)	-
unit 5 of the existing syllabus has been removed and added in 5th semester.				

Semester	Paper	Unit	Changes	
			Existing	**Modified**
IV	ORGANIC CHEMISTRY – II (Compounds containing oxygen and synthetic reagents) 54 Hours	1 16 Hours	Alcohols, Phenols and Ethers	UNIT 1. Organometallics, Hydroxy Compounds and Ethers (18 Hours) 16 hours of unit of existing syllabus retained Topic on organometallics is added to make it as a unit of 18 Hours
		2 20 Hours	Aldehydes and Ketones	UNIT 2. Carbonyl Compounds (15 Hours) 20 Hours of unit 2 of existing syllabus changed to 15 hr unit. Topic on Preparation of aldehydes deleted All other contents remain same as unit 2 of existing syllabus
		3 18 Hours	Carboxylic Acids, Sulphonic Acids and their Derivatives	UNIT 3. Organic Acids:- (14 Hours) Same as Unit 3 of existing syllabus
				UNIT 4. Synthetic Reagents:- (3 Hours) Unit 4 is added Topic:synthetic reagents
				UNIT 5. Active Methylene Compounds:- (4 Hours) Unit 5 is added Topic:Activemethylene compounds

PHYSICAL CHEMISTRY

Semester	Paper	Unit	Changes	
			Existing	**Modified**
V	Physical Chemistry-I 36Hours	1 (12Hours)	Gaseous State	Deducted Virial equation of state , Van der Waals equation expressed in virial form (1Hour) Added Van der Waal's equation of state , Relation between different velocities (1 hour)
		2 (4Hours)	Liquid State	Types of liquids- Polar and non-polar- Examples. Physical properties of liquids- Surface Tension and Viscosity, Factors affecting Viscosity- Nature of liquid, temperature, molecular mass. NOTHING ADDED, BUT THE ABOVE MENTIONED TOPICS ARE MORE SPECIFIED ANDONE HOUR IS ADDED
		3 (13Hours)	Solid State	Deducted Electrical conductivity,semiconductors,n-type,p-type,Superconductivity–Anintroduction. The topics likeWeiss indices, no.of atoms per unit cell and problems based on crystal structure are added, Types of voids (Interstitious sites and coordination sites), Types of voids (Interstitious sites and coordination sites) more specifically mentioned and added onehour
		4 (7 Hours)	Surface Chemistry and Colloidal State	NO CHANGE IN TOPICS BUT DEDUCTED 2 Hours

V	PHYSICAL CHEMISTRY – II36 Hours			
		I (14 Hours)	Quantum Mechanics	Deducted molecular orbital theory and added Threedimensionalbox,concept of degeneracy etc
		II (12 Hours)	Molecular spectroscopy - I	Nothing deducted but some topics are more specifically mentioned
		III (10 Hours)	Molecular spectroscopy-II	Nothing deducted but some topics are more specifically mentioned
VI	Physical Chemistry IV 54 Hours			
		I (15 Hours)	Thermodynamics - I	Only rearrangement of topics were done, Problems are more specified. No change in hours
		II (12 Hours)	Thermodynamics-II	Only rearrangement of topics were done, Problems are more specified. No change in hours
		III (3 Hours)	Chemical equilibria	Only rearrangement of topics were done, Problems are more specified. No change in hours
		IV (8 Hours)	Ionic equilibrium	Only rearrangement of topics were done, Problems are more specified. No change in hours
		V (6 Hours)	Phase equilibria	Only rearrangement of topics were done, Problems are more specified. No change in hours
		VI (10 Hours)	Chemical Kinetics	Only rearrangement of topics were done, Problems are more specified. No change in hours

VI	Physical Chemistry IV(54 Hours)			
		I (12 Hours)	Solutions	Only rearrangement of topics were done, Problems are more specified. No change in hours
		II (12 Hours)	Electrical Conductance	Only rearrangement of topics were done, Problems are more specified. No change in hours
		III (15 Hours)	Electromotive force	Only rearrangement of topics were done, Problems are more specified. No change in hours
		IV (6Hours)	Photochemistry	Only rearrangement of topics were done, Problems are more specified. No change in hours
		V (9 Hours)	Group theory	Only rearrangement of topics were done, Problems are more specified. No change in hours

INDUSTRIAL CHEMISTRY

Semester I	Paper	Unit	Changes	
			Existing	**Modified**
I	INDUSTRIALASPECTSOFINORGANICANDORGANIC CHEMISTRY (72 Hours) {There is no change for total credits and workload	Unit 1 26 Hours	Fuels and Petroleum 26 hours	New topics introduced in unit areFuels, Calorific values, Petroleum industries in India, and alternate fuels total teaching hours is increased by 2 hours
		Unit 11 14 Hours	Food Chemistry 14 hours	New additions areFood quality tests, methods of preservation and food adulteration

		Unit III 15 Hours	Metallurgy 15 hours	Additions-metal polishes. An additional 3 hours is also allotted
		Unit IV 9 hours	Industrial Important Inorganic materials.	No change
		Unit V 8 Hours	Insulators, Semiconductors and Superconductors	Addition - Types of superconductors (2 hours)
		Unit VI	Entire Unit is Removed	Those hours are divided among various units
II	CHEMICALINDUSTRIESANDINDUSTRIAL ASPECTS OF PHYSICALCHEMISTRY (72 Hours) (There is no change for total credits and workload)	Unit 1 14 Hours	Surface Chemistry	Unit 1 and Unit 2 are merged Topics like preparation and properties of colloids are removed from first unit
		Unit II 9 hours	Industrial Catalysts	New topics on application of colloids in environmental chemistry; analytical chemistry; chemical industry; pharmaceutical industry and in food industry are included. No change

		Unit III 12 Hours	Hydrochemistry	Drinking water characteristics, Muncipal water treatment, water purifier systems etc are newly added- 2 HOURS
		Unit IV 12 Hours Unit V 9 hours Unit VI 7 Hours	Polymer Chemistry Lubricants Cement Industry	Small shuffling and additions have done. For this, teaching hours is increased by 3. No change Chemical composition of portland cement and ISI Specifications of cement are included.
		Unit VII 9 hours	Batteries	No change.
III	UNITOPERATIONSIN CHEMICALINDUSTRY 54 Hours	Unit I 18 hours	Distillation and Absorption	All the content of the old syllabus is retained in the revised syllabus. A modification in this paper includes the combining of chapter 1&2.
		Unit II 12 hours	Evaporation	No change
		Unit III 12 hours	Filtration	No change
		Unit IV 12 hours	Crystallisation	No change
	UNITPROCESSESINORGANIC CHEMICALS MANUFACTURE 54 Hours	Unit I 8 hours	Nitration	All the content of the old syllabus is retained in the revised syllabus. No remarkable changes in all units.

III		Unit II 12 hours	Halogenation	No change
		Unit III 6 hours	Oxidation	No change
		Unit IV 9 hours	Hydrogenation	No change
		Unit V 8 hours	Esterification	No change
		Unit VI 6 hours	Amination	No change
		Unit VII 5 hours	Alkylation	No change
IV	INSTRUMENTALMETHODSOF CHEMICAL ANALYSIS-I 54 hours	Unit I 14 hours	Principles of instrumentation	No significant change in this paper
		Unit II 9 hours	Typical Analytical Instruments 1	No change
		Unit III 12 hours	Typical Analytical Instruments 2	No change
		Unit IV 12 hours	Electro Analytical Instrumentation	No change
		Unit V 7 hours	Chromatographic Instrumentation	No change
IV	INSTRUMENTAL METHODSOF CHEMICAL ANALYSIS-II 54 hours	Unit I 12 hours	Process instrumentation	No significant change in this paper
		Unit II 9 hours	Microprocessor based instruments	No change
		Unit III 10 hours	Surface analysis and microscopic techniques	No change
		Unit IV 7 hours	Optical methods	No change
		Unit V 8 hours	Thermoanalytical techniques	No change
		Unit VI 8 hours	SFC and electrophoresis	No change