



Mahatma Gandhi University, Kottayam

PRIYADARSHINI HILLS, KOTTAYAM-686560

BSc Chemistry (CBCSS) Syllabus

Prepared by

Board of Studies (UG) in Chemistry

&

Faculty of Science

May 2017



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Dean, Faculty of Science
Mahatma Gandhi University

Priyadarsini Hills
May 03, 2017



1. INTRODUCTION

Mahatma Gandhi University introduced choice based credit and semester and Grading System in colleges affiliated to the University from the Academic year 2009-2010, under **Direct Grading System**. Subsequently, the Kerala State Higher Education Council constituted a committee of experts headed by Prof. B. Hridayakumari, to study and make recommendations for the improvement of the working of the Choice Based Credit and Semester System in Colleges affiliated to the Universities in the State. The State Government accepted the recommendations of the Committee and the Syndicate and the Academic Council of the Mahatma Gandhi University have resolved to reform the existing CBCSS regulations. Accordingly, REGULATIONS FOR UNDER GRADUATE PROGRAMMES UNDER CHOICE BASED COURSE-CREDIT-SEMESTER SYSTEM AND GRADING, 2013 was introduced in the University from the Academic year 2013-14 onwards, under **Indirect Grading System**. The University Grants Commission, in order to facilitate student mobility across institutions within and across countries and also to enable potential employers to assess the performance of students, insisted to introduce uniform grading system in the Universities. The Academic Council of the Mahatma Gandhi University at its meeting held on 23rd May 2015 resolved to introduce the UGC Guidelines for Choice Based Credit Semester System from the Academic year 2016-17 onwards and the syndicate of the University at its meeting held on 1st August 2015 approved the resolution of the Academic Council. Meanwhile, the Hon'ble Supreme Court of India has issued orders to include core courses on Environmental Studies and Human Rights in the syllabi and curricula of all UG Programmes of universities all over India. In continuation to this the University Grants Commission has issued circulars regarding the implementation of the above said changes by accepting the directions of the Hon'ble Supreme Court as a National Policy. Hence, the Syndicate of Mahatma Gandhi University has decided to modify the syllabi and curricula of all UG programmes in accordance with the directions of the Hon'ble Supreme Court and the UGC. Further, the Syndicate has decided to implement the new regulations and syllabi with effect from the academic year 2017-2018. In view of this, the BOS – Chemistry (UG) and the Faculty of Science of MG University have prepared the following syllabus for UG programmes in Chemistry.



2. TITLE

B. Sc. CHEMISTRY PROGRAMME - Graduate Programmes under Choice Based Credit System, 2017” (UGCBCSS 2017).

3. SCOPE

- 3.1 Applicable to all regular Under Graduate Programmes conducted by the University with effect from 2017 admissions, except for Professional and B.Voc programmes. Also applicable to Distance/Private Undergraduate Programmes with suitable modifications. Under Graduate Programmes in Management Studies are included as non-professional programmes. Provided that the existing CBCSS Regulations 2013 shall be applicable to students who were admitted prior to the commencement of these Regulations and who are continuing their studies.
- 3.2 Examinations of the courses being run under the Distance/Private registration scheme shall be conducted annually.
- 3.3 The provisions herein supersede all the existing regulations for the Regular/Distance/Private Undergraduate programmes to the extent herein prescribed.

4. AIMS AND OBJECTIVES OF THE PROGRAMME

4.1 AIMS

The Faculty of Science, Mahatma Gandhi University and Board of Studies in Chemistry (UG) recognizes that curriculum, course content and assessment of scholastic achievement play complementary roles in shaping education. The committee is of the view that assessment should support and encourage the broad instructional goals such as basic knowledge of the discipline of Chemistry including theories and techniques, concepts and general principles. This should also support the ability to ask physical questions and to obtain solutions to physical questions by use of qualitative and quantitative reasoning and by experimental investigation. The important student attributes including keen observation, curiosity, creativity and reasoned skepticism and understanding links of Chemistry to other disciplines and to societal issues should be given encouragement. With this in mind, we aim to provide a firm foundation in every aspect of Chemistry and to explain a broad spectrum of modern trends in chemistry and to develop experimental, computational and mathematics skills of students.

The programme also aims to develop the following abilities:

1. Read, understand and interpret chemical information – verbal, mathematical and graphical.
2. Impart skills required to gather information from resources and use them.
3. To give need based education in chemistry of the highest quality at the undergraduate level.
4. Offer courses to the choice of the students.
5. Perform experiments and interpret the results of observation.
6. Provide an intellectually stimulating environment to develop skills and enthusiasms of students to the best of their potential.
7. Use Information Communication Technology to gather knowledge at will.
8. Attract outstanding students from all backgrounds.

4.2 OBJECTIVES

The syllabi are framed in such a way that it bridges the gap between the plus two and post graduate levels of Chemistry by providing a more complete and logical framework in almost all areas of basic Chemistry.



5. COURSE DESIGN

The U.G. programme in Chemistry must include (a) Common courses, (b) Core courses, (c) Complementary Courses, (d) Choice based courses (e) open courses and (f) Project, Industrial Visit (I.V.) and Comprehensive viva - voce. No course shall carry more than 4 credits. The student shall select any one open course in Sem V offered by the Departments which offers the core courses or physical education department, depending on the availability of infrastructure facilities, in the institution. The number of Courses for the restructured programme should contain 12 compulsory core courses, 1 open course, 1 choice based course from the frontier area of the core courses, 6 core practicals, 1 project & I.V. in the area of core, 8 complementary courses, 2 complementary practicals otherwise specified, from the relevant subjects for complementing the core of study. There should be 10 common courses, or otherwise specified, which includes the first and second language of study.

6. B. Sc. PROGRAMME IN CHEMISTRY

6.1. PROGRAMME STRUCTURE

(i) MODEL I BSC CHEMISTRY

A	Programme Duration	6 Semesters
B	Total Credits required for successful completion of the Programme	120
C	Credits required from Common Course I	22
D	Credits required from Common Course II	16
E	Credits required from Core course and Complementary courses including Project	79
F	Open Course	3
G	Minimum attendance required	75%

(ii) MODEL II BSC CHEMISTRY

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%

**(iii) MODEL III BSC CHEMISTRY**

A	Programme Duration	6 Semesters
B	Total Credits required for successful completion of the Programme	120
C	Credits required from Common Course I	8
D	Credits required from Core + Complementary + Vocational Courses including Project	109
e	Open Course	3
f	Minimum attendance required	75%

6.2. COURSES

There shall be three different types (models) of courses in Chemistry programme. The programme (Model I) consists of common courses with 38 credits, core course, Choice based course, and complementary courses with 79 credits and open course with 3 credits. The programme (Vocational -Model II) consists of common courses with 24 credits, core courses; Choice based courses, and complementary courses with 93 credits and open course with 3 credits. The programme (Model III) consists of common courses with 8 credits, core, Choice based course and complementary courses with 109 credits and open course with 3 credits.

6.3 SCHEME OF COURSES

The different types of courses and its number are as the following:

Model- I		Model- II		Model- III	
<i>Courses</i>	<i>No.</i>	<i>Courses</i>	<i>No.</i>	<i>Courses</i>	<i>No.</i>
Common Courses	10	Common Courses	6	Common Courses	2
Core Courses (Theory)	12	Core Courses (Theory)	12	Core Courses (Theory)	12
Project, Industrial Visit. and Comprehensive viva-voce	1	Project, Industrial Visit. and Comprehensive viva-voce	1	Project, Industrial Visit. and Comprehensive viva-voce	1
Core practical	6	Core Practical	6	First Core practical	6
Open Course	1	Open Course	1	Open Course	1
Choice based Course	1	Choice based Course	1	Choice based Course	1
		Vocational courses	6	Second core Courses	6
		Vocational practical	3	Second Core practical	2
		OJT	1	OJT	1
Complementary Courses	10	Complementary Courses	4	Complementary Courses	8
		Complementary practical	2	Complementary practical	2
Total	41	Total	43	Total	42

6.4. COURSE CODE

Every course in the programme should be coded with an eight digit alphanumeric code according to the following criteria. The first two letters of the code indicates the name of programme ie. CH for Chemistry. One digit to indicate the semester. ie., CH1 (Chemistry, 1st semester). Two letters form the type of courses such as, CC for common courses, CR for core course, VO for vocational course, CM for Complementary courses, OP for Open Course,



CB for Choice based core, OJ for On the Job Training, OC for Optional Core, PR for project i.e., CH1CR (Chemistry, 1st semester Core course). The letter T may be used to denote theory paper and the letter P may be used to denote practical papers. Two digits to indicate the paper's relative position in the programme, i.e., CH5CRT06 (Chemistry, 5th semester, Core course, Theory, sixth paper).

6.5. COURSES WITH CREDITS

Courses with Credits of different courses and scheme of examinations of the programme is the following:

Courses	Credits		
	Model I	Model II	Model III
Core Courses	46	46	46
Open Course	3	3	3
Choice Based Core	3	3	3
Project, I.V. & Viva	2	2	2
Vocational Courses	Nil	24	Nil
OJT	-	2	2
2nd Core Courses	Nil	Nil	24
Total	54	80	80
Complementary Courses I	14	16	16
Complementary Courses II	14	Nil	16
Total	28	16	32
Common Courses	38	24	8
Total	38	24	8
Grand Total	120	120	120

6.6. SCHEME OF DISTRIBUTION OF INSTRUCTIONAL HOURS FOR CORE COURSES

Semester	Model I		Model II		Model III	
	Theory	Practical	Theory	Practical	Theory	Practical
First	2	2	6	4	6	4
Second	2	2	6	4	6	4
Third	3	2	9	6	10	4
Fourth	3	2	9	6	10	4
Fifth	15	10	15	10	15	10
Sixth	15	10	15	10	15	10

7. DURATION OF COURSE

- The duration of U.G. Programmes shall be **6 semesters**.
- A student may be permitted to complete the programme, on valid reasons, within a period of 12 continuous semesters from the date of commencement of the first semester of the programme.
- Attendance: Students having a minimum of 75% average attendance for all the courses only, can register for the examination.



8. MARKS DISTRIBUTION FOR EXTERNAL EXAMINATION AND INTERNAL EVALUATION

The external theory examination of all semesters shall be conducted by the University at the end of each semester. Internal evaluation is to be done by continuous assessment. For all papers (theory and practical) total percentage of marks of external examination is 80 and total percentage of 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:

Components of the internal evaluation and their marks are as below.

8.1. FOR ALL THEORY PAPERS:

- (a) Marks of external Examination : 60
 (b) Marks of internal evaluation : 15

All the three components of the internal assessment are mandatory.

Components of theory Internal Evaluation	MARKS
Attendance	4
Assignment/Seminar/Viva	4
Test Paper(s) (1×7=7)	7
Total	15

8.2 FOR ALL PRACTICAL PAPERS (conducted only at the end of even semesters):

- (a) Marks of external Examination : 40
 (b) Marks of internal evaluation : 10

All the three components of the internal assessment are mandatory

Components of Practical-internal evaluation	Marks
Attendance	3
Record*	5
Lab involvement	2
Total	10

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

8.3 FOR PROJECTS, INDUSTRIAL VISIT AND COMPREHENSIVE VIVA-VOCE*:

- (a) Marks of external Examination : 80
 (b) Marks of internal evaluation : 20

Components of Project I.V. and Viva – Evaluation External	Marks
Dissertation and I.V. report (External)	50
Comprehensive Viva-voce (External)	30
Total	80

* Bonafide reports of the project work and Industrial Visit conducted shall be submitted at the time of examination.



All the four components of the internal assessment are mandatory.

Components of Project & I.V. - Internal Evaluation	Marks
Punctuality	5
Experimentation / Data Collection	5
Knowledge	5
Report	5
Total	20

8.4 OJT EVALUATION

For On the J ob Training there is only internal evaluation.

8.5 ASSIGNMENTS

Assignments are to be done from 1st to 4th Semesters. At least one assignment should be done in each semester for all papers.

8.6 SEMINAR / VIVA

A student shall present a seminar in the 5th semester and appear for Viva- voce in the 6th semester for all papers.

8.7 INTERNAL ASSESSMENT TEST PAPERS

Two internal test- papers are to be attended in each semester for each paper. The evaluations of all components are to be published and are to be acknowledged by the candidates. All documents of internal assessments are to be kept in the college for two years and shall be made available for verification by the University. The responsibility of evaluating the internal assessment is vested on the teacher(s) who teach the paper.

9. CONDUCT OF PRACTICAL EXAMINATIONS

9.1 PRACTICAL EXAMINATION

Practical examinations will be conducted only at the end of even semesters for all programmes.

9.2. PATTERN OF QUESTION PAPERS

Pattern of questions for external examination of practical papers will decided by the concerned Board of practical examination.

CONSOLIDATED SCHEME FOR I TO VI SEMESTERS PROGRAMME STRUCTURE

1. BSC CHEMISTRY PROGRAMME – (MODEL - I)

Sem	Title with Course code	Course Category	Hours per week	Credits
I	English I	Common	5	4
	English/ Common Course I	Common	4	3
	Second Language I	Common	4	4
	CHICRT01 General and Analytical Chemistry	Core	2	2
	CH2CRP01 Volumetric Analysis	Core	2	-
	Complementary Mathematics	Complementary	4	3
	Complementary Physics	Complementary	2	2
	Complementary Physics Practical	Complementary	2	-
II	English II	Common	5	4
	English/ Common Course II	Common	4	3
	Second Language II	Common	4	4
	CH2CRT02 Theoretical and Inorganic Chemistry	Core	2	2
	CH2CRP01 Volumetric Analysis	Core	2	2
	Complementary Mathematics	Complementary	4	3
	Complementary Physics	Complementary	2	2
	Complementary Physics Practical	Complementary	2	2
III	English III	Common	5	4
	II Lang/Common Course I	Common	5	4
	CH3CRT03 Organic Chemistry-I	Core	3	3
	CH4CRP02 Qualitative Organic Analysis	Core	2	-
	Complementary Mathematics	Complementary	5	4
	Complementary Physics	Complementary	3	3
	Complementary Physics Practical	Complementary	2	-
IV	English IV	Common	5	4
	II Lang/ Common Course II	Common	5	4
	CH4CRT04 Organic Chemistry-II	Core	3	3
	CH4CRP02 Qualitative Organic Analysis	Core	2	2
	Complementary Mathematics	Complementary	5	4
	Complementary Physics	Complementary	3	3
	Complementary Physical Practical	Complementary	2	2
V	CH5CRT05 Environmental Studies and Human Rights	Core	4	4
	CH5CRT06 Organic Chemistry-III	Core	3	3
	CH5CRT07 Physical Chemistry - I	Core	2	2
	CH5CRT08 Physical Chemistry - II	Core	2	3
	CH5OPT Open course	Open	4	3



	CH6CRP03 Qualitative Inorganic Analysis	Core	3	-
	CH6CRP04 Organic Preparations and Basic Laboratory Techniques	Core	2	-
	CH6CRP05 Physical Chemistry Practical	Core	3	-
	CH6PRP01 Project	Core	2	-
VI	CH6CRT09 Inorganic Chemistry	Core	3	3
	CH6CRT10 Organic Chemistry-IV	Core	3	3
	CH6CRT11 Physical Chemistry - III	Core	3	3
	CH6CRT12 Physical Chemistry - IV	Core	3	3
	CH6CBT Choice Based Course	Core	3	3
	CH6CRP03 Qualitative Inorganic Analysis	Core	3	2
	CH6CRP04 Organic Preparations and Basic Laboratory Techniques	Core	2	2
	CH6CRP05 Physical Chemistry Practical	Core	3	2
	CH6CRP06 Gravimetric Analysis	Core	2	2
	CH6PR01 Project & Industrial visit and comprehensive viva-voce	Core	-	2

OPEN COURSES:

Sl. No.	Semester	Course Code	Course Title
1	V	CH5OPT01	Chemistry in Everyday Life
2	V	CH5OPT02	Nanoscience and Nanotechnology
3	V	CH5OPT03	Forensic Science

CHOICE BASED COURSES:

Sl. No.	Semester	Course Code	Course Title
1	VI	CH6CBT01	Polymer Chemistry
2	VI	CH6CBT02	Nanochemistry and Nanotechnology
3	VI	CH6CBT03	Soil and Agricultural Chemistry


2. BSC CHEMISTRY PROGRAMME – (MODEL - II)

Sem	Title with Course code	Course Category	Hours per week	Credits
I	English I	Common	5	4
	Second Language I	Common	5	4
	CHICRT01 General and Analytical Chemistry	Core	2	2
	CH2CRP01 Volumetric Analysis	Core	2	-
	Complementary Mathematics	Complementary	5	4
	CH1VOT01 Industrial Aspects of Inorganic and Organic Chemistry	Core	4	3
	CH2VOP01 Vocational Practical	Core	2	-
II	English I	Common	5	4
	Second Language I	Common	5	4
	CH2CRT02 Theoretical and Inorganic Chemistry	Core	2	2
	CH2CRP01 Volumetric Analysis	Core	2	2
	Complementary Mathematics	Complementary	5	4
	CH2VOT02 Industrial Applications of Physical	Core	4	3
	CH2VOP01 Vocational Practical	Core	2	2
III	English III	Common	5	4
	CH3CRT03 Organic Chemistry-I	Core	3	3
	CH4CRP02 Qualitative Organic Analysis	Core	2	-
	Complementary Mathematics	Complementary	5	4
	CH3VOT03 Unit Operations in Chemical Industry	Core	3	3
	CH3VOT04 Unit Processes in Organic Chemicals Manufacture	Core	3	3
	CH2VOP02 Vocational Practical	Core	2	-
	CH2VOP02 Vocational Practical	Core	2	-
IV	English IV	Common	5	4
	CH4CRT04 Organic Chemistry-II	Core	3	3
	CH4CRP02 Qualitative Organic Analysis	Core	2	2
	Complementary Mathematics	Complementary	5	4
	CH4VOT05 Instrumental Methods of Chemical Analysis-I	Core	3	3
	CH4VOT06 Instrumental Methods of Chemical Analysis-II	Core	3	3
	CH2VOP02 Vocational Practical	Core	2	2
	CH2VOP03 Vocational Practical	Core	2	2
V	CH5CRT05 Environmental Studies and Human Rights	Core	4	4
	CH5CRT06 Organic Chemistry-III	Core	3	3
	CH5CRT07 Physical Chemistry - I	Core	2	2
	CH5CRT08 Physical Chemistry - II	Core	2	3
	CH5OPT Open course	Open	4	3



	CH6CRP03 Qualitative Inorganic Analysis	Core	3	-
	CH6CRP04 Organic Preparations and Basic Laboratory Techniques	Core	2	-
	CH6CRP05 Physical Chemistry Practical	Core	3	-
	CH6PRP01 Project	Core	2	-
VI	CH6CRT09 Inorganic Chemistry	Core	3	3
	CH6CRT10 Organic Chemistry-IV	Core	3	3
	CH6CRT11 Physical Chemistry - III	Core	3	3
	CH6CRT12 Physical Chemistry - IV	Core	3	3
	CH6CBT Choice Based Course	Core	3	3
	CH6CRP03 Qualitative Inorganic Analysis	Core	3	2
	CH6CRP04 Organic Preparations and Basic Laboratory Techniques	Core	2	2
	CH6CRP05 Physical Chemistry Practical	Core	3	2
	CH6CRP06 Gravimetric Analysis	Core	2	2
	CH6PRP01 Project, Industrial visit and comprehensive viva - voce	Core	-	2
	CH6OJP01 OJT	Core	-	2

On the Job Training All the students have to undergo on the job training in a chemical industry 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 COURSES:

Sl. No.	Semester	Course Code	Course Title
1	V	CH5OPT1.1	Chemistry in Everyday Life
2	V	CH5OPT1.2	Nanoscience and Nanotechnology
3	V	CH5OPT1.3	Forensic Science

CHOICE BASED COURSES:

Sl. No.	Semester	Course Code	Course Title
1	VI	CH6CBT1.1	Polymer Chemistry
2	VI	CH6CBT1.2	Nanochemistry and Nanotechnology
3	VI	CH6CBT1.3	Soil and Agricultural Chemistry



3. BSC CHEMISTRY PROGRAMME – (MODEL - III)

Sem	Title with Course code	Course Category	Hours per week	Credits
I	English I	Common	5	4
	CHICRT01 General and Analytical Chemistry	Core	2	2
	CH2CRP01 Volumetric Analysis	Core	2	-
	CH1PCT01 Petroleum Geology	Core	4	3
	CH2PCP01 Practical I	Core	2	-
	Complementary Mathematics	Complementary	5	4
	Complementary Computer Science	Complementary	3	3
	Complementary Practical –I	Complementary	2	-
II	English I	Common	5	4
	CH2CRT02 Theoretical and Inorganic Chemistry	Core	2	2
	CH2CRP01 Volumetric Analysis	Core	2	2
	CH2PCT02 Test Methods and Petroleum Processes	Core	4	3
	CH2PCP01 Practical I	Core	2	2
	Complementary Mathematics	Complementary	5	4
	Complementary Computer Science	Complementary	3	3
	Complementary Practical –I	Complementary	2	2
III	CH3CRT03 Organic Chemistry-I	Core	3	3
	CH4CRP02 Qualitative Organic Analysis	Core	2	-
	CH3PCT03 Production and Application of Compounds from Petroleum	Core	4	4
	CH3PCT04 Manufacture of Petrochemicals-I	Core	3	3
	CH4PCP02 Practical –II	Core	2	-
	Complementary Mathematics	Complementary	5	4
	Complementary Computer Science	Complementary	4	3
	Complementary Practical –II	Complementary	2	-
IV	CH4CRT04 Organic Chemistry-II	Core	3	3
	CH4CRP02 Qualitative Organic Analysis	Core	2	2
	CH4PCT05 Manufacture of Petrochemicals-II	Core	4	4
	CH4PCT06 Petroleum Industries in India	Core	3	3
	CH4PCP02 Practical –II	Complementary	2	2
	Complementary Mathematics	Complementary	6	4
	Complementary Computer Science	Complementary	3	3
	Complementary Practical –II	Core	2	2
V	CH5CRT05 Environmental Studies and Human Rights	Core	4	4
	CH5CRT06 Organic Chemistry-III	Core	3	3
	CH5CRT07 Physical Chemistry - I	Core	2	2
	CH5CRT08 Physical Chemistry - II	Core	2	3
	CH5OPT Open course	Open	4	3
	CH6CRP03 Qualitative Inorganic Analysis	Core	3	-



	CH6CRP04 Organic Preparations and Basic Laboratory Techniques	Core	2	-
	CH6CRP05 Physical Chemistry Practical	Core	3	-
	CH6PRP01 Project	Core	2	-
VI	CH6CRT09 Inorganic Chemistry	Core	3	3
	CH6CRT10 Organic Chemistry-IV	Core	3	3
	CH6CRT11 Physical Chemistry - III	Core	3	3
	CH6CRT12 Physical Chemistry - IV	Core	3	3
	CH6CBT Choice Based Course	Core	3	3
	CH6CRP03 Qualitative Inorganic Analysis	Core	3	2
	CH6CRP04 Organic Preparations and Basic Laboratory Techniques	Core	2	2
	CH6CRP05 Physical Chemistry Practical	Core	3	2
	CH6CRP06 Gravimetric Analysis	Core	2	2
	CH6PRP01 Project, Industrial visit and comprehensive viva-voce	Core	-	2
CH6OJP01 OJT	Core	-	2	

On the Job Training All the students have to undergo on the job training in a chemical industry 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 COURSES:

Sl. No.	Semester	Course Code	Course Title
1	V	CH5OPT1.1	Chemistry in Everyday Life
2	V	CH5OPT1.2	Nanoscience and Nanotechnology
3	V	CH5OPT1.3	Forensic Science

CHOICE BASED COURSES:

Sl. No.	Semester	Course Code	Course Title
1	VI	CH6CBT1.1	Polymer Chemistry
2	VI	CH6CBT1.2	Nanochemistry and Nanotechnology
3	VI	CH6CBT1.3	Soil and Agricultural Chemistry



SYLLABUS FOR CHEMISTRY CORE COURSES



SEMESTER I

CH1CRT01 – GENERAL AND ANALYTICAL CHEMISTRY

Credits: 2 (36 Hrs)

Unit 1: Methodology of Chemistry

(7 Hrs)

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.

Evolution of Chemistry-ancient speculation on the nature of matter. Early form of chemistry- alchemy, origin of modern chemistry. Structure of chemical science: Scope, theory and experiment - branches of chemistry. Role of chemistry as a central science connecting physics, biology and other branches of science. Interdisciplinary areas involving chemistry: Nanotechnology and biotechnology.

Unit 2: Periodic Table and Periodic Properties

(5 Hrs)

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) – electronegativity. Electronegativity scales: Pauling and Mullikan scales. Effective nuclear charge – Slater rule and its applications – polarising power.

Unit 3: Analytical Methods in Chemistry

(12 Hrs)

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

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).

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 $\text{Cr}_2\text{O}_7^{2-}$ - redox indicators. Complexometric titrations – EDTA titrations - titration curves – metal ion indicators. Gravimetric analysis: Unit operations in gravimetric analysis - illustrations using iron and barium estimation. Separation and purification techniques – filtration, crystallization and precipitation – fractional distillation, solvent extraction.

Unit 4: Chromatographic Methods

(7 Hrs)

Column Chromatography: Principle, types of adsorbents, preparation of the column, elution, recovery of substances and applications. Thin Layer Chromatography: Principle, choice of adsorbent and solvent, preparation of Chromatoplates, R_f -values, significance of R_f values. Ion exchange chromatography: Principle and experimental techniques. Gas Chromatography: Principle and experimental techniques. High Performance Liquid Chromatography (HPLC): Principle and experimental techniques.



Unit 5: Evaluation of Analytical Data

(5 Hrs)

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.

References

1. J.A.Lee, Scientific Endeavour, Addison Wesley Longman
2. C.N.R.Rao, University General Chemistry, MacMillan India (Ltd.)
3. 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.
4. J. D. Lee, Concise Inorganic Chemistry, 5th edn., Blackwell Science, London, 2010.
5. B.R. Puri, L.R. Sharma and K.C. Kalia, *Principles of Inorganic Chemistry*, 31st Edition, Milestone Publishers and Distributors, New Delhi, 2013.
6. Satya Prakash, *Advanced Inorganic Chemistry, Volume 1*, 5th Edition, S. Chand and Sons, New Delhi, 2012.
7. J. Mendham, R.C. Denney, J. D. Barnes and M. Thomas, *Vogel's Text Book of Quantitative Chemical Analysis*, 6th Edition, Pearson Education, Noida, 2013.
8. R. Gopalan, *Inorganic Chemistry for Undergraduates*, Universities Press, Hyderabad, 2009.
9. Vogel's Textbook of Quantitative Chemical Analysis, 6thEdn., Pearson Education Ltd.

**SEMESTER II****CH2CRT02 – THEORETICAL AND INORGANIC CHEMISTRY****Credits - 2 (36 hrs)****Unit 1: Atomic Structure****(6 Hrs)**

Introduction based on historical development (Dalton's atomic theory, Thomson's atom model Rutherford's atom model) - failure of classical physics – black body 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 - Sommerfeld 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.

Unit 2: Chemical Bonding – I**(9 Hrs)**

Introduction – Octet rule and its limitations.

Types of bonds: Ionic bond - factors favouring the 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.

Unit 3: Chemical Bonding – II**(9 Hrs)**

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



Unit 4: Chemistry of s and p Block Elements (3 Hrs)

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

Unit 5: Chemistry of d and f Block Elements (9 Hrs)

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. Preparation, properties, structure and uses of KMnO_4 and $\text{K}_2\text{Cr}_2\text{O}_7$.

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.

References

1. R.K. Prasad, *Quantum Chemistry*, New Age International, 2001
2. McQuarrie, J. D. Simon, *Physical Chemistry – A molecular Approach*, Viva Books.
3. I. N. Levine, *Physical Chemistry*, Tata McGraw Hill,
4. ManasChanda, *Atomic structure and Chemical bonding in Molecular Spectroscopy*” Tata McGraw Hill.
5. J. D. Lee, *Concise Inorganic Chemistry*, 5th edn., Blackwell Science, London.
6. B. R. Puri, L. R. Sharma, Kalia, *Principles of Inorganic Chemistry*, Milestone Publishers, New Delhi.
7. F. A. Cotton, G. Wilkinson and P. L. Gaus, *Basic Inorganic Chemistry*, 3rd edn., John Wiley.
8. B. Douglas, D. Mc Daniel, J. Alexander, *Concepts and models in Inorganic Chemistry*.
9. Satya Prakash, *Advanced Inorganic Chemistry, Volume 1*, 5th Edition, S. Chand and Sons, New Delhi, 2012.
10. R. Gopalan, *Inorganic Chemistry for Undergraduates*, Universities Press, Hyderabad, 2009.



SEMESTER I AND II - CORE CHEMISTRY PRACTICALS

CH2CRP01 - VOLUMETRIC ANALYSIS

Credits: 2 (72 Hrs)

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:

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

**SEMESTER III****CH3CRT03 - ORGANIC CHEMISTRY – I****Credits – 3 (54 Hrs)***(Reaction mechanisms expected only wherever mentioned)***Unit 1: Fundamentals of Organic Chemistry (8 Hrs)**

Classification and IUPAC system of nomenclature of common organic compounds (both aliphatic and aromatic).

Line diagram drawing. Factors affecting reaction mechanism. Polarity of bonds.

Electronic displacements: Inductive effect, electromeric effect, mesomeric effect, resonance and hyperconjugation. steric effects.

Cleavage of bonds: Homolysis and heterolysis with suitable examples. curly arrow rules, formal charges.

Types of reagents: Nucleophiles and electrophiles.

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

Types of organic reactions: Addition, elimination, substitution, rearrangement and redox reactions (definition and one example each).

Unit 2: Stereochemistry (15 Hrs)

Stereoisomerism – definition, classification.

Optical isomerism: Optical activity, specific rotation, concept of chirality (upto two carbon atoms). Configuration. Enantiomerism, diastereomerism and meso compounds. Racemic mixture and methods of resolution. Asymmetric synthesis (partial and absolute). Threo and erythro; *d* and *l* designations; Cahn-Ingold-Prelog rules: R/ S notation (for upto 2 chiral carbon atoms).

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

Conformational analysis: Conformational analysis with respect to ethane, butane and cyclohexane. Relative stability and energy diagrams. Interconversion of Wedge formula, Newman, Sawhorse and Fischer projection formulae. Chair, boat and twist boat forms of cyclohexane with energy diagrams. Conformation of methyl cyclohexane.

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

Unit 3: Aliphatic Hydrocarbons and Alkyl Halides (12 Hrs)

Alkanes: Preparation - catalytic hydrogenation, Wurtz reaction, Wurtz-Fittig reaction, from Grignard reagent. Reactions - free radical substitution - halogenation.

Alkenes: Preparation - Elimination reactions - mechanism of E1 and E2 reactions. Dehydration of alkenes and dehydrohalogenation of alkyl halides (Saytzeff's and Hofmann's rules). Reactions - *cis*-addition (alkaline KMnO₄) and *trans*-addition (bromine). Addition of HX (Markownikoff's and anti-Markownikoff's addition with mechanisms), Hydration, Ozonolysis.



Alkynes: Preparation - Acetylene from CaC_2 and conversion into higher alkynes; by dehalogenation of tetra halides and dehydrohalogenation of vicinal dihalides. Reactions - Acidity of alkynes, formation of metal acetylides, alkylation of terminal alkynes and conversion into higher alkynes, addition of bromine and alkaline KMnO_4 .

Alkyl Halides: Preparation - From alkenes and alcohols. Reactions - Types of aliphatic nucleophilic substitution reactions - S_N^1 and S_N^2 mechanisms with stereochemical aspects and effects of substrate structure, solvent, nucleophile and leaving group.

Organometallic compounds of Mg (*Grignard reagents*) – Formation, structure and important reactions/synthetic applications.

Unit 4: Aromatic Hydrocarbons and Aryl Halides (15 Hrs)

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

Benzene: Molecular orbital picture and resonance energy. Preparation - from phenol, by decarboxylation, from acetylene, from aromatic acids. Reactions - Electrophilic aromatic substitution: 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.

Naphthalene and Anthracene: Molecular orbital picture and resonance energy. Preparation - (of Naphthalene): Haworth synthesis

Reactions - Electrophilic substitutions (halogenation, nitration and sulphonation) of naphthalene.

Aryl Halides: Preparation - chloro, bromo and iodo-benzene from phenol, Sandmeyer and Gattermann reactions. Reactions - aromatic nucleophilic substitutions – bimolecular displacement mechanism, elimination-addition (benzyne intermediate) mechanism.

Unit 5: Pericyclic Reactions (4 Hrs)

Classification – electrocyclic reactions, cycloadditions - Diels-Alder reaction and Sigmatropic rearrangements - Claisen rearrangement (with mechanism).

References

1. Morrison, R.T., Boyd, R.N. & Bhattacharjee, S.K. *Organic Chemistry*, 7th ed., Dorling Kindersley (India) Pvt. Ltd (Pearson Education), 2011.
2. Graham Solomon, T.W., Fryhle, C.B. & Snyder, S.A. *Organic Chemistry*, John Wiley & Sons, 2014.
3. McMurry, J. *Organic Chemistry*, 7th ed. Cengage Learning, 2013.
4. Sykes, P. *A Guidebook to Mechanism in Organic Chemistry*, Orient Longman, 1988.
5. Eliel, E.L. & Wilen, S.H. *Stereochemistry of Organic Compounds*, Wiley, 1994.
6. Finar, I.L. *Organic Chemistry* (Vol. 1 & 2), Dorling Kindersley (India) Pvt. Ltd (Pearson Education).
7. Jain, M.K. & Sharma, S.C. *Modern Organic Chemistry*, Vishal Publishing Co. 2010.
8. Bahl, A. & Bahl, B.S. *Advanced Organic Chemistry*, S. Chand, 2010.



9. Kalsi, P. S. *Stereochemistry - Conformation and Mechanism*; New Age International, 2005.
10. Pillai, C.N. *Organic Chemistry*, Universities Press, 2008.
11. Gupta, S.S. *Organic Chemistry*, Oxford University Press, 2014.



SEMESTER IV

CH4CRT04 - ORGANIC CHEMISTRY –II

Credits – 3 (54 Hrs)

(Reaction mechanisms expected only wherever mentioned)

Unit 1: Alcohols, Phenols and Ethers

(16 Hrs)

Alcohols

Preparation - 1°, 2° and 3° alcohols using Grignard reagent, ester hydrolysis, reduction of aldehydes, ketones, carboxylic acids and esters (Bouveault-Blanc reduction).

Reactions - with sodium, HX (Lucas test), esterification, oxidation (with PCC, alkaline KMnO₄, OsO₄, acidic dichromate, conc. HNO₃). Oppenauer oxidation (with mechanism). Ascent and descent of alcohol series.

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 LiAlH₄.

Unit 2: Aldehydes and Ketones

(20 Hrs)

Preparation, properties and reactions of formaldehyde, acetaldehyde, acetone, benzaldehyde and benzophenone.

Preparation - from alcohols, acid chlorides, esters and nitriles.

Reactions - Structure of the carbonyl group and acidity of α-hydrogen. (i) Additions reactions - with HCN, ROH, NaHSO₃, Grignard reagents and ammonia derivatives. Aldol, Claisen, Claisen-Schmidt, Knoevenagel and Benzoin condensations (with mechanisms). Cannizzaro reaction, Wittig reaction and Mannich reaction (with mechanisms). Michael addition (with mechanism) (ii) Oxidation reactions - Tollen's and Fehling's tests, Iodoform test, Baeyer-Villiger oxidation (with mechanism) (iii) Reduction reactions - Clemmensen, Wolff-Kishner, Meerwein-Ponndorf-Verley, LiAlH₄, and NaBH₄ reductions (with mechanisms) (iv) Rearrangement reactions - Beckmann, and benzil-benzilic acid rearrangements (with mechanisms).

Unit 3: Carboxylic Acids, Sulphonic Acids and their Derivatives

(18 Hrs)

Carboxylic acids (aliphatic and aromatic)

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 and descent of acid series. Reduction and decarboxylation reactions. Reactions with PCl₅, PCl₃



and SOCl_2 . Reaction with ammonia, esterification and halogenation. Hell – Volhard - Zelinsky reaction (with mechanism).

Carboxylic acid derivatives (aliphatic):

Preparation - acid chlorides, anhydrides, esters and amides from acids.

Reactions - comparative study of nucleophilicity of acyl derivatives. Perkin condensation and Reformatsky reaction (with mechanisms).

Dicarboxylic acids, hydroxy acids and unsaturated acids

Methods of formation, important reactions and uses of dicarboxylic acids, hydroxy acids and unsaturated acids like 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.

References

1. Morrison, R.T., Boyd, R.N. & Bhattacharjee, S.K. *Organic Chemistry*, 7th ed., Dorling Kindersley (India) Pvt. Ltd (Pearson Education), 2011.
2. Graham Solomon, T.W., Fryhle, C.B. & Snyder, S.A. *Organic Chemistry*, Wiley, 2014.
3. McMurry, J. *Organic Chemistry*, 7th ed. Cengage Learning, 2013.
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5. Carey, F.A., Giuliano, R.M. *Organic Chemistry*, 8th ed., Tata McGraw Hill, 2012.
6. Jain, M.K. & Sharma, S.C. *Modern Organic Chemistry*, Vishal Publishing Co. 2010.
7. Bahl, A. & Bahl, B.S. *Advanced Organic Chemistry*, S. Chand, 2010.
8. Tewari, K.S. & Vishnoi, N.K. *Organic Chemistry*, Vikas Publishing House, 2012.
9. Pillai, C.N. *Organic Chemistry*, Universities Press, 2008.
10. Gupta, S.S. *Organic Chemistry*, Oxford University Press,



SEMESTER III AND IV ORGANIC CHEMISTRY

PRACTICALS- I

CH4CRP02 - QUALITATIVE ORGANIC ANALYSIS

Credit-2 (72 Hrs)

1. Determination of physical constants of solids and liquids – melting and boiling points.
2. Tests for elements: Nitrogen, Halogens and Sulphur
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 halogen compounds.
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 halogen compounds.

(Minimum twelve compounds to be analysed)

References

1. 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.
2. Mann, F.G.; Saunders, B.C. *Practical Organic Chemistry*, 4th ed., Pearson Education, 2009.
3. Ahluwalia, V.K.; Dhingra, S. *Comprehensive Practical Organic Chemistry – Qualitative Analysis*, Universities Press, 2000.
4. Vishnoi, N.K. *Advanced Practical Organic Chemistry*, 3rd ed., Vikas Publishing House, New Delhi, 2010.



SEMESTER V

CH5CRT05 - ENVIRONMENTAL STUDIES AND HUMAN RIGHTS

Credits – 4 (72 Hrs)

Unit 1: Multidisciplinary Nature of Environmental Studies (12 Hrs)

Definition, scope and importance. Need for public awareness. Natural resources: Renewable and non-renewable resources, forest resources - use and over-exploitation, deforestation. Water resources - use and over-utilization of surface and ground water, floods, drought, conflicts over water, dams-benefits and problems. Mineral resources - use and exploitation, environmental effects of extracting and using mineral resources. Food resources - World food problems, changes caused by agriculture and overgrazing, effects of modern agriculture, fertilizer-pesticide problems. Energy resources -growing energy needs, renewable and non renewable energy sources, use of alternate energy sources. Land resources - land as a resource, land degradation, man induced landslides, soil erosion and desertification

Unit 2: Ecosystems (8 Hrs)

Concept of an ecosystem. Structure and function of an ecosystem. Producers, consumers and decomposers. Energy flow in the ecosystem. Ecological succession. Food chains, food webs and ecological pyramids. Introduction, types, characteristic features, structure and function of the given ecosystem:- Forest ecosystem.

Unit 3: Social Issues and the Environment (8 Hrs)

Urban problems related to energy. Water conservation, rain water harvesting, water shed management. Resettlement and rehabilitation of people: its problems and concerns. Environmental ethics: Issues and possible solutions. Environment Protection Act, Air (Prevention and Control of Pollution) Act, Water (Prevention and control of Pollution) Act, Wildlife Protection Act, Forest Conservation Act, Issues involved in enforcement of environmental legislation, Public awareness.

Unit 4: Air, Water and Soil Pollution (12 Hrs)

Air pollution: Causes, effects and control measures. Acid rain, smog, green house effect, Global warming, ozone depletion – causes and consequences. Introduction to noise pollution, hazards of noise pollution.

Water pollution: Causes- organic, inorganic and macroscopic contaminants, effects of pesticides, insecticides and detergents on water pollution. Marine pollution, eutrophication, biomagnification, water quality parameters-DO, BOD, COD.

Soil pollution: Causes and effects: Agrochemicals, industrial wastes, petroleum wastes, electronic wastes, landfill and dumping. Genetically modified plants.

Unit 5: Toxicology and Toxicological Effects (6 Hrs)

Toxic chemicals in the environment, impact of toxic chemicals on enzymes, biochemical effects of As, Cd, Pb, Hg, CO, Oxides of Nitrogen and Sulphur.

**Unit 6: Introduction to Green Chemistry****(4 Hrs)**

Introduction to green chemistry, twelve principles of green chemistry, atom economy – examples.

Unit 7: Environmental Aspects of Nuclear Chemistry**(10 Hrs)**

Nuclear particles, size of the nucleus - nuclear forces - nuclear stability – N/P ratio – packing fraction – mass defect – binding energy - magic numbers. Nuclear models – shell model and liquid drop model.

Natural radioactivity. Modes of decay- group displacement law — rate of decay – decay constant – half-life period – Gieger-Nuttall rule – disintegration series – transmutation reactions using protons, deuterons, α -particles and neutrons. Artificial radioactivity – positron emission and K electron capture – trans uranic elements, spallation reactions .

Applications of radioactivity: Radio carbon dating – rock dating – isotopes as tracers – study of reaction mechanism (ester hydrolysis). Application of radioactive isotopes in medicine. Nuclear fission - atom bomb - nuclear reactors – fast breeder reactors. Nuclear fusion and hydrogen bomb. Nuclear waste and its impact on environment – nuclear waste management

Unit 8: Introduction to Human Rights**(12 Hrs)**

An Introduction to Human Rights, meaning, concept and development. Three generations of human rights (civil and political rights; economic, social and cultural rights). Human Rights and United Nations – contributions, main human rights related organs - UNESCO, UNICEF, WHO, ILO, Declarations for women and children, Universal Declaration of Human Rights. Human Rights in India: Fundamental rights and Indian Constitution, Rights for children and women, Scheduled Castes, Scheduled Tribes, Other Backward Castes and Minorities. Environment and Human Rights - right to clean environment and public safety. Issues of industrial pollution, prevention, rehabilitation and safety aspect of new technologies such as chemical and nuclear technologies, issues of waste disposal, protection of environment.

References

1. Bharucha Erach, Text Book of Environmental Studies for undergraduate Courses. University Press, IInd Edition 2013 (TB)
2. Clark.R.S., Marine Pollution, Clanderson Press Oxford (Ref)
3. Cunningham, W.P.Cooper, T.H.Gorhani, E & Hepworth, M.T.2001 Environmental Encyclopedia, Jaico Publ. House. Mumbai. 1196p .(Ref)
4. Dc A.K.Environmental Chemistry, Wiley Eastern Ltd.(Ref)
5. Down to Earth, Centre for Science and Environment (Ref)
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7. Jadhav.H & Bhosale.V.M. 1995. Environmental Protection and Laws. Himalaya Pub. House, Delhi 284p (Ref)
8. Mekinney, M.L & Schock.R.M. 1996 Environmental Science Systems & Solutions. Web enhanced edition 639p (Ref)
9. Miller T.G. Jr., Environmental Science, Wadsworth Publishing Co. (TB)



10. Odum.E.P 1971. Fundamentals of Ecology. W.B. Saunders Co. USA 574p (Ref)
11. Rao.M.N & Datta.A.K. 1987 Waste Water treatment Oxford & IBII Publication Co.Pvt.Ltd.345p (Ref)
12. Rajagopalan. R, Environmental Studies from crisis and cure, Oxford University Press, Published: 2016 (TB)
13. Sharma B.K., 2001. Environmental Chemistry. Geol Publ. House, Meerut (Ref)
14. Townsend C., Harper J, and Michael Begon, Essentials of Ecology, Blackwell Science (Ref)
15. Trivedi R.K., Handbook of Environmental Laws, Rules Guidelines, Compliances and Stadards, Vol I and II, Enviro Media (Ref)
16. Trivedi R. K. and P.K. Goel, Introduction to air pollution, Techno-Science Publication (Ref)
17. Wanger K.D., 1998 Environmental Management. W.B. Saunders Co. Philadelphia, USA 499p (Ref)
18. H.J. Arnikar, Essentials of Nuclear Chemistry, 4th Edition, New Age International (P) Ltd., New Delhi, 1995 (Reprint 2005).
19. S. Glasstone, Source Book on Atomic Energy, 3rd Edition, East-West Press Pvt. Ltd., New Delhi, 1967.
20. U.N. Dash, Nuclear Chemistry, Sultan Chand and Sons (1991).



CH5CRT06 - ORGANIC CHEMISTRY - III
(*Reaction mechanisms expected only wherever mentioned*)

Credits – 3 (54 Hrs)

Unit 1: Nitrogen Containing Compounds **(15 Hrs)**

Nitro compounds (aliphatic and aromatic):

Preparation: Methods of preparation of nitroalkanes and aromatic nitro compounds.

Reactions: Tautomerism of nitromethane. Reduction products of nitrobenzene in acidic, neutral and alkaline media. Electrolytic reduction and selective reduction of polynitro compounds. Formation of charge transfer complexes.

Amines (aliphatic and aromatic):

Preparation: From alkyl halides, Reduction of nitro compounds and nitriles, Reductive amination of aldehydes and ketones, Gabriel's phthalimide synthesis, Hofmann bromamide reaction (with mechanism).

Reactions: Hofmann vs. Saytzeff elimination, Carbylamine test, Hinsberg test, with HNO₂. Separation of a mixture of 1°, 2° and 3° amines using Hinsberg reagent. 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 amines.

Reactions: Structure and stability of benzene diazonium salts. Conversion to benzene, phenol, chloro, bromo, iodo and fluoro benzenes, nitro benzene and azo dyes. 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.

Unit 2: Heterocyclic Compounds **(8 Hrs)**

Classification and nomenclature. Structure and aromaticity of 5-membered 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).

Unit 3: Active Methylene Compounds **(5 Hrs)**

Preparation: Ethyl acetoacetate by Claisen ester condensation.

Reactions: Keto-enol tautomerism. Synthetic uses of ethylacetoacetate, diethyl malonate and ethyl cyanoacetate (preparation of non-heteromolecules only).

Alkylation of carbonyl compounds *via* enamines.

**Unit 4: Carbohydrates** (11 Hrs)

Classification of carbohydrates. Reducing and non-reducing sugars. General Properties of Glucose and Fructose, their open chain structure. Epimers, mutarotation and anomers. Determination of configuration of Glucose (Fischer proof). Cyclic structure of glucose. Haworth projections. Cyclic structure of fructose. Chain lengthening and chain shortening of aldoses - Kiliani-Fischer synthesis and Wohl degradation. Interconversion of aldoses and ketoses. Linkage between monosaccharides. Structure of the disaccharides sucrose, maltose and cellobiose (excluding their structure elucidation). Reactions and uses of sucrose. Artificial sugars (sweeteners) – sucralose. Structure of the polysaccharides starch and cellulose (excluding their structure elucidation). Industrial applications of cellulose.

Unit 5: Drugs (5 Hrs)

Classification of drugs. Structure, therapeutic uses and mode of action (synthesis not required) of Antibiotics: Ampicillin and Chloramphenicol, Sulpha drugs: Sulphanilamide, Antipyretics: Paracetamol, Analgesics: Aspirin and Ibuprofen, Antimalarials: Chloroquine, Antacids: Ranitidine, Anti-cancer drugs: Chlorambucil and Anti-HIV agents: Azidothymidine (Zidovudine). Psychotropic drugs: Tranquilizers, antidepressants and stimulants with examples. Drug addiction and abuse. Prevention and treatment.

Unit 6: Dyes (4 Hrs)

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: Azo dyes – Methyl orange; Triphenyl methane dyes - Malachite green and Rosaniline; Phthalein dyes – Phenolphthalein and Fluorescein; Indigoid dyes - Indigotin; Anthraquinoid dyes – Alizarin. Edible dyes (Food colours) with examples.

Unit 7: Polymers (6 Hrs)

Introduction and classification. Polymerisation reactions - Addition and condensation - Mechanism of cationic, anionic and free radical addition polymerization; Metallocene-based Ziegler-Natta polymerisation of alkenes. Preparation and applications of plastics – thermosetting (Phenol-formaldehyde, Urea-formaldehyde, Polyurethane) and thermosoftening (Polythene, PVC); Fibres (acrylic, polyamide, polyester). Synthetic rubbers – SBR, Nitrile rubber and Neoprene. Introduction to conducting polymers with examples. Environmental hazards and biodegradability of polymers. Recycling of plastics.

References

1. Morrison, R.T., Boyd, R.N. & Bhattacharjee, S.K. *Organic Chemistry*, 7th ed., Dorling Kindersley (India) Pvt. Ltd (Pearson Education), 2011.
2. Graham Solomon, T.W., Fryhle, C.B. & Snyder, S.A. *Organic Chemistry*, Wiley, 2014.
3. McMurry, J. *Organic Chemistry*, 7th ed. Cengage Learning, 2013.
4. Finar, I.L. *Organic Chemistry* (Vol. 1 & 2), Dorling Kindersley (India) Pvt. Ltd (Pearson Education).
5. Jain, M.K. & Sharma, S.C. *Modern Organic Chemistry*, Vishal Publishing Co. 2010.



6. Bahl, A. & Bahl, B.S. *Advanced Organic Chemistry*, S. Chand, 2010.
7. John R. Dyer: *Applications of Absorption Spectroscopy of Organic Compounds*, Prentice Hall.
8. R.M. Silverstein, G.C. Bassler & T.C. Morrill: *Spectroscopic Identification of Organic Compounds*, Wiley.
9. Pillai, C.N. *Organic Chemistry*, Universities Press, 2008.
10. Gupta, S.S. *Organic Chemistry*, Oxford University Press, 2014.

**CH5CRT07 – PHYSICAL CHEMISTRY - I****Credits – 2 (36 Hrs)****Unit 1: Gaseous State****(12 Hrs)**

Postulates of Kinetic Theory of Gases and derivation of the kinetic gas equation. Deviation of real gases from ideal behaviour, compressibility factor, causes of deviation. van der Waals equation of state for real gases. Boyle temperature (derivation not required). Critical phenomena and Andrews isotherms of CO₂, critical constants and their calculation from van der Waals equation. Virial equation of state, van der Waals equation expressed in virial form.

Maxwell Boltzmann distribution laws of molecular velocities and molecular energies (graphical representation – derivation not required) and their importance. Temperature dependence of these distributions. Most probable, average and root mean square velocities (no derivation).

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.

Unit 2: Liquid State**(3 Hrs)**

Intermolecular forces in liquids (qualitative idea only). Surface tension and its measurement by stalagmometer method, factors affecting Surface tension, Viscosity, Poiseuille's equation, Determination of viscosity by Ostwald's viscometer..

Unit 3: Solid State**(12 Hrs)**

The nature of the solid state – anisotropy – Forms of solids. Unit cells, crystal systems, Bravais lattice types and identification of lattice planes. Laws of Crystallography – Law of constancy of interfacial angles, Law of rational indices. Miller indices. X-Ray diffraction by crystals, Bragg's law. Bragg's X-ray diffractometer method and powder pattern method. Analysis of powder diffraction patterns of NaCl and KCl, density of cubic crystals.

Structure of ionic compounds of the type AX (NaCl, CsCl, ZnS) and AX₂ (CaF₂, Na₂O) Defects in crystals – stoichiometric and non-stoichiometric defects, extrinsic and intrinsic defects. Electrical conductivity, semiconductors, n-type, p-type, Superconductivity – An introduction.

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

Unit 4: Surface Chemistry and Colloidal State**(9 Hrs)**

Adsorption – types, adsorption of gases by solids – factors influencing adsorption – Freundlich adsorption isotherm – Langmuir adsorption isotherm – 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.

References

1. R P W Atkins, "*Physical Chemistry*", Oxford University Press
2. R J Silby and R A Alberty, "*Physical Chemistry*", John Wiley & Sons
3. F Daniels and A Alberty, "*Physical Chemistry*", Wiley Eastern
4. Puri, Sharma and Pathania, "*Principles of Physical Chemistry*", Millennium Edition, Vishal Publishing Co
5. Barrow, G.M. "*Physical Chemistry*", Tata McGraw-Hill (2007).
6. Castellan, G.W. "*Physical Chemistry*", 4th Ed. Narosa (2004).
7. K. L. Kapoor, "*A Textbook of Physical chemistry*", Volume 1, Macmillan India Ltd.,
8. B. R. Puri, L. R. Sharma, M. S. Pathania, "*Elements of Physical chemistry*", Vishal Pub. Co.,
9. L V Azaroff, "*Introduction to Solids*", McGraw Hill.
10. N B Hannay, "*Solid State Chemistry*", Prentice Hall.
11. A. McQuarrie, J. D. Simon, "*Physical Chemistry – A molecular Approach*", Viva Books Pvt. Ltd.
12. Anthony R. West, "*Solid State Chemistry and its Applications*", Wiley Eastern.

**CH5CRT08 – PHYSICAL CHEMISTRY – II****Credits - 3 (36 Hrs)****Unit 1: Quantum Mechanics****(14 Hrs)**

Classical mechanics: Concepts, Radiation phenomena –Blackbody radiation, Photoelectric effect, Compton effect and Atomic spectra. Plank's quantum theory and explanation of the radiation phenomena. de Broglie hypothesis, dual nature of electrons – Davisson and Germer'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 1-D box, normalization of wave function, application to linear conjugated polyene (butadiene).

Introductory treatment of Schrödinger 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.

Molecular orbital theory: basic ideas – criteria for forming MO from AOs, construction of molecular orbital by LCAO method for H_2^+ ion (elementary idea only), physical picture of bonding and anti bonding wave functions, concept of σ , σ^* , π , π^* orbitals and their characteristics.

Unit 2: Molecular Spectroscopy-I**(12 Hrs)**

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, Rotational energy levels, Selection rules.

Vibrational spectroscopy: Introduction, Selection Rules, Classical equation of vibration, calculation of force constant, concept of anharmonicity, Morse potential, dissociation energies, fundamental frequencies, 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, Qualitative treatment of Rotational Raman effect; Vibrational Raman spectra, Stokes and anti-Stokes lines: their intensity difference, rule of mutual exclusion.

Unit 3: Molecular Spectroscopy-II**(10 Hrs)**

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.



Nuclear Magnetic Resonance (NMR) spectroscopy: Principles of NMR spectroscopy, Larmor precession, chemical shift and low resolution spectra, different scales, spin-spin coupling.

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

References

1. R.K. Prasad, *Quantum Chemistry*, New Age International, 2001
2. Mc Quarrie, J. D. Simon, *Physical Chemistry – A molecular Approach*, Viva Books.
3. I. N. Levine, *Physical Chemistry*, Tata McGraw Hill,
4. Banwell, C. N. & Mc Cash, E. M. *Fundamentals of Molecular Spectroscopy*, 4th Ed. Tata McGraw-Hill: New Delhi (2006).
5. Manas Chanda, *Atomic structure and Chemical bonding in Molecular Spectroscopy*” Tata McGraw Hill.
6. D. L. Pavia, G. M. Lampman, G. S. Kriz, *Introduction to spectroscopy*, 3rd edn, ThomsonBrooks/Cole, 2001.
7. D. N. Satyanarayana, *Electronic absorption spectroscopy and related techniques*, Universities Press.
8. D.N. Sathyanarayana, *Introduction To Magnetic Resonance Spectroscopy ESR, NMR, NQR*, IK International, 2009.
9. Lowe, J. P. & Peterson, K. *Quantum Chemistry*, Academic Press (2005).
10. GurdeepRaj, *Photochemistry*, 6thEdn, Goel Publishing House, 2014
11. Rohatgi-Mukherjee, *Fundamentals of Photochemistry*, New Age International (P) Ltd.
12. Puri, Sharma & Pathania, *Principles of Physical Chemistry*, Vishal Publishing Co.
13. N. J. Turro, *Modern Molecular Photochemistry*, 4th Edition University Science Books, Sausalito, 1991.
14. Gurdeep Raj, “*Advanced Physical Chemistry*”, Goel Publishing House



CH5OPT – OPEN COURSE

CH5OPT01 - CHEMISTRY IN EVERYDAY LIFE

(Chemical structures are non-evaluative)

Credits – 3 (72 Hrs)

Unit 1: Food Additives

(12 Hrs)

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.

Unit 2: Soaps and Detergents

(10 Hrs)

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.

Unit 3: Cosmetics

(10 Hrs)

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.

Unit 4: Plastics, Paper and Dyes

(12 Hrs)

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).

Unit 5: Drugs

(9 Hrs)

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.

**Unit 6: Chemistry and Agriculture (12 Hrs)**

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.

Unit 7: Nanomaterials (7 Hrs)

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:

1. B. Sreelakshmi, *Food Science*, New Age International, New Delhi, 2015.
2. Shashi Chowla; *Engineering Chemistry*, Danpat Rai Publication.
3. B.K. Sharma; *Industrial Chemistry*. Goel Publishing House, Meerut, 2003.
4. C.N.R. Rao; *Understanding Chemistry*, Universities Press.
5. M.K. Jain and S.C. Sharma; *Modern Organic Chemistry*, Vishal Pub. Co., Jalandhar, 2009.
6. A.K. De; *Environmental Chemistry*, New Age International Ltd., New Delhi, 2006.
7. S.S. Dara; *A Textbook of Environmental Chemistry and Pollution Control*, S. Chand & Company Ltd.
8. J.W. Hill; T.W. McCreary and D.K. Kolb; *Chemistry for Changing Times*, Prentice Hall, 12th edn., 2010.
9. V.R.Gowariker; N.V. Viswanathan and J. Sreedhar; *Polymer Science*, 2nd edn., New Age, New Delhi, 2015.
10. D. Sriram and P. Yogeeswari; *Medicinal Chemistry*, 2nd edn. Pearson, 2011.
11. S.L. Tisdale; W.L.Nelson and J.D.Beaton; *Soil Fertility and Fertilizers*, Macmillan Publishing Company, New York, 1990.
12. K.H.Buchel; *Chemistry of Pesticides*, John Wiley & Sons, New York, 1983.
13. P.C. Pall; K. Goel and R.K. Gupta; *Insecticides, Pesticides and Argobased Industries*.
14. T. Pradeep; *Nano- The Essentials*, McGraw Hill Publishing Co., New Delhi, 2007.
15. V.S.Muraleedharan, A. Subramania; *Nanoscience and Nanotechnology*, Ane Books, New Delhi, 2009.
16. K.J. Klabunde; *Nanoscale Materials in Chemistry*, Wiley.
17. Singh, K., *Chemistry in Daily Life*; Prentice Hall of India, New Delhi, 2008.



CH5OPT02 - NANOSCIENCE AND NANOTECHNOLOGY

Credits – 3 (72 Hrs)

Unit 1: History of Nanotechnology (18 Hrs)

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.

Unit 2: Nanoscience: Its Social, Economic and Ethical Perspectives (18 Hrs)

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 of nanotechnology.

Unit 3: Seeing the Nanoworld (18 Hrs)

Fundamental particles-electromagnetic 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).

Unit 4: Applications of Nanotechnology (18 Hrs)

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

1. T. Pradeep, Nano: The Essentials, Mc Graw Hill Publishing Company, New Delhi (2007).
2. V. S. Muraleedharan and A. Subramania, Nanoscience and nanotechnology, Ane Books Pvt. Ltd. New Delhi, 2009.
3. C. N. R. Rao and A. Govindraj, Nanotubes and Nanowires, Royal Society of Chemistry (2005).
4. J. M. M. Duart, R. J. M. Palma and F.A. Rueda, Nanotechnology and Microelectronics and optoelectronics, Elsevier (2002).
5. R. Booker and , E. Boysen, Nanotechnology, Wiley India Pvt Ltd, 2008.
6. K. J. Klabunde, Nanoscale materials in chemistry, John Wiley and Sons.
7. C. P. Poole Jr and F J Owens, Introduction to nanotechnology, Wiley India Pvt Ltd 2009.
8. L. E. Foster, Nanotechnology: Science, Innovation and Opportunity, Pearson Education (2008).
9. <http://www.zyvex.com/nanotech/feynman.html>



CH5OPT03 - FORENSIC SCIENCE

Credits – 3 (72 Hrs)

Unit 1: Poisons (12 Hrs)

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.

Unit 2: Crime Detection (12 Hrs)

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.

Unit 3: Forgery and Counterfeiting (12 Hrs)

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 of diamond.

Unit 4: Tracks and Traces (18 Hrs)

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 markpains – 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 race horses.

Unit 5: Medical Aspects (18 Hrs)

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:

1. T.H.James, Forensic Sciences, Stanley Thornes Ltd.
2. Richard, Criminalistics - An Introduction to Forensic Science (College Version), 8th Edition, Sofestein, Printice Hall.

**SEMESTER VI****CH6CRT09 - INORGANIC CHEMISTRY****Credits - 3 (54 Hrs)****Unit 1: Coordination Chemistry - I (7 Hrs)**

Introduction of coordination compounds, Types of ligands – Anionic, cationic and neutral – IUPAC Nomenclature, Isomerism in coordination compounds – Structural isomerism and stereo isomerism. 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.

Unit 2: Coordination Chemistry - II (14 Hrs)

Bonding theories: Valence bond theory - Geometries of coordination numbers 4 and 6 – Inner orbital and outer orbital complexes- Limitations of VBT. Crystal field 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 high spin 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).

Unit 3: Coordination Chemistry III (6 Hrs)

Spectral and magnetic properties of complexes – electronic absorption spectrum of $[\text{Ti}(\text{H}_2\text{O})_6]^{3+}$, Calculation of magnetic moments – spin only formula. Reactivity of complexes – Ligand substitution reactions- $\text{S}_{\text{N}}1$ and $\text{S}_{\text{N}}2$ substitution reactions of square planar complexes- Trans effect 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+} .

Unit 4: Organometallic Compounds (12 Hrs)

Definition – Classification based on the nature of metal-carbon bond and on the basis of hapticity. Naming of organometallic compounds. The 18- 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). Preparation and properties of mononuclear carbonyls - Structures of $\text{Mo}(\text{CO})_6$, $\text{Fe}(\text{CO})_5$ and $\text{Ni}(\text{CO})_4$. Polynuclear carbonyls, bridged carbonyls and bonding in carbonyls – $\text{Mn}_2(\text{CO})_{10}$ and $\text{Fe}_2(\text{CO})_9$. EAN of metals in metal carbonyls – indication of metal-metal bonding. - Quadruple bond – structure of $\text{Re}_2\text{Cl}_8^{2-}$.

**Unit 5: Bioinorganic Chemistry (6 Hrs)**

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. Metalloenzymes of zinc and copper, nitrogenase. Treatment of metal toxicity by chelation therapy. Anti cancer drugs – cis platin and carboplatin– Structure and significance.

Unit 6: Boron Compounds (3 Hrs)

Preparation, properties and structure of diborane, borazine, boric acid, boron nitride.

Unit 7: Inter-halogen and Noble Gas Compounds (6 Hrs)

Interhalogens - classification- general preparation- structures of AB, AB₃, AB₅ and AB₇ types. Reactivity (ClF, ICl₃, ClF₃, IF₅ and IF₇). Comparison of pseudohalogens with halogens. Electropositive character of iodine. Separation of noble gases (charcoal adsorption method). Compounds of noble gases.

References

1. F.A. Cotton and G. Wilkinson, *Advanced Inorganic Chemistry*, 6th Edition, Wiley India Pvt. Ltd., New Delhi, 2009 (Reprint).
2. J.E. Huheey, E.A. Keitler and R.L. Keitler, *Inorganic Chemistry–Principles of Structure and Reactivity*, 4th Edition, Pearson Education, New Delhi, 2013.
3. D.F. Shriver and P. Atkins, *Inorganic Chemistry*, 5th Edition, Oxford University Press, New York, 2010.
4. B.R. Puri, L.R. Sharma and K.C. Kalia, *Principles of Inorganic Chemistry*, 31st Edition, Milestone Publishers and Distributors, New Delhi, 2013.
5. P.L. Soni and Mohan Katyal, *Textbook of Inorganic Chemistry*, 20th Edition, S. Chand and Sons, New Delhi, 2013.
6. Satya Prakash, *Advanced Inorganic Chemistry, Volume 2*, S. Chand and Sons, New Delhi, 2005.
7. J.D. Lee, *Concise Inorganic Chemistry*, 5th Edition, Oxford University Press, New Delhi 2008.
8. R. Gopalan and V. Ramalingam, *Concise Coordination Chemistry*, 1st Edition, Vikas Publishing House, New Delhi, 2001.
9. Wahid U. Malik, G D. Tuli and R.D. Madan, *Selected Topics in Inorganic Chemistry*, S. Chand and Co., New Delhi, 2010 (Reprint).

**SEMESTER VI****CH6CRT10 - ORGANIC CHEMISTRY - IV**

Credits - 3 (54 Hrs)

Unit 1: Natural Products (6 Hrs)**Terpenoids**

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

Alkaloids

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

Unit 2: Lipids (6 Hrs)

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. Acid value, Saponification value, Iodine value and RM value.

Biological functions of waxes, phospholipids and glycolipids.

Soaps - Types of soaps. Cleansing action of soaps.

Synthetic detergents - Classification. Detergent additives. Comparison between soaps and detergents. Environmental aspects. ABS and LAS detergents.

Unit 3: Vitamins, Steroids and Hormones (6 Hrs)**Vitamins**

Vitamins – Classification. Structure, biological functions and deficiency diseases of vitamins A, B₁, B₂, B₃, B₅, B₆, C and D.

Steroids

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

Hormones

Hormones – Introduction. Examples and biological functions of steroid hormones, peptide hormones and amine hormones (structure not required). Artificial hormones.

Unit 4: Amino Acids, Peptides and Proteins (8 Hrs)

Classification of amino acids. Synthesis, ionic properties and reactions of α -amino acids. Zwitterion structure and Isoelectric point.

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

Classification of proteins. Overview of Primary, Secondary, Tertiary and Quaternary structure of proteins. Determination of primary structure of proteins. Determination of N-



terminal amino acid (by FDNB and Edman method) and C-terminal amino acid (by hydrazinolysis and with carboxypeptidase enzyme). Helical and sheet structures. Denaturation of proteins.

Unit 5: Nucleic Acids**(4 Hrs)**

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.

Unit 6: Enzymes**(3 Hrs)**

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 and their importance. Uses of enzymes.

Unit 7: Supramolecular Chemistry**(3 Hrs)**

Introduction. Molecular recognition. Host-guest interactions. Types of non-covalent interactions and molecular receptors. Role of molecular recognition in biopolymer (DNA and protein) structure organisation (elementary idea only).

Unit 8: Organic Photochemistry**(4 Hrs)**

Introduction. Photochemical versus Thermal reactions. Electronic excitation and fate of excited molecules. Jablonski diagram. Fluorescence and phosphorescence. Photosensitisation. Photochemical reactions: Norrish type I and II reactions of acyclic ketones, Paterno-Buchi reaction and Photo-Fries reaction (with mechanisms).

Unit 9: Organic Spectroscopy**(14 Hrs)**

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; Fingerprint 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.

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

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

References

1. Finar, I. L. *Organic Chemistry (Volume 2)*, Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
2. Morrison, R.T., Boyd, R.N. & Bhattacharjee, S.K. *Organic Chemistry*, 7th ed., Dorling Kindersley (India) Pvt. Ltd (Pearson Education), 2011.
3. Nelson, D. L. & Cox, M. M. *Lehninger's Principles of Biochemistry*, 7th ed., W. H. Freeman.
4. Berg, J.M., Tymoczko, J.L. & Stryer, L. *Biochemistry*, W.H. Freeman, 2002.
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9. Billmeyer, F.W. *Textbook of Polymer Science*, Wiley.
10. Gowariker, V.R., Viswanathan, N.V. & Sreedhar J. *Polymer Science*, 2nd ed., New Age, 2015
11. Steed, J. W. & Atwood, J.L. *Supramolecular Chemistry*, 2nd ed., Wiley, 2009.
12. Dodziuk, H. *Introduction to Supramolecular Chemistry*, Springer, 2002.

**CH6CRT11 – PHYSICAL CHEMISTRY – III****Credits – 3 (54 Hrs)****Unit 1: Thermodynamics-I (15 Hrs)**

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. Definition of internal energy and enthalpy. Heat capacities at constant volume (C_v) and at constant pressure (C_p), relationship between C_p and C_v .

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.

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

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

Unit 2: Thermodynamics-II (12 Hrs)

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.

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. Third law of thermodynamics-statement and determination of absolute entropies of substances.

Unit 3: Chemical Equilibria (3 Hrs)

Law of mass action-equilibrium constant – Relation between K_p , K_c and K_x – 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 K_p .

Unit 4: Ionic Equilibria (8 Hrs)

Introduction – Concepts of acids and bases, relative strength of 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..

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.

**Unit 5: Phase equilibria****(6 Hrs)**

The phase rule-derivation, equilibrium between phases – conditions. 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.

Unit 6: Chemical Kinetics**(10 Hrs)**

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 order reactions, half life.

Theories of chemical kinetics: Effect of temperature on the rate of reaction: 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

1. R. P. Rastogi, R. R. Misra, *An Introduction to Chemical Thermodynamics*, 6th edn., Vikas Pub. Pvt. Ltd. (2003).
2. P. Atkins and J Paula, *The elements of Physical chemistry*, 7th edn., Oxford University Press.
3. K.K. Sharma, L.K. Sharma, *A Textbook of Physical Chemistry*, 4th edn, Vikas publishing House.
4. B. R. Puri, L. R. Sharma, M. S. Pathania, *Elements of Physical chemistry*, Vishal Pub. Co. Jalandhar
5. J. Rajaram and J. C. Kuriakose, *Thermodynamics*, Shoban Lal Nagin Chand & Co (1986).
6. D. A. McQuarrie, J. D. Simon, *Physical Chemistry – A molecular Approach*, Viva Books Pvt. Ltd.
7. F. A. Alberty and R. J. Silby, *Physical Chemistry*, John Wiley.
8. F Daniels and R A Alberty, *Physical Chemistry*, Wiley Eastern.
9. Gurdeep Raj, *Advanced Physical Chemistry*, Goel Publishing House.
10. S. Glasstone, *Thermodynamics for Chemists*, Affiliated East West Publishers.
11. G.S. Rush Brooke, *Statistical Mechanics*, Oxford University Press.
12. K. L. Kapoor, *A Textbook of Physical chemistry, Volumes 3*, Macmillan India Ltd.
13. Gurdeep Raj, *Chemical Kinetics*, Krishna's Educational Publishers (2014).
14. K. J. Laidler, *Chemical kinetics*, 3rd edn, Pearson education, 2004.

**CH6CRT12– PHYSICAL CHEMISTRY – IV****Credits – 3 (54 Hrs)****Unit 1: Solutions****(12 Hrs)**

Introduction – Binary liquid solutions – Raoult's law- ideal and non-ideal solutions– ΔG_{mix} , ΔV_{mix} , and ΔS_{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 immiscible 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 (thermodynamic derivation). Molar mass determination-related problems – Osmotic pressure – laws of osmotic pressure – Reverse osmosis – purification of sea water. Abnormal molecular masses – van't Hoff factor – Degree of association and Degree of dissociation.

Unit 2: Electrical Conductance**(12 Hrs)**

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

Ionic mobility – relation with ion conductivity, influence of temperature on ion conductivity, ion conductivity and viscosity – Walden's rule. Abnormal ion 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.

Unit 3: Electromotive Force**(15 Hrs)**

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 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.

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, determination of pH using hydrogen electrode, quinhydrone electrode and glass electrode.

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

Corrosion of metals – forms of corrosion, corrosion monitoring and prevention methods.

Unit 4: Photochemistry

(6 Hrs)

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.

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

Unit 5: Group Theory

(9 Hrs)

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

References

1. B. R. Puri, L. R. Sharma, M. S. Pathania, *Elements of Physical chemistry*, VishalPub. Co. Jalandhar.
2. K. L. Kapoor, *A Textbook of Physical chemistry, Volume 4*, Macmillan India Ltd.
3. Barrow, G.M. *Physical Chemistry*, Tata McGraw-Hill (2007).
4. Castellan, G.W. *Physical Chemistry*, 4th Ed. Narosa (2004).
5. Kotz, J.C., Treichel, P.M. & Townsend, J.R., *General Chemistry*, Cengage Learning India Pvt. Ltd. New Delhi (2009).
6. Mahan, B.H. *University Chemistry*, 3rd Ed. Narosa (1998).
7. K. L. Kapoor, *A Textbook of Physical chemistry, Volumes 1*, Macmillan India Ltd,
8. Glasstone S, *An Introduction to Electrochemistry*, East-West Press (Pvt.) Ltd. (2006).
9. Gurdeep Raj, *Advanced Physical Chemistry*, Goel publishing house.
10. Glasstone and Lewis, *Elements of Physical Chemistry*, Macmillan



11. K. L. Kapoor, *A Textbook of Physical chemistry, Volumes 3*, Macmillan IndiaLtd.
12. I.N. Levine, *Physical Chemistry*, Tata McGraw Hill
13. F A Alberty and R J Silby, *Physical Chemistry*, John Wiley.
14. P. W. Atkins, *The elements of Physical chemistry*, 8thedn, Oxford University Press.
15. D. A. McQuarrie, J. D. Simon, *Physical Chemistry – A molecular Approach*, Viva Books Pvt.Ltd.
16. S. H. Marron and J. B. Lando, *Fundamentals of Physical Chemistry*, MacmillanLtd.
17. G. K. Vemulapalli, *Physical Chemistry*, Prentice-Hall of India Pvt. Ltd. (1997) V Ramakrishnan and M S Gopinathan, “*Group Theory in Chemistry*”, Vishal Publishing.



PRACTICALS SEMESTER V & VI

CH6CRP03 - QUALITATIVE INORGANIC ANALYSIS

Credit – 3 (108 Hrs)

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^- , $\text{C}_2\text{O}_4^{2-}$, $\text{C}_4\text{H}_4\text{O}_6^{2-}$, 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 by Semi-micro method only. (Minimum of 10 mixtures to be analysed)

References

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

CH6CRP04 - ORGANIC PREPARATIONS AND LABORATORY TECHNIQUES

Credits-2 (72 Hrs)

A. Basic Laboratory Techniques

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

B. Organic Preparations

Organic preparations involving:

1. Oxidation (benzaldehyde to benzoic acid).
2. Hydrolysis (methyl salicylate or ethyl benzoate to the acid).
3. Nitration (*m*-dinitrobenzene and picric acid).



4. Halogenation (*p*-bromoacetanilide from acetanilide).
5. Acylation (Benzoylation of aniline, phenol, β -naphthol).
6. Esterification (benzoic acid ester).
7. Iodoform from acetone or ethyl methyl ketone.
8. Side chain oxidation (benzyl chloride to benzoic acid).
9. Claisen – Schmidt reaction: Dibenzal acetone from benzaldehyde.

C. Chromatography

1. TLC - Separation and identification- Determination of R_f value of *o*- and *p*-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

1. 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.
2. Mann, F.G.; Saunders, B.C. *Practical Organic Chemistry*, 4th ed., Pearson Education, 2009.
3. Ahluwalia, V.K.; Aggarwal, R. *Comprehensive Practical Organic Chemistry – Preparation and Quantitative Analysis*, Universities Press, 2000.
4. Vishnoi, N.K. *Advanced Practical Organic Chemistry*, 3rd ed., Vikas Publishing House, New Delhi, 2010.

CH6CRP05 - PHYSICAL CHEMISTRY PRACTICALS

Credits 3 (108 hrs)

1. Viscosity – percentage composition of a mixture.
2. Heat of solution – KNO₃, NH₄Cl
3. Heat of neutralization
4. Determination of equivalent conductance of an electrolyte
5. Conductometric titration – strong acid vs. strong base, weak acid-strong base
6. Transition temperature of salt hydrates. (Sodium thiosulphate, sodium acetate)
7. Determination of the surface tension of a liquid (Drop number method or Drop weight method)
8. Critical solution temperature of phenol-water system.
9. Effect of electrolytes on the CST of phenol-water system.
10. Molecular weight determination by Rast's method. (using naphthalene, camphor or biphenyl as solvent and acetanilide, *p*-dichlorobenzene etc. absolute.)
11. Kinetics of simple reactions eg. Acid hydrolysis of methyl acetate.
12. Potentiometric titration – Fe²⁺ vs. Cr₂O₇²⁻, I vs. MnO₄⁻
13. Data analysis of kinetic experiments using spreadsheet program (determination of rate constant)



14. Determination of equivalence point of potentiometric and conductometric titrations using spreadsheet program.

References

1. W. G. Palmer: 'Experimental physical chemistry', Cambridge University Press.
2. J.B. Yadav: Advanced Practical Physical Chemistry Goel Publishing House.
3. R.C. Das and B. Behra; 'Experiments in Physical Chemistry' , Tata McGraw hill.
4. K.K. Sharma : 'An Introduction of Practical Chemistry': Vikas Publishing House, New Delhi
5. Khosla, B. D.; Garg, V. C. & Gulati, A. *Senior Practical Physical Chemistry*, R. Chand & Co.: New Delhi (2011).

CH6CRP06 GRAVIMETRIC ANALYSIS

2 Credits (36 Hrs) – Semester VI only

1. Estimation of Barium as barium sulphate
2. Estimation of iron as Fe_2O_3
3. Estimation of sulphate as barium sulphate
4. Estimation of copper as cuprous thiocyanate
5. Estimation of nickel as nickel dimethyl glyoxime.

References

1. J. Mendham. R.C. Denney, J.D. Barnes and M. Thomas, *Vogel's Textbook of Quantitative Chemical Analysis*, 6th Edition, Pearson Education, Noida, 2013.
2. 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.
3. G. D. Christian, *Analytical Chemistry*, John Wiley and Sons.
4. R. D. Day, A. L. Underwood, *Quantitative analysis*,



Semester VI
CHOICE BASED COURSES
CH6CBT01 - POLYMER CHEMISTRY
Credits – 3 (54 Hrs)

Unit 1: Introduction and History of Polymeric Materials (4 Hrs)
 History of Polymers. Terminology. Different schemes of classification of polymers. Polymer nomenclature.

Unit 2: Mechanisms of Polymerization (6 Hrs)
 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 transfer polymerisations.

Unit 3: Polymerisation Techniques (4 Hrs)
 Polymerisation techniques: Bulk, solution, suspension and emulsion polymerisations. Melt, solution and interfacial polycondensation techniques.

Unit 4: Physical Properties of Polymers (14 Hrs)
 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 .

Unit 5: Reactions of Polymers (4 Hrs)
 Hydrolysis, hydrogenation, addition, substitution, crosslinking, vulcanisation and cyclisation reactions.

Unit 6: Polymer Degradation (4 Hrs)
 Types of degradation. Thermal, mechanical, photo and oxidative degradations of polymers.

Unit 7: Polymer Processing (4 Hrs)
 Polymer processing techniques: Compression moulding, Injection moulding, Blow moulding, Extrusion moulding, Thermoforming, Die casting, Film casting, Rotational casting, Calendering and Spinning.

**Unit 8: Chemistry of Commercial Polymers****(8 Hrs)**

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, epoxy resins.

Unit 9: Specialty Polymers**(6 Hrs)**

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

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



CH6CBT02 - NANOCHEMISTRY AND NANOTECHNOLOGY

Credits - 3 (54 hours)

Unit 1: Introduction to Nanomaterials (15 Hrs)

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 metal nanoparticles.

Unit 2: Characterization of Nanomaterials (15 Hrs)

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).

Unit 3: Electrical and Optical Properties of Nanomaterials (12 Hrs)

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

Unit 4: Applications of Nanomaterials (12 Hrs)

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

References

1. T. Pradeep, Nano: The Essentials, Mc Graw Hill Publishing Company, New Delhi (2007).
2. V. S. Muraleedharan and A. Subramania, Nanoscience and nanotechnology, Ane Books Pvt. Ltd. New Delhi, 2009.
3. C. N. R. Rao and A. Govindraj, Nanotubes and Nanowires, Royal Society of Chemistry (2005).
4. J. M. M. Duart, R. J. M. Palma and F.A. Rueda, Nanotechnology and microelectronics and optoelectronics, Elsevier (2002).
5. R. Booker and , E. Boysen, Nanotechnology, Wiley India Pvt Ltd, 2008.
6. K. J. Klabunde, Nanoscale materials in chemistry, John Wiley and Sons.
7. C. P. Poole Jr and F J Owens, Introduction to nanotechnology, Wiley India Pvt Ltd 2009.
8. <http://www.zyvex.com/nanotech/feynman.html>.
9. G.L Hornyak, J.Dutta, H.F Tibbals, A.K Rao, Introduction to Nanoscience, CRC Press



CH6CBT03 - SOIL AND AGRICULTURAL CHEMISTRY

Credits - 3 (54 hours)

Unit 1: Origin of Soil

(9 Hrs)

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.

Unit 2: Physical Properties of Soil

(9 Hrs)

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.

Unit 3: Chemistry Aspects of Soil

(9 Hrs)

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.

Unit 4: Plant Nutrients

(18 Hrs)

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.



Unit 5: Pesticides, Fungicides and Herbicides

(9 Hrs)

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

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



SYLLABUS FOR B.SC. CHEMISTRY (COMPLEMENTARY)

SEMESTER I

CH1CMT01 - BASIC THEORETICAL AND ANALYTICAL CHEMISTRY

(Common for students who have opted Life Sciences, Family & Community Science,
Physical Sciences and Geology as core)

Credits - 2 (36 Hrs)

Unit 1: Atomic Structure and Chemical Bonding (9 Hrs)

Atomic Structure: Bohr atom model and its limitations, Dual nature of matter and radiation. Photoelectric effect, de Broglie equation, Heisenberg's uncertainty principle, Concept of orbital, Quantum numbers, shapes of orbitals (*s*, *p*, *d*), Electronic configuration of atoms - Aufbau principle, Hund's rule of maximum multiplicity, Pauli's exclusion principle.

Chemical Bonding: Introduction – Type of bonds. Ionic bond: Factors favouring the formation of ionic bonds - Lattice energy of ionic compounds and its applications. Covalent bond: Lewis theory - Valence bond theory – Coordinate bond. VSEPR theory and examples. Hybridisation: - sp^3 , sp^2 and sp (ethane, ethene, ethyne). Intermolecular forces - Hydrogen bonding in H_2O - Dipole-dipole interactions.

Unit 2: Fundamental Concepts in Chemistry (9 hrs)

Periodic Properties: Modern periodic law – Long form of periodic table. Periodicity in properties: Atomic radii, ionic radii, ionization enthalpy, electron affinity (electron gain enthalpy) and electronegativity (Pauling scale). Atomic mass - Molecular mass - Mole concept – Molar volume - Oxidation and reduction – Oxidation number and valency - Equivalent mass. Methods of expressing concentration: Weight percentage, molality, molarity, normality, mole fraction, ppm and millimoles.

Concept of Equilibrium: Acids and Bases - Arrhenius, Lowry-Bronsted and Lewis theories. Ionic product of water - pH and pOH, Strengths of acids and bases - K_a and K_b , pK_a and pK_b . Buffer solution. Preparation of buffer solution having a known pH. Solvation, solubility, solubility product, common ion effect and their applications.

Unit 3: Basic Principles of Analytical Chemistry (9 Hrs)

Laboratory Operations (Non-evaluative): Laboratory safety and first aid. Use of different glassware like pipette, burette, standard measuring flask, distillation apparatus; heating methods, filtration techniques, weighing principle in chemical balance, weighing in electronic balance.

Methods of Analysis: Volumetric method of analysis - General principles. Primary and secondary standards, criteria for primary standards, preparation of standard solutions, standardization of solutions, end point. Acid base, redox and complexometric titrations and corresponding indicators. Double burette method of titration: Principle and advantages. Microanalysis and its advantages. Gravimetric method of analysis: General principles.

Reporting of Analytical Data: Units, significant digits, rounding, scientific and prefix notation, graphing of data - Precision and accuracy – Types of errors – Ways of expressing precision – Methods to reduce systematic errors.



Separation and Purification Techniques: Recrystallisation, use of drying agents, sublimation. General principles of distillation, fractional distillation, distillation under reduced pressure. Solvent extraction.

Unit 4: Chromatographic Techniques

(9 Hrs)

Chromatography - Principle of differential migration. Classification of chromatographic methods. Basic principle and uses of Thin layer chromatography (TLC), Paper chromatography (PC), R_f value, Column chromatography, Gas chromatography(GC), High performance Liquid chromatography (HPLC), Ion Exchange chromatography (IEC).

References

1. B. R. Puri, L. R. Sharma, M.S. Pathania, *Elements of Physical Chemistry*, 3rd edn. Vishal Pub. Co., 2008.
2. C. N. R. Rao, *University General Chemistry*, Macmillan, 2009.
3. Manas Chanda, *Atomic Structure and Molecular Spectroscopy*.
4. P. L. Soni, *Inorganic Chemistry* .
5. R. A. Day Junior, A.L. Underwood, *Quantitative Analysis*, 5th edn. Prentice Hall of India Pvt. Ltd. New Delhi, 1988.
6. J. Mendham, R. C. Denney, J.D. Barnes, M. Thomas, *Vogel's Text Book of Quantitative Chemical Analysis*, 6th edn. Pearson Education (2003).
7. R. Gopalan, *Analytical Chemistry*, S. Chand and Co., New Delhi.



SEMESTER II

CH2CMT02 - BASIC ORGANIC CHEMISTRY

(Common for students who have opted Life Sciences, Family & Community Science, Physical Sciences and Geology as core)

Credits – 2 (36 Hrs)

Unit 1: Fundamental Concepts of Organic Chemistry (9 Hrs)

Introduction: Origin of organic chemistry – Uniqueness of carbon – Homologous series. IUPAC nomenclature of alkyl halides, alcohols, aldehydes, ketones, carboxylic acids and amines. Structural isomerism: Chain isomerism, position isomerism, functional isomerism, metamerism and tautomerism. Arrow formalism in organic chemistry. Bond fission - homolytic and heterolytic fission. Types of reagents - Electrophiles and nucleophiles. Polarity of bonds. Reaction Intermediates: Carbocations, carbanions and free radicals (preparation, structure, hybridization and stability). Types of organic reactions: Addition, Elimination, Substitution, Rearrangement and Redox reactions (definition and one example each).

Unit 2: Mechanisms of Organic Reactions (9 Hrs)

Meaning of reaction mechanism. Polarity of bonds. Electron Displacement Effects: Inductive effect - Definition - Characteristics - +I and -I groups. Applications: Explanation of substituent effect on the acidity of aliphatic carboxylic acids. Mesomeric effect: Definition – Characteristics - +M and -M groups. Applications: Comparison of electron density in benzene, nitrobenzene and phenol. Hyperconjugation: Definition – Characteristics. Applications: Baker-Nathan effect, Comparison of stability of 2-methyl-1-butene & 2-methyl-2-butene. Steric effect (causes and simple examples). *Substitution reactions*: nucleophilic substitution of alkyl halides- S_N1 and S_N2 mechanisms. Electrophilic substitutions in benzene - reaction mechanism. Addition reactions: electrophilic addition to alkene and alkynes - Markwonikoff's rule, Peroxide effect. Elimination reactions: E1 and E2 mechanisms.

Unit 3: Stereochemistry of Organic Compounds (9 Hrs)

Stereoisomerism – definition, classification.

Geometrical Isomerism: Definition – Condition – Geometrical isomerism in but-2-ene and but-2-ene-1,4-dioic acid. cis and trans, *E* and *Z* configurations. Methods of distinguishing and interconversion of geometrical isomers.

Optical Isomerism: Optical activity – Chirality – Enantiomers - Meso compounds - Diastereoisomers – Optical isomerism in lactic acid and tartaric acid - Racemisation and resolution (elementary idea only).

Conformations: Newman projection, Saw-horse projection. Conformations of ethane, n-butane, and cyclohexane - Relative stability and energy diagrams. Conformation of methyl cyclohexane.

Unit 4: Natural and Synthetic Polymers (9 Hrs)

Introduction. Classification of polymers: Natural, synthetic; linear, cross-linked and network; plastics, elastomers, fibres; homopolymers and copolymers. Polymerization reactions. Typical examples: Polyethylene, polypropylene, PVC, phenol-formaldehyde and melamine-formaldehyde resins, polyamides (nylons) and polyesters. Natural rubber: structure, latex processing methods, vulcanization and uses. Synthetic rubbers: SBR, nitrile rubber and neoprene. Biodegradability of polymers, environmental hazards. Recycling of plastics.



References

1. I. L. Finar, *Organic Chemistry Vol. I*, 6th edn. Pearson.
2. M.K. Jain, S.C. Sharma, *Modern Organic Chemistry*, Vishal Publishing Co. 2010.
3. S. M. Mukherji, S. P Singh, R. P Kapoor, *Organic Chemistry Vol.1*, New Age International Pvt. Ltd, 2006.
4. S. Sengupta, *Basic Stereochemistry of Organic Molecules*, 2014.
5. E. L. Eliel, S.H. Wilen, *Stereochemistry of Organic Compounds*, Wiley, 1994.
6. Peter Sykes, *A Guide Book to Mechanism in Organic Chemistry*, 6th edn. Orient Longman, 1988.
7. S. M. Mukherji, S.P Singh, *Reaction Mechanism in Organic Chemistry*, Macmillan, 3rd edn., 2003.
8. V.R. Gowarikar, N.V. Viswanathan, J. Sreedhar, *Polymer Science*, 2nd edn., New Age International Pvt. Ltd., 2015.



SEMESTER-III

CH3CMT03 - PHYSICAL CHEMISTRY – I

(For students who have opted Physical Sciences and Geology as Main)

Credits-3 (54 Hrs)

Unit 1: Solids and Crystalline State

(18 Hrs)

Classification of solids: amorphous, crystalline – differences. Lattice, lattice energy (general idea), unit cell, examples of simple cubic, bcc and fcc lattices, calculation of number of atoms in a unit cell, calculation of lattice parameters of cubic unit cell. Theories of Solid: band theory, conductors, semiconductors and insulators, mention of super conductors. Magnetic Properties: classification - diamagnetic, paramagnetic, antiferromagnetic, ferro and ferrimagnetic, permanent and temporary magnets.

Symmetry of molecules-symmetry elements and symmetry operations – centre of symmetry, plane of symmetry, proper and improper axes of symmetry, crystallographic point groups, Schoenflies symbol. Symmetry elements in crystals - The seven crystal systems – Weiss and Miller indices - Bravais lattices – Bragg's equation (derivation required) and its applications (mention only), structure determination of NaCl by X-ray diffraction.

Unit 2: Liquid State and Solutions

(12 Hrs)

Liquids: Intermolecular forces, liquids compared with gases and solids (qualitative idea only), viscosity, surface tension (method of determination not expected), structure of liquids (a qualitative description). Liquid crystals – the intermediate phase between solid and normal liquid phases, thermographic behaviour, classification, structure of nematic and cholesteric phases.

Solutions: Kinds of solutions - Solubility of gases in liquids – Henry's law and its applications - Colligative properties - Osmotic pressure - Reverse osmosis and its applications - Determination of molecular mass using colligative properties.

Unit 3: Gaseous State

(9hrs)

Gaseous State: Introduction - Kinetic molecular model of gases – Maxwell distribution of velocities and its use in calculating molecular velocities – Average velocity, RMS velocity and most probable velocity (derivations not required) – Boyle's law – Charles's law – Ideal gas equation – Behaviour of real gases – Deviation from ideal behaviour - Van der Waals equation (derivation not required).

Unit 4: Surface Chemistry and Colloids

(9 Hrs)

Adsorption – types of adsorption of gases by solids, factors influencing adsorption, Freundlich adsorption isotherm – Langmuir adsorption isotherm (derivation not required).

True solution, colloidal solution and suspension. Classification of colloids: Lyophilic, lyophobic, macromolecular, multimolecular and associated colloids with examples. Purification of colloids by electrodialysis and ultrafiltration. Properties of colloids: Brownian movement – Tyndall effect – Electrophoresis. Origin of charge and stability of colloids – Zeta potential – Coagulation - Hardy Schulze rule – Protective colloids - Gold number. Emulsions. Applications of colloids: Delta formation, medicines, emulsification, cleaning action of detergents and soaps.



Unit 5: Phase Equilibrium

(6Hrs)

The phase rule, definition, equilibrium between phases, one component system – water system, two component systems: solid- liquid equilibrium – simple eutectic, lead-silver system, solid solution. Distribution law, partition coefficient, applications.

References

1. B.R. Puri, L.R. Sharma, M.S. Pathania, *Elements of Physical Chemistry*, 40th edn. Vishal Pub. Co. Jalandhar (2013)
2. B. R. Puri, L.R. Sharma and K.C. kalia, *Principles of Inorganic Chemistry*, Milestone Publishers New Delhi. 2013.
3. J.A. K. Tareen and T.R. N. Kutty, *A basic course in Crystallography*, University Press, 2000.
4. Anthony R West, *Solid State Chemistry and its Applications*”, Wiley Eastern
5. V.Ramakrishnan and M.S.Gopinathan, “Group Theory in Chemistry”, Vishal Publishing Co.
6. Gurdeep Raj, “Advanced Physical Chemistry”, Goel Publishing House.
7. Walter J. Moore, *Physical Chemistry*, 4thEdn. Longmans Green and Co. Ltd.
8. P. W Atkins, “Physical Chemistry”, Oxford University Press.
9. R. J Silby and R.A Alberty, “Physical Chemistry”, John Wiley & Sons.



SEMESTER III

CH3CMT04: INORGANIC AND ORGANIC CHEMISTRY (For students who have opted Life Sciences and Family & Community Science as core)

Credits - 3 (54 Hrs)

Unit 1: Nuclear Chemistry (12 Hrs)

Nuclear Stability - Mass defect, Binding energy, Nuclear forces, Magic number, Packing fraction, n/p ratio. Natural and induced radioactivity, radioactivity – detection, Units of radioactivity. Modes of decay – Group displacement law. Isotopes, isobars and isotones with examples. Nuclear fission - Atom bomb – Nuclear fusion – Hydrogen bomb - Nuclear reactors - Nuclear reactors in India. Application of radioactive isotopes – ^{14}C dating – Rock dating – Isotopes as tracers – Radio diagnosis and radiotherapy.

Unit 2: Bioinorganic Chemistry (6 Hrs)

Thermodynamics of Living cell- Exergonic and endergonic reactions, coupled reactions. Metal ions in biological systems - Biochemistry of iron – Metalloporphyrins - Haemoglobin and myoglobin, pH of blood, cytochromes, Ferredoxine - Mechanism of O_2 and CO_2 transportation - Chlorophyll and photosynthesis (mechanism not expected) elementary idea of photophosphorylation. Photosynthesis and respiration – comparison. – Elementary idea of structure and mechanism of action of sodium potassium pump. Biochemistry of zinc and cobalt.

Unit 3: Chemistry and Agriculture (12 Hrs)

Fertilizers: NPK, superphosphates, triple super phosphate, uses of mixed fertilizers, micronutrients and their role, bio-fertilizers, plant growth hormones.

Pesticides: Classifications with simple examples, Biopesticides. Insecticides – stomach poisons, contact insecticides, fumigants. Method of preparation and use of DDT, BHC, pyrethrin. Herbicides - structure and function of 2, 4,-D and 2,4,5 -T, Fungicides- inorganic and organic- Bordeaux mixture. Excessive use of pesticides – environmental hazards.

Unit 4: Heterocyclic Compounds (12 Hrs)

Aromaticity – Huckel's rule, preparation (any one method), properties, structure and aromaticity of furan, pyrrole, pyridine and indole. Pyrimidines & purines - adenine, guanine, thymine, cytosine and uracil.

Unit 5: Drugs (6 Hrs)

Classification of drugs. Structure, therapeutic uses and mode of action (synthesis not required) of Antibiotics: Ampicillin, Sulpha drugs: Sulphanilamide, Antipyretics: Paracetamol, Analgesics: Aspirin, Antacids: Ranitidine, Antimalarials: Chloroquine and Anti-cancer drugs: Chlorambucil. Psychotropic drugs: Tranquilizers, antidepressants and stimulants with examples. Drug addiction and abuse. Prevention and treatment.



Unit 6: Food Additives and Cosmetics

(6 Hrs)

Food Additives: Food preservatives, artificial sweeteners, flavours, emulsifying agents, antioxidants, leavening agents and flavour enhancers (definition and examples, structures not required) – Structure of BHT, BHA and MSG - Commonly used permitted and non-permitted food colours (structures not required) - Fast foods and junk foods & their health effects – Soft drinks and their health effects.

Cosmetics: Introduction, classification. Dental cosmetics, Shampoos, Hair dyes, Skin products, Shaving cream, Talcum powder, Perfumes and Deodorants (composition and health effects).

References

1. H.J. Arnikaar, *Essentials of Nuclear Chemistry* (Revised IV edn.), New Age, 1995.
2. B. R. Puri, L. R. Sharma, M.S. Pathania, *Elements of Physical Chemistry*, 3rd edn. Vishal Pub Co., 2008.
3. I. L. Finar, *Organic Chemistry* Vol. 1 & 2, 6th edn., Pearson, 2002.
4. C.N. R. Rao, *University General Chemistry*, Macmillan 2009.
5. B. R. Puri, L.R. Sharma and K.C. Kalia, *Principles of Inorganic Chemistry*, Milestone Publishers New Delhi. 2013.
6. G. R. Chatwal, *Synthetic Drugs*, Himalaya Publishing House, Bombay, 1995.
7. J.Ghosh, *A Textbook of Pharmaceutical Chemistry*, S. Chand & Co Ltd., 1997
8. B. Sreelakshmi, *Food Science*, New Age International Pvt. Ltd, New Delhi, 2015.
9. J.W. Hill, T.W. McCreary, D.K. Kolb, *Chemistry for Changing Times*, Prentice Hall, 12th edn., 2010.



SEMESTER-IV

CH4CMT05 - PHYSICAL CHEMISTRY – II

(For students who have opted Physical Sciences and Geology as Main)

Credits-3 (54 Hrs)

Unit 1: Introduction to Spectroscopy

(9 Hrs)

Interaction of electromagnetic radiation with matter, electromagnetic spectrum, quantization of energy, electronic, vibrational and rotational energy levels, Boltzmann distribution of energy (formula only), population of levels.

UV- Visible Spectroscopy: Beer Lambert's law, molar extinction coefficient and its importance, UV spectrum, max, chromophore, auxochrome, red shift, blue shift, types of transition.

Infra-red spectroscopy: vibrational degrees of freedom, types of vibrations – symmetric and asymmetric stretching and bending, calculation of force constant, concept of group frequencies-frequencies of common functional groups in organic compounds, Fingerprint region in IR spectra.

Rotational Spectroscopy: diatomic molecules, determination of bond length.

Unit 2: Nano Chemistry

(9 Hrs)

Terminology- scales of nanosystems- nanoparticles. Nanomaterials – synthesis – chemical precipitation, mechano-chemical method, micro emulsion method, reduction technique, chemical vapour deposition and sol-gel method (brief study). Properties and applications of fullerenes and carbon nanotubes. Nanochemical devices- optoelectronic devices- photodetectors- LEDs and lasers.

Unit 3: Kinetics, Catalysis & Photochemistry

(18 Hrs)

Kinetics: Rates of reactions - Factors influencing rate of reactions - Order and molecularity - Zero, first, second and third order reactions - Derivation of integrated rate equations for first order and second order reactions (single reactant only) - Half-life period for first order reaction - Units of rate constants - Influence of temperature on reaction rates - Arrhenius equation - Calculation of Arrhenius parameters - Collision theory of reaction rate, Activated complex theory-basic concepts-no derivation required.

Catalysis: Types of catalysis – Homogeneous and heterogeneous catalysis. Theories of catalysis: Outline of intermediate compound formation theory and adsorption theory.

Laws of photochemistry, Grothus Draper law, Stark-Einsten's Law, Beer Lambert's Law. Photochemical equivalence and quantum explanation for low and high quantum yields. Photosensitization, Jablonski diagram- Fluorescence and phosphorescence, flash photolysis and chemiluminescence.

Unit 4: Electrochemistry

(18 Hrs)

Introduction- Faraday's laws of electrolysis, electrochemical equivalent and chemical equivalent, Specific conductance, equivalent conductance and molar conductance – Variation of conductance with dilution - Kohlrausch's law - Degree of ionization of weak electrolytes - Application of conductance measurements –Determination of degree of dissociation of weak electrolytes, conductometric titrations involving strong acid- strong base, strong acid-weak base, weak acid- strong base, and precipitation titration.



Galvanic cells - Cell and electrode potentials - IUPAC sign convention, Types of electrodes: Reference electrodes – Standard hydrogen electrode and calomel electrode, Indicator electrodes-metal-metal ion electrodes, Quinhydrone electrode and Redox electrodes. Standard electrode potential - Nernst equation, electro chemical series. Gibb's Helmholtz equation and EMF of a cell.

Fuel cells- H₂-O₂ fuel cell. Potentiometric titrations of acid-base and redox reactions-precipitation reactions.

References

1. Banwell, C. N. & Mc Cash, E. M. *Fundamentals of Molecular Spectroscopy* 4th Ed. Tata McGraw-Hill: New Delhi (2006).
2. D. L. Pavia, G. M. Lampman, G. S. Kriz, *Introduction to spectroscopy* 3rd edn, Thomson Brooks/Cole, 2001.
3. V. S. Muraleedharan and A. Subramania, *Nanoscience and nanotechnology*, Ane Books Pvt. Ltd. New Delhi, 2009
4. T. Pradeep, *Nano: The Essentials*, McGraw-Hill education, New Delhi, 2006.
5. K.K. Sharma and L.K. Sharma, *A Textbook of Physical Chemistry*, 5th Edition, Vikas Publishing House, New Delhi, 2012.
6. B. R. Puri, L.R. Sharma, M. S. Pathania, *Elements of Physical Chemistry*, 40th edn. Vishal Pub. Co. Jalandhar (2003).
7. G. M. Barrow, *Physical Chemistry*, 5th Edition, Tata McGraw Hill Education, New Delhi, 2006.
8. G. K. Vemulapalli, *Physical Chemistry*, Prentice-Hall of India Pvt. Ltd. (1997)
9. Gurdeep Raj, *Photochemistry*, 6th Edn, Goel Publishing House, 2014.



SEMESTER IV

CH4CMT06 ADVANCED BIO-ORGANIC CHEMISTRY

(For students who have opted Life Sciences and Family & Community Science as core)

Credits - 3 (54 Hrs)

Unit 1: Natural Products (6 Hrs)

Terpenoids: Classification with examples – Isoprene rule – Isolation of essential oils by steam distillation – Uses of lemongrass oil, eucalyptus oil and sandalwood oil - Source, structure and uses of citral and geraniol.

Alkaloids: Classification – Isolation, general properties. Source, structure and physiological activity of nicotine, coniine and piperine.

Unit 2: Lipids (6 Hrs)

Lipids: Classification – Oils, fats and waxes (definition, structure, biological functions and examples). Hydrogenation and Rancidity - Acid value, Saponification value and Iodine value –. Biological functions of phospholipids and glycolipids

Soaps and Detergents: Soaps – Types of soaps. Cleansing action of soaps. Synthetic detergents - Classification. Comparison between soaps and detergents. Environmental aspects.

Unit 3: Amino Acids and Proteins (12 Hrs)

Amino acids: Classification – Zwitter ion formation and isoelectric point- Synthesis of glycine, alanine, and phenyl alanine (any one method). Peptides: Peptide bond. Synthesis of peptides (upto dipeptides). Proteins: Classification of proteins – Primary, secondary and tertiary structure of proteins – Denaturation of proteins – Tests for proteins.

Unit 4: Enzymes and Nucleic Acids (9 Hrs)

Enzymes: Nomenclature, classification and characteristics. Mechanism of enzyme action. Theory of enzyme catalysis – Michaelis-Menten theory. Cofactors and coenzymes. Enzyme inhibitors. Uses of enzymes.

Nucleic acids: Structure of pentose sugar, nitrogenous base, nucleoside and nucleotide – Double-helical structure of DNA – Differences between DNA and RNA. Biological Functions – Replication and protein biosynthesis. Transcription and Translation. Genetic code.

Energy rich molecules: Elementary structure of ATP, ADP and AMP.

Unit 5: Carbohydrates (12 Hrs)

Carbohydrates: Classification with examples. Preparation and properties of glucose, fructose and sucrose. Cyclic structures and Haworth projections of glucose, fructose, maltose and sucrose (ring size determination not expected). – Mutarotation. Conversion of glucose to fructose and vice versa. – Structure of starch and cellulose (structure elucidation not expected). Industrial applications of cellulose.

Unit 6: Vitamins, Steroids and Hormones (9 Hrs)

Vitamins: Classification. Structure, biological functions and deficiency diseases of vitamins A, B₁, B₂, B₃, B₅, B₆, B₁₂ (structure not required), C and D.

Steroids: Introduction. Structure and functions of cholesterol. Elementary idea of HDL and LDL. Bile acids.



Hormones: Introduction. Steroid hormones, peptide hormones and amine hormones (examples, endocrine gland and biological functions, structure not required). Artificial hormones (elementary study only).

References

1. Maya Shankar Singh, L.G.Wade, *Organic Chemistry*, 6th Edition, Pearson Education, New Delhi, 2013.
2. P.Y. Bruice, *Essential Organic Chemistry*, 1st Edition, Pearson Education, New Delhi, 2013.
3. I.L. Finar, *Organic Chemistry Vol. I & II*, 5th Edition, Pearson Education, New Delhi, 2013.
4. M.K. Jain, S.C. Sharma, *Modern Organic Chemistry*, Vishal Publishing Co. 2010.
5. K.S. Tewari, N.K. Vishnoi and S.N. Mehrotra, *A Textbook of Organic Chemistry*, 2nd Edition, Vikas Publishing House (P) Ltd., New Delhi, 2004.
6. A. Bahl and B.S. Bahl, *Advanced Organic Chemistry*, 1st Multicolour Edition, S. Chand & Company, New Delhi, 2010.
7. A.C. Deb, *Fundamentals of Biochemistry*, 9th Edn. New Central Book Agency, 2001.
8. Rastogi, *Biochemistry*, Tata Mc Graw –Hill Publication, 1996.
9. Bhat S.V., Nagasampagi, B.A. & Sivakumar M. *Chemistry of Natural Products*, Narosa, 2005.



PRACTICAL-I

(Semester I and II)

(Common to Physical sciences, Life sciences, Geology and Family & Community sciences)

CH2CMP01 - VOLUMETRIC ANALYSIS

Credit – 2 (72 Hrs)

Standard solution must be prepared by the student.

1. Acidimetry and Alkalimetry

1. Standardization of HCl with standard Na_2CO_3 solution
2. Standardization of NaOH with standard oxalic acid solution
3. Estimation of any acid using standard NaOH
4. Estimation of any alkali using standard HCl.

2. Permanganometry

1. Standardization of KMnO_4 using (i) oxalic acid (ii) Mohr's salt
2. Estimation of Fe^{2+} in Mohr's salt and crystalline Ferrous Sulphate using standard KMnO_4 .

3. Dichrometry

1. Estimation of Ferrous ions (external indicator)
2. Estimation of Ferrous ions (internal indicator)
3. Estimation of $\text{FeSO}_4 \cdot 7 \text{H}_2\text{O}$ (external indicator)

4. Iodimetry and Iodometry

1. Standardization of Iodine solution
2. Standardization of Sodium thiosulphate
3. Estimation of KMnO_4
4. Estimation of Copper

References

1. D. A. Skoog, D. M. West, and S. R. Crouch, *Fundamentals of Analytical Chemistry* 8th edn, Brooks/Cole Nelson
2. *Vogel's Textbook of Quantitative Chemical Analysis* 6th edn., Pearson Education. Ltd.
3. G. D. Christian, *Analytical Chemistry*, JohnWiley and Sons
4. R.D Day, A.L. Underwood, *Quantitative Analysis*, 6th Edn., Prentice Hall of India Pvt. Ltd.



PRACTICAL – II
(Semesters III and IV)

CH4CMP02 - PHYSICAL CHEMISTRY PRACTICALS
(For students who have opted Physical Sciences and Geology as Main)

Credit – 2 (72 Hrs)

1. Viscosity-percentage composition of sucrose solution.
2. Determination of Partition coefficient of a non-volatile solute
3. Transition temperature of salt hydrates, eg. Sodium thiosulphate Sodium acetate etc.
4. Critical solution temperature of phenol water system
5. Phase diagram of two component systems
6. Heat of Solution KNO_3 , NH_4Cl
7. Heat of neutralization
8. Determination of equivalent conductance of an electrolyte
9. Conductometric titration of strong acid Vs. strong base
10. Potentiometric titrations : Fe^{2+} Vs. $\text{Cr}_2\text{O}_7^{2-}$ and Fe^{2+} Vs. KMnO_4
11. Determination of molecular weight by Rast's method. (Using naphthalene, or biphenyl as solvent and acetanilide, p-dichlorobenzene etc.as solute)
12. Kinetics of simple reactions, e.g. Acid hydrolysis of methyl acetate

References

1. W. G. Palmer: 'Experimental physical chemistry', Cambridge University Press.
2. J. B. Yadav: Advanced Practical Physical Chemistry Goel Publishing House.
3. R. C. Das and B. Behra; 'Experiments in Physical Chemistry' , Tata McGraw hill.
4. K. K. Sharma : 'An Introduction of Practical Chemistry': Vikas Publishing House, New Delhi



CH4CMP03 - ORGANIC CHEMISTRY PRACTICALS
(For students who have opted Life Sciences and Family & Community Science as Core)

Credit – 2 (72 Hrs)

1. Tests for elements: Nitrogen, Halogen and Sulphur
2. Determination of physical constants
3. Study of reactions of common functional groups.
4. Qualitative analysis with a view to characterization of functional groups and identification of the following compounds: Naphthalene, anthracene, chlorobenzene, benzyl chloride, p-dichlorobenzene, benzyl alcohol, phenol, o-, m- and p- cresols, α -naphthol, β -naphthol, resorcinol, benzaldehyde, acetophenone, benzophenone: benzoic acid, phthalic acid, cinnamic acid, salicylic acid, ethyl benzoate, methyl salicylate, benzamide, urea, aniline, o-, m- and p- toluidines, dimethyl aniline, nitrobenzene, o-nitrotoluene, m-dinitrobenzene and glucose. (minimum of ten compounds to be analysed).
5. Organic preparation involving halogenation, nitration, oxidation, reduction, acetylation, benzylation, hydrolysis, diazotization.
6. Isolation of an organic compound from a natural source.

References:

1. A. I Vogel, *A Text Book of Practical Organic Chemistry*, Longman.
2. F. G. Mann and B.C. Saunders, *Practical Organic Chemistry*, 4th Edn., Pearson Education.
3. V. K. Ahluwalia and S. Dhingra, *Comprehensive Practical Organic Chemistry*, Universities Press.

N. B: These complementary courses are applicable to relevant Model-II and other course



BSC CHEMISTRY (VOCATIONAL) – MODEL -II SYLLABUS FOR VOCATIONAL COURSES

INDUSTRIAL CHEMISTRY

SEMESTER I

CH1VOT01 - INDUSTRIAL ASPECTS OF INORGANIC AND ORGANIC CHEMISTRY

Credits-3 (72 Hrs)

Unit 1 (24 Hrs)

Petroleum-Natural gas-fraction of crude oil-fractional distillation-cracking-reforming-hydro forming-isomerisation. Octane number and Cetane number, Knocking and antiknock compounds.

Non-petroleum fuels - CNG, LNG, Biodiesel, bio-gas, fuels derived from bio-mass; fuel from waste; Gaseous fuels.

Basic idea about Synthetic fuels-Fischer-Tropsch synthesis and Bergius process.

Coal: types-distillation of coal-carbonization-types of carbonization. Distillation of coal-tar-chemicals derived from them. Analysis of coal-ultimate analysis and proximate analysis.

Unit 2 (12 Hrs)

Industrially important organic chemicals Cellulose-starch-properties-modification important Industrial chemicals derived from them-Manufacture of oxalic acid and furfural structure and properties of artificial sweeteners-saccharin, cyclamate and aspartame. Natural and artificial Food flavours-esters, aldehydes and heterocyclic compounds. Properties and examples of food colours; restricted use; spurious colours; emulsifying agents, preservatives, leavening agents-baking powder, yeast; taste makers-MSG and vinegar.

Unit 3 (12 Hrs)

Basic metallurgical operations: Pulverisation-calcination-roasting-refining. Physicochemical principle of extraction of iron-copper-silver-sodium-aluminium-magnesium-zinc-uranium and titanium, classification of steel, heat treatment of steel, passivity, different theories of rusting of iron and its prevention.

Corrosion- Introduction - Dry or Chemical Corrosion - Wet or electrochemical corrosion - Mechanism of Electrochemical Corrosion - Factors Influencing Corrosion - Corrosion Control - Proper designing - Using pure metal - Using metal alloys - Cathodic protection. Chemical conversion - Coating - Phosphating - Chromising - Treatment of metal surfaces hot dipping - Use of inhibitors.

Unit 4 (9 Hrs)

Inorganic materials of industrial importance:



Their availability-forms-structure and modification. Alumina-silica-silicates-clays-mica-zeolites –carbon (graphite, diamond, carbon nanotubes and fullerene) – Chlor-alkali compounds (chlorine, caustic soda, soda ash, lime

Unit 5

(8 Hrs)

Insulators, Semi-conductors and superconductors

Electrical Insulating Materials - Dielectric properties - Requirements of an Electrical Insulating Material - Classification of insulating material - Electrical Rigid Insulations.

Semiconductors and superconductors– Classification, applications, Manufacture.

Unit 6

(7 Hrs)

An introduction to Nanochemistry: Definition, length scales and importance of nanoscale and its technology – self assembly of materials – self assembly of molecules – porous solids, nanowires, nanomachines and quantum dots.

Nano particles: Introduction – types of nanoparticles –Techniques to synthesize nanoparticles – top down and bottom up approaches – common growth methods. Preparation, properties and applications of carbon nanotubes, nanorods, nano fibre and nanoclay – toxic effects of nanomaterials.

References

1. E.J.Hoffmann, Coal conversion-the Energon Co. Lavamic, WyomingUSA
2. L.F.Hath, S.Matarm, From Agro Carbon to petrochemicals, Gulf publishing Co., Houston
3. Steiner, Introduction to petroleum chemicals, Pergamon press
4. Satheesh Babu, Textbook for Engineering Chemistry Aspirants; Saradhi Publishers, Kerala.
5. G. Hall, Cotton, Cellulose, its Chemistry and Technology Cellulose
6. E. Heuser, Chemistry of cellulose
7. R. L. Whistle, Methods in Carbohydrate Chemistry Vol.3
8. R.W.Kerr, Chemistry and industry of starch
9. O. B. Wurzburg, Modified starches-properties and uses
10. Herbash, Principles of extractive metallurgy Vol.1 and 2
11. Volskky, E. Sergievskaya, Theory of metallurgical process
12. R. Baiky, Clays, H. Ries, Textbook of Metallurgy, John Wiley and sons
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15. R.Gopalan, D.Venkappaya, S. Nagarajan; Engineering Chemistry; Vikas Publications, New Delhi.
16. Jayashree Ghosh, Fundamental Concepts of Applied Chemistry, S. Chand and Co.
17. B. Sreelakshmi, Food Science, New Age.
17. Nano: The Essentials, T. Pradeep, Tata Mc-Graw Hill, New Delhi (2007).
18. The Chemistry of Nanomaterial: Synthesis, Properties and Applications, Vol. I and II, CNR Rao, Springer (2006).
19. Nanotechnology: Basic Science and Emerging Technologies, Mick Wilson, Kamali Kannangara, Geoff Smith, Michelle Simmons, Burkhard Raguse, Overseas Press (2005).



SEMESTER II
CH2VOT02 - CHEMICAL INDUSTRIES AND INDUSTRIAL ASPECTS
OF PHYSICAL CHEMISTRY

Credits-3 (72 Hrs)

Unit 1 **(12 Hrs)**

Surface and interfacial phenomena: Colloids- Preparation of colloids-Dispersion method – mechanical dispersion-electrical dispersion-peptization-electrolytic disintegration-dispersion by ultrasonic waves, Aggregation methods of preparation of colloids(chemical methods only) General properties of colloids -optical properties of sols –optical rotation-optical anisotropy, tyndal effect-tyndal cone, kinetic properties of sols- Brownian movement, Electrical properties of sols- charge on sol particles-electric double layer-Zeta potential- electrophoresis and electro osmosis, sedimentation potential and streaming potential, Methods for coagulation –Hardy –Schulze rule

Protective action of sols-protective colloids-gold number

Stability of sols, macromolecular colloids and determination of molecular weights of macromolecules.

Unit 2 **(9 Hrs)**

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 - micro emulsions(elementary idea only)-micelles CMC and Kraft temperature-, hydrotropes.Aerosols-classification of aerosols.

Unit 3 **(9 Hrs)**

Catalysis: Introduction-types-homogeneous and heterogeneous–basic principles–mechanism-factors affecting the performance. Introduction to phase transfer catalysis.

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

Unit 4 **(9 Hrs)**

Hydrochemistry: Characteristics of water, hardness of water– unit of hardness; water softening methods-Clark’s process,lime sodaprocess, modified lime soda process, permutit or zeolite process . Water purification-potabilityof water,clarification, coagulation,contact and electrochemical coagulation, sterilization and disinfections ofwater, precipitation – aeration – ozonisation-chlorination.

Unit 5 **(9 Hrs)**

Polymer industry: Plastics- thermosetting and thermo plastics-moulding of plastics into articles- compression moulding, injection moulding, transfer moulding, extrusion moulding,



blow moulding. Other methods for plastic processing- calendaring, casting, thermoforming, foaming

Rubber processing: Rubber latex-processing of latex- Mastication –compounding of rubber-vulcanisation of rubber-techniques, sulphur and non-sulphur vulcanisation. Basic idea about reclaimed rubber, foam rubber and sponge rubber

Unit 6 (9 Hrs)

Lubricants: Classification of lubricants, lubricating oils (conducting and non-conducting), solid and semisolid lubricants, synthetic lubricants. Properties of lubricants (viscosity index, cloudpoint, pour point, aniline point, flash point.

Unit 7 (6 Hrs)

Cement Industry: 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.

Unit 8 (9 Hrs)

Batteries: Primary and secondary batteries, Characteristics of battery- The discharge plot, the ragon plot, and measures of battery performance. Working of: Lead acid battery, Lithium ion battery, Zinc-air battery, Nickel-metal hydride battery, Nickel-cadmium cell, solar cell.

References

1. Shepherd, Aerosol science and technology
2. B. Delmon, G. Janner, Catalysis-Heterogeneous and homogeneous.
3. J. Anderson, Catalysis science and technology
4. J. Fendler, E. Fendler, Catalysis in micellar and macro molecular systems
5. E. K. Rideal, H. S. Taylor, Catalysis in theory and practice
6. C. Starles, Phase transfer catalysis, Principles and techniques
7. J.J. Bikermann, Surface chemistry, Academic press
8. A.W. Adamson, Physical chemistry of surfaces
9. Delmon, Catalysis: Heterogeneous and homogeneous, Elsevier science publisher
10. R. Gopalan, D. Venkappayya, S. Nagarajan: Engineering Chemistry, Vikas Publications, New Delhi
11. T. Sathesh Babu, A text book for Engineering Chemistry Aspirants, Saradhi Publishers, Kerala.
12. B.K. Sharma: Engineering Chemistry, Goel Publishing House, Meerut.
13. Baron, Paul A., and Klaus Willeke. Aerosol Measurement: Principles, Techniques, and Applications. 2nd ed. Hoboken, NJ: Wiley-Interscience,
14. Friedlander, S. K. Smoke, Dust and Haze: Fundamentals of Aerosol Behavior. New York: John Wiley & Sons.
15. John O.M. Bockris and A K N Reddy, Modern Electrochemistry 2B, 2nd Edition, Kluwer Academic Publishers.



SEMESTER I & II PRACTICAL
CH2VOP01 - INDUSTRIAL INORGANIC CHEMISTRY PRACTICAL
Credits-2 (72 Hrs)

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

1. D. A. Skoog, D. M. West, and S. R. Crouch, Fundamentals of Analytical Chemistry 8th edn, Brooks/Cole Nelson
2. Vogel's Textbook of Quantitative Chemical Analysis 6th edn, Pearson Education Ltd.
3. R. D Day, A.L. Underwood, Quantitative analysis, 6th Edn., Prentice Hall of India Pvt. Ltd.
4. 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.
5. Laboratory Manual on Engineering Chemistry, Dr. Subdharani, Dhanpat Rai Publishing.
6. Gurdeep Raj, Advanced Practical Inorganic Chemistry, Goel Publishing House.



SEMESTER-III
CH3VOT03 - UNIT OPERATIONS IN CHEMICAL INDUSTRY
Credits-3 (54Hrs)

Unit 1 **(9 Hrs)**
Distillation: 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.

Unit 2 **(9 Hrs)**
Absorption: Introduction, selection criteria for Solvent, Gas absorption Equipments: mechanically agitated vessels, packed and plate columns, types of tower packing, HETP, Liquid distribution devices.

Unit 3 **(12 Hrs)**
Evaporation: Introduction: Equipment-short tube (standard) evaporator, forced circulation evaporators. Falling film evaporators. Climbing film (upward flow) evaporators, wiped (agitated) film evaporators.

Unit 4 **(12 Hrs)**
Filtration: Introduction: Filter media and filter aids, Equipment-plate and frame filterpress, nutsch 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.

Unit 5 **(12 Hrs)**
Crystallization: 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

1. W.L.Badger and J.T.Bachero, Introduction to Chemical Engineering, Tata McGraw Hill, U.S.A
2. W.L.McCabe and J.C.Smith, Unit operations in Chemical Engineering, Tata McGraw Hill N.Y
3. J.H.Perry, Chemical Engineering Hand Book, McGraw Hill, N.Y.
4. D.D.Kale, Unit Operations- 1 and 2, Pune Vidyarthi Griha Prakashan, Pune
5. K.A.Gavhane, Unit Operations-II Heat and Mass transfer, Nirali Prakashan.
6. J. D. Seader, Ernest J. Henley and D. Keith Roper, Separation Process Principles, John Wiley & Sons, Inc.
7. J.F. Richardson, J. H. Harker, J. R. Backhurst, Particle Technology and Separation Processes, Butterworth-Heinemann.



CH3VOT04 - UNIT PROCESSES IN ORGANIC CHEMICALS
MANUFACTURE
Credits-3 (54 Hrs)

Unit 1 **(8 Hrs)**

Nitration: Introduction: Nitrating agents, mechanism of nitration processes such as nitration of (a) Paraffinic hydrocarbons (b) Benzene to nitro benzene and meta-dinitro benzene (c) Chlorobenzene to o- and p- nitrochlorobenzene d) Toluene. Continuous and Batch Nitration Process

Unit 2 **(12 Hrs)**

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

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

Unit 3 **(6 Hrs)**

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

Unit 4 **(9 Hrs)**

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.

Unit 5 **(8 Hrs)**

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.

Unit 6 **(6 Hrs)**

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.



Unit 7

(5 Hrs)

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

References

1. P.H. Groggins, Unit Process in Organic Synthesis, McGraw Hill, N.Y
2. Diraiswamy L.k.: Organic Synthesis Engineering, Academic Press, New York.
3. Sheenhan W.F.: Principles of Physical Chemistry, Prentice Hall of India Pvt. Ltd. New Delhi
4. Dryden C.E., Outline of chemical technology: East West Press.
5. P.L. Soni: Organic chemistry, S. Chand Co., New Delhi
6. Gopal Rao. M. & Sitting M., "Dryden's Outlines of Chemical Tech.", 2nd Ed., East-West Pub., New Delhi, 1997.
7. Austin G. T., "Shreve's Chemical Process Industries", 5th Ed. McGraw-Hill Pub., 1994.
8. Felder R.M., Rousseau R.W., "Elementary Principles of Chemical Processes", 3rd ed., John Wiley, New York, 2000.
9. Kent J.A., "Riggel's Handbook of Industrial Chemistry", Van Nostrand Reinhold, 1974.
10. K. Weissermal, H.J. Arpe, Wiley VCH .Industrial organic Chemistry.
11. James G. Speight, Mcgraw-Hill, Chemical and process design handbook
12. Andreas Jess, Peter Wasserscheid, Chemical Technology. Wiley-VCH Verlag & Co. KGaA,
13. Robert A. Smiley, Harold L. Jackson, Chemistry and the Chemical industry. CRC PRESS Boca Raton London New York Washington, D.C.
14. Mohammad Farhat Ali, Bassam M. El Ali, James G. Speight, .Handbook of Industrial Chemistry.



SEMESTER IV
CH4VOT05 - INSTRUMENTAL METHODS OF CHEMICAL
ANALYSIS-I
Credits - 3 (54 Hrs)

Unit 1: Principles of Instrumentation (14 Hrs)

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- techniques for S/N enhancement – hardware and software methods.

Transducers – characteristics of transducers, sensitivity and transfer function- some typical examples. Photo emissive- photo conductive and photovoltaic systems- photomultiplier and photo diode.

Unit 2: Typical Analytical Instruments -1 (9 Hrs)

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.

Unit 3: Typical Analytical Instruments -2 (12 Hrs)

Molecular fluorescence: spectrofluorimetry – factors affecting fluorescence –typical instrumentation Atomic spectroscopy: (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.

Unit 4: Electro Analytical Instrumentation (12 Hrs)

(1)Potentiometric methods: Principle- technique and detection limit

(2)Non Potentiometric methods:(a) Conductometry (b) Polarography (c) Amperometry

(d)Anodic stripping analysis (e) coulometry (primary and secondary)

Unit 5: Chromatographic instrumentation (7 Hrs)

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

HPLC: Instrumentation, methods of detection, derivatisation and industrial applications.



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

References:

1. Jeffry, Basset, Mendhem, R.C Denwy, Vogel's Text Book of Quantitative Inorganic Analysis, 4th & 5th Edition.
2. Skoog and Leary, Principles of Instrumental analysis, 4th Edition, Sanders College Publishing.
3. D. Patranabis, Principles of Industrial Instrumentation, 2nd Edition, Tata McGraw-Hill Company, Delhi.
4. James W. Robinson, Eileen M. Skelly Frame and George M. Frame II, Undergraduate Instrumental analysis, 6th Edition, Marcel Dekker, New York.
5. Francis Rouessac and Annick Rouessac, Chemical Analysis: Modern Instrumentation Methods and Techniques, 2nd Edition, John Wiley & Sons.
6. Frank A. Settle, Handbook of Instrumental Techniques for Analytical Chemistry, Prentice Hall PTR.
7. Skoog and West, Fundamentals of Analytical Chemistry, 9th edition, Sanders College Publishing.
8. John Kenkel. Analytical Chemistry for Technicians, 4th Edition, CRC Press.



**CH4VOT06 - INSTRUMENTAL METHODS OF CHEMICAL
ANALYSIS-II
Credits-3 (54 Hrs)**

Unit 1: Process Instrumentation (12 Hrs)

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)

Unit 2: Microprocessor Based Instruments (9 Hrs)

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

Unit 3: Surface Analysis and Microscopic techniques (10 Hrs)

Theory, instrumentation and applications of the following techniques: ESCA, XPS and UPES techniques. Auger-electron spectroscopy. X-ray techniques. SEM, TEM, STM, SPL, AFM and SIMS.

Unit 4: Optical Methods (7 Hrs)

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.

Unit 5: Thermo analytical techniques (8 Hrs)

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

Unit 6: SFC and Electrophoresis (8 Hrs)

Super critical Fluid Chromatography (SFC): Basic Principles, Instrumentation, mobile phases, stationary phases, detectors, comparison with other column chromatographic methods, applications.

Electrophoresis: capillary zone electrophoresis (CZE) - sample injection and detection, Modes of CE, Applications.



References:

1. D. P. Eckman, Industrial Instrumentation, John Wiley & Sons
2. D. Patranabis, Principles of Industrial Instrumentation, 2nd Edition, Tata McGraw-Hill Company, Delhi.
3. Skoog and Leary, Principles of Instrumental analysis, 4th Edition, Sanders College Publishing.
4. Willard, Merrit, Dean & Settle- Instrumental Methods of Analysis, C.B.S Publishers, 4th Edition 2. J.G. Dick, Analytical Chemistry, McGraw Hill
5. James W. Robinson, Eileen M. Skelly Frame and George M. Frame II, Undergraduate Instrumental analysis, 6th Edition, Marcel Dekker, New York.
6. Francis Rouessac and Annick Rouessac, Chemical Analysis: Modern Instrumentation Methods and Techniques, 2nd Edition, John Wiley & Sons.
7. Frank A. Settle, Handbook of Instrumental Techniques for Analytical Chemistry, Prentice Hall PTR.
8. Skoog and West, Fundamentals of Analytical Chemistry, 9th edition, Sanders College Publishing.
9. John Kenkel. Analytical Chemistry for Technicians, 4th Edition, CRC Press.
10. C. Richard Brundle, Charles K Evans, Jr., and Shaun Wilson, Encyclopedia of Material Characterization, Butterworth-Heinemann.
11. Narendra Kumar, Sunita Kumbhat, Essentials in Nanoscience and Nanotechnology, John Wiley & Sons.
12. Tattamangalam R. Padmanabhan, Industrial Instrumentation Principles and Design, Springer.
13. William C. Dunn, Fundamentals of Industrial Instrumentation and Process Control, McGraw-Hill.



SEMESTER (III&IV) PRACTICALS

CH4VOP02 - INDUSTRIAL ORGANIC CHEMISTRY PRACTICAL

Credits-2

(72 Hrs)

1. Unit Process:

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

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

References

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



CH4VOP03 - INDUSTRIAL PHYSICAL CHEMISTRY PRACTICAL

Credits - 2 (72 Hrs)

1. Colorimetry:
 - i) Estimation of Iron in water colorimetrically.
 - 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:
 - i) To determine the coefficient of viscosity of a given liquid with the help of Ostwald's viscometer.
 - ii) 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:
 - i) Determine the refractive index of given liquid by Abbe's refractometer and find the specific and molar refraction.
 - ii) Determination of concentration of given KCl solution by refractive index measurements.
10. 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

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



Model III. BSc PETROCHEMICALS

SEMESTER- 1

CH1PCT01 - PETROLEUM GEOLOGY

Credits- 3 (72 Hrs)

Unit 1. (16 Hrs)

Theories of origin of petroleum-biogenic (organic) and abiogenic (inorganic) theory. Differences between biogenic and abiogenic theory. Berthelot's view, Mendeleeff's view, Engler's theory and modern theory.

Establishment of Source Beds- nature of source material- transformation of organic matter into petroleum- accumulation in Reservoir sediments- in situ transformation of petroleum- thermal alteration-deasphalting - biodegradation and water washing.

Unit 2 (18 Hrs)

Resource and reserves—proved, unproved, probable, possible and undiscovered reserves. Geological framework of migration and accumulation. Concept of hydrocarbon migration from source bed to the carrier beds—carrier beds to reservoir. Mechanics of entrapment of hydrocarbon—traps in the path of migration-entrapment and accumulation of hydrocarbon. Classification and types of traps-structural, stratigraphic and combination type of traps. Genesis of various types of Traps—Anticlinal theory-traps caused by faulting- traps caused by fracturing.

Unit 3 (18 Hrs)

Oil Exploration methods- geophysical exploration---magnetic method, gravimetric method , seismic survey Borehole logging-electrical method--radio active method, density- Core sampling. **Drilling operations.** Recovery of oil - natural method (primary oil recovery)—dissolved gas drive— gas cap drive, water drive, gravity drive- secondary methods. Other source of petroleum. Petroleum from coal, natural gas and its constitution.

Elemental analysis of crude oil, hydrocarbon compounds, non -hydrocarbon compounds in crude oil, metallic constituents.

Unit 4 (20 Hrs)

Transportation and storage of crude oil: Crude transportation and product transferring. Type of storage tanks - Cone roof and floating roof, nitrogen blanketing, truck and tankers, LPG bullets. Pipe line transfer, Rail way. Crude Reservoirs .Indian resources of petroleum

Function of refineries: simple refinery, complex refinery, integrated refinery- sweetening process- stripping, distillation procedures, heat exchangers-separation of products from crude oil, reduced crude oil ,vacuum distillation- Composition of different distillates.



References

1. Speight G James, Marcel Dekker, The Chemistry and Technology of Petroleum , Inc 1991
2. Tripathi G.N , Indian Petroleum Directory , Indian Petroleum Publishers
3. Asphalt hand book, Manual series , Asphalt institute 1989
4. W.L.Nelson, Petroleum refining engineering, Mc.Graw Hill
5. R.A.Meyers, Handbook of petroleum refining process
6. B.K Sharma, Industrial Chemistry, Goyal Publication
7. Sukumar Maiti , Introduction to Petrochemicals
8. D.S.J Jones , Elements of Petroleum Processing
9. Dr.KochuBaby Manjooran , Modern Petroleum Chemistry –An Overview
10. R.A.Meyers , Handbook of petroleum refining process
11. B.K Sharma , Industrial Chemistry, Goyal Publication
12. D.S.J Jones , Elements of Petroleum Processing
13. Hunt J M, Petroleum Geochemistry and Geology, 1996, 2nd Edn WH Freeman, San Francisco..
14. Richard C Selly, Elements of Petroleum Geology, Academic press, London.

SEMESTER- II

CH2PCT02 - TEST METHODS AND PETROLEUM PROCESSES

Credits- 3 (72 Hrs)

Unit 1 (15 Hrs)

Type of hydrocarbon fuels and its characteristics. ASTM methods of product testing. Specifications for various fuels. Detailed study of Naphtha, LPG , Gasoline, Kerosene, Diesel, Fuel oils , Bitumen, Rubberized bitumen and bitumen emulsion

Unit 2 (20 Hrs)

Introduction – Significance –effect of blending and illustration of the following: Pour point, Cloud point , Cetane number , Pour point Depressants Octane number and octane boosters, Distillation, viscosity and its reducers Flash point ,copper corrosion, calorific value, Reid vapour pressure, Aniline point, Diesel index. Detailed study of Abel and PMC method. Doctor solution and its uses. API gravity, existent gum and potential gum.

Unit 3 (15 Hrs)

Evaluation of Bitumen: Elastic recovery, ductility, softening point, penetration test. Aviation fuels: Different types of Aviation fuels .and analysis; silver corrosion , WSIM, JEFTOT ,anti oxidants, static electricity reducers, final boiling point, total sulphur, mercaptans, lubricity, smoke point freezing point, calorific value. Manufacture of gasoline by cracking, antiknock performance, research octane number, motor octane number, road octane number



Unit 4

(22 Hrs)

Cracking operations :Different types of cracking. Thermal cracking of petroleum products, thermal cracking of vacuum gas oil. Types of thermal cracking: mixed phase cracking , vapour phase cracking, selective cracking, visbreaking. Catalytic cracking-Commercial processes. Feed stocks of catalytic cracking, process variables of cracking. Catalysts for cracking. Hydro cracking, hydro processing. Comparison of hydro cracking and hydro treating. Hydro forming , plat forming, uniforming, ultra forming, auto forming. Catalysts for hydro cracking. Reforming: Thermal reforming, catalytic reforming , fixed bed reforming, hyperforming. Isomerism . Hysomer process. Penex process-Alkylation.

References

1. ASTM Methods, Indian standards(Methods of test for petroleum and its Products,)
2. Speight G James, Marcel Dekker ,The chemistry and technology of Petroleum ,Inc 1991
3. Tripathi G.N,Indian Petroleum Directory , Indian Petroleum Publishers
4. Asphalt hand book, Manual series , Asphalt institute 1989,
5. W.I. Nelson, Petroleum engineering .
6. B.K. Sharma ,Industrial Chemistry
7. Navid Nader Pow ,Petrochemical Production Process,S.B.S Publishers
8. Dr.KochuBaby Manjooran ,Modern Petroleum Chemistry



CH2PCP01 - PRACTICAL -I
(SEMESTER I AND II)

Credits- 2 (72 Hrs)

1. Determination of softening point
2. Determination of penetration of bitumen
3. Determination of Ductility of Bitumen
4. Determination of Aniline point of diesel fuel
5. Determination of Diesel Index
6. Distillation of Petrol
7. Distillation of Kerosene
8. Distillation of Diesel
9. Determination of water content in diesel –Dean Stark Method
10. Determination of water content in furnace oil- Dean Stark Method

Reference:

ASTM Methods, Indian standards(Methods of test for petroleum and its Products,)



SEMESTER III
CH3PCT03 - PRODUCTION AND APPLICATION OF COMPOUNDS
FROM PETROLEUM

Credits-4 (72 Hrs)

Unit 1 (24 Hrs)

Manufacture of sulphur from under ground --Froeh process--From hydrogen sulphide. Partial oxidation method and Engineering problems-- Hydrogen --Properties--hydrogen as a fuel--- manufacture of hydrogen from naphtha cracking,--From hydrocarbons by partial oxidation.-- Petroleum coke--Uses-manufacture by Hot oven method---thermal cracking--- fluidized coking--- Delayed coking--- and Nitrogen compounds in petroleum. Nitroparaffins-- Nitro ethane---I nitro propane---2nitropropane.--manufacture of nitrogen compounds from petroleum

Unit 2 (24 Hrs)

Study of following reactions and their applications :

Amoxidation-- Applications of amoxidation --.preparation of acrylonitrile-- Terephthalic acid by amoxidation -Lummns process—Hydroformylation ---oxo process--Modifications of oxo process --Uses of oxo process—Hydrogenation-- Aldex process--Aldol condensation-- -oxidation-- Hydration – categories of hydration--Clathrates-Applications of hydration--- preparation of ethyl alcohol--Isopropyl alcohol—acrylamide(Dow chemical process)-- Acetaldehyde--Oxidation-type of oxides--Classification of oxides--application of oxidation in petroleum compounds.---union carbide process --weaker process

Unit 3 (12 Hrs)

Steam naphtha cracking of Hydrocarbons:

Manufacture of Ethylene--- Acetylene—Propylene-- Higher olefins from naphtha-- Process-- economics (present day procedures and its economics)

Unit 4 (12 Hrs)

Polymers: Classification- Addition and Condensation polymerisation – Examples.

Plastics: Properties—uses-thermoplastics- thermosetting plastics - moulding constituents of a plastic-moulding of plastics into articles- compression moulding-injection moulding-transfer moulding—extrusion moulding—engineering plastics.

References

1. W.L. Faith, Donald B Keyes, Ronald L Clark, Industrial Chemicals.
2. Speight G James, Marcel Dekker Inc 1991,The chemistry and technology of Petroleum
3. Tripathi G.N, Indian Petroleum Directory
4. B.K Sharma , Industrial Chemistry and Chemical Engineering ,Spits Petrochemicals-Wiley
5. A.L Waddan , Chemicals from petroleum
6. I.F Hatels and S. Mater Gulf, From Hydrocarbons to Petrochemicals
7. Jain an d Jain, Engineering chemistry
8. Navid Nadar Pow , Ptrochemical production process
9. H Steiner ,Introduction to petrochemicals



CH3PCT04 - MANUFACTURE OF PETROCHEMICALS-I

Credits-3 (54 Hrs)

Unit 1: Manufacture from Natural gas (14 Hrs)

Methanol-properties and uses- manufacturing methods –catalytic hydration method.-side reactions, Carbon black-uses and properties-Channel black-Furnace black(gas and oil)-thermal black-Acetylene black-manufacture, Hydrogen cyanide-uses and properties-manufacture by Andrew sons process-By Degusser process, Shawnigan process

Unit 2: Manufacture from Methane (13 Hrs)

Chlorinated methane-uses ,Manufacture of methyl chloride-methyl dichloride-Chloroform-carbon tetra chloride, carbon disulphide –uses- manufacture by Thacker process –Acetylene-uses-manufacture by sachse process-wulf process

Unit 3 (13Hrs)

Ethyl chloride-uses-manufacture by hydrochlorination ,Ethanol-Different process of manufacture-uses-manufacture by catalytic hydration-, Ethylene oxide –uses and properties-Manufacture by oxidation ,Ethanolamines- monoethanol amine - diethanol amine-triethanol amines--uses- manufacture- Engineering problems

Ethylene glycol-uses-Different methods of preparation-Manufacture through chlorohydrin-Manufacture by oxidation.

Unit 4 (14 Hrs)

Acetaldehyde-Process of manufacture- recent advances-uses-., Acetic acid-Uses and manufacture by oxidation, styrene-uses-manufacture-by benzene-Purification--

Vinyl acetate-uses and manufacture by acetic acid and oxygen-- Vinyl chloride-uses-manufacture by thermal pyrolysis- Acrylonitrile- uses and Manufacture by ethylene oxide and hydrogen cyanide

References

1. W.L. Faith, Donald B Keyes, Ronald L Clark, Industrial Chemicals.
2. Speight G James, Marcel Dekker Inc 1991,The chemistry and technology of Petroleum
3. Tripathi G.N, Indian Petroleum Directory
4. B.K Sharma , Industrial Chemistry and Chemical Engineering ,Spits Petrochemicals-Wiley
5. ASTM Methods, Indian standards
6. Sukumar Maiti ,Introduction to Petrochemicals



SEMESTER IV

CH4PCT05 - MANUFACTURE OF PETROCHEMICALS -II

Credits - 4 (72 Hrs)

Unit 1: Manufacture from propylene (16 Hrs)

Isopropanol---uses-properties-manufacture by hydration method-- Cumene-uses-manufacturing methods- Propylene-alkylation method,---Glycerin uses-natural glycerin synthetic glycerin--manufacture by allyl chloride-- manufacture via acrolein--- Acrylonitrile - - uses-- manufacture by amoxidation method

Unit 2: Manufacture from Acetylene (18 Hrs)

Vinyl chloride-uses-manufacture-engineering problems-economics-- Acetaldehyde-uses-properties-hydration of acetylene-hydration solutions-process of manufacture--- Chloroprene --uses- Neoprene- manufacture,---Acrylonitrile --uses-properties-manufacture by hydrogen cyanide process---disadvantages. Acrylic acid- Reppe's synthesis. Vinylacetate, acetone, Trichloroethylene, Perchloroethylene, vinyl ether and aceto nitrile (method of production only)

Unit 3 (20 Hrs)

Butadiene-uses-occurrence-methods of preparation-manufacture by Houdry Process--- Benzene-uses--manufacture by hydrodealkylation- C-4 oligomers. BTX aromatics --Principal sources-Benzene-Toluene-Xylenes-uses --manufacture. Naphthalene-uses-sources-manufacture by hydrodealkylation, Linear alkyl benzene-General reactions-side reactions-manufacture.

Unit 4 (18 Hrs)

Synthetic Fibres and Detergents-Production techniques of synthetic fibres-melt spinning, dry spinning and solution (wet) spinning. Polyesters, Polyethylene terephthalate (PET) from p-Xylene ,Poly carbonates, poly amides-Nylon6,Nylon6,6-Acrylic fibres (Orlon)- manufacture. Synthetic paper-advantages over conventional paper- method of preparation. Classification of detergents-uses of detergents-surfactants-additives-manufacture-cleaning action of detergents. Difference between soap and detergents. LAS and ABS detergents.

References:-

1. W.L. Faith, Donald B Keyes, Ronald L Clark, Industrial Chemicals.
2. Speight G James, Marcel Dekker Inc 1991, The chemistry and technology of Petroleum
3. Tripathi G.N, Indian Petroleum Directory
4. B.K Sharma , Industrial Chemistry and Chemical Engineering ,Spits Petrochemicals-Wiley
5. ASTM Methods, Indian standards
6. Sukumar Maiti, Introduction to Petrochemicals
7. Dr. BK Baskara Rao- A text book on petrochemicals, Khanna publishers, Delhi



CH4PCT06 - PETROLEUM INDUSTRIES IN INDIA

Credits-3 (54 Hrs)

Unit 1 (8 Hrs)

Energy crisis ---coal as an alternative to oil-Hydrogen- fuel of tomorrow-advantages –non-conventional sources of energy—solar energy—bio gas-advantages-tidal energy –geothermal energy-wind energy—nuclear fuels (general study only)

Unit 2 (16 Hrs)

Importance of Petroleum and petrochemical industry in the contest of Indian economy – general cost-capital cost-production cost-R&D economics-
Major govt oil companies engaged in refining and marketing petroleum, Function of ONGC. Indian petrochemical industry –Difficulties encountered in Indian petro chemical industries.- Public sector and private sector –Petroleum conception pattern
Indian reserves, Developments in petrochemical industry -developments in quality of petroleum fuels and future –Future of petrochemical industry.

Unit 3 (18 Hrs)

Catalysts in petroleum industry –General properties-classification—catalytic activity-catalysts in refining process-Reforming catalysts-hydro treating catalysts-catalysts in petro chemical industry-Ziegler catalyst-preparation-properties-disadvantages-miscellaneous polymerization catalysts- recent advances in catalysts-Role of polymers in catalysts-enzyme catalysts- preparation, structure, selectivity and application

Unit 4 (12 Hrs)

Pollution from petroleum industry—refinery pollution-water pollution—air pollution-sea water pollution-effect of oil pollution- physical and chemical—control methods-- environmental protection-- National standards of air and water pollution

References

1. W.L. Faith, Donald B Keyes, Ronald L Clark, Industrial Chemicals.
2. Trimn , Catalysts in petrochemical refining
3. Jain and Jain, Engineering Chemistry
4. B.K Sharma , Industrial Chemistry and Chemical Engineering ,Spits Petrochemicals-Wiley
5. ASTM Methods, Indian standards
6. Sukumar Maiti, Introduction to Petrochemicals



SEMESTER III AND IV
CH4PCP02 - PRACTICAL -II

Credits-2 (72 Hrs)

1. Determination of density of light oils
2. Determination of density of medium type oils
3. Determination of surface tension of kerosene
4. Determination of Viscosity of Diesel
5. Determination of Reid vapour pressure of petrol
6. Determination of Pour point.
7. Determination of Cloud point.
8. Determination of Flash point-PMC method.
9. Determination of Flash point-Abel's method.
10. Determination of Smoke point of kerosene.

Reference: ASTM methods, Indian standards