File Ref.No.23552/GA - IV - J2/2013/CU

**UNIVERSITY OF CALICUT**

**Abstract**

General and Academic - Faculty of Science - Syllabus of BSc Chemistry Programme under CBCSS UG Regulations 2019 with effect from 2019 Admission onwards - Implemented - Orders Issued

**G & A - IV - J**

U.O.No. 9082/2019/Admn Dated, Calicut University.P.O, 09.07.2019

*Read:*-1. U.O.No. 4368/2019/Admn dated 23.03.2019

2. Item No. 1 of the minutes of the combined meeting of the Boards of Studies in Chemistry UG, Polymer Chemistry and Industrial Chemistry held on 27.05.2019

3. Item No. I.16 of the minutes of the meeting of Faculty of Science held on 27.06.2019

ORDER

The Regulations for Choice Based Credit and Semester System for Under Graduate (UG) Curriculum 2019 (CBCSS UG Regulations 2019) for all UG Programmes under CBCSS-Regular and SDE/Private Registration w.e.f. 2019 admission has been implemented vide paper read first above.

The combined meeting of the Boards of Studies in Chemistry UG, Polymer Chemistry and Industrial Chemistry on 27.05.2019 has approved the Syllabus of BSc Chemistry Programme in tune with the new CBCSS UG Regulations with effect from 2019 Admission onwards, vide paper read second above.

The Faculty of Science at its meeting held on 27.06.2019 has approved the minutes of the combined meeting of the Boards of Studies in Chemistry UG, Polymer Chemistry and Industrial Chemistry on 27.05.2019 vide paper read third above.

Under these circumstances, considering the urgency, the Vice Chancellor has accorded sanction to implement the Scheme and Syllabus of BSc Chemistry Programme in accordance with the new CBCSS UG Regulations 2019, in the University with effect from 2019 Admission onwards, subject to ratification by the Academic Council.

The Scheme and Syllabus of BSc Chemistry Programme in accordance with CBCSS UG Regulations 2019, is therefore implemented in the University with effect from 2019 Admission onwards.

Orders are issued accordingly. (Syllabus appended)

Biju George K

Assistant Registrar

To

The Principals of all Affiliated Colleges

Copy to: PS to VC/PA to PVC/ PA to Registrar/PA to CE/JCE I/JCE IV/DoA/EX and EG Sections/GA I F/CHMK Library/Information Centres/SF/DF/FC

Forwarded / By Order

Section Officer

# UNIVERSITY OF CALICUT

## B.Sc. DEGREE PROGRAMME

**IN**

## CHEMISTRY

(CBCSSUG 2019)

**UNDER CHOICE BASED CREDIT AND SEMESTER SYSTEM**

# SCHEME AND SYLLABI

## 2019 ADMISSION ONWARDS

# UNDERGRADUATE PROGRAMME – AN OVERVIEW

**Programme** means the entire course of study and examinations for the award of a degree. **Duration** of an undergraduate programme is six semesters distributed in a period of 3 years. An **academic week** is a unit of five working days in which distribution of work is organized from Monday to Friday with five contact periods of one hour duration on each day. A sequence of 18 such weeks (16 instructional weeks and two weeks for examination) constitutes a **semester**.

**Course** means a segment of subject matter to be covered in a semester. The undergraduate programme includes 5 types of courses, *viz.*, common courses, core courses, complementary courses, open course and audit course. **Common courses** include English and additional language courses. Every undergraduate student shall undergo 10 common courses [6 English courses and 4 additional language courses] for completing the programme. **Core courses** comprise compulsory course in a subject related to a particular degree programme offered by the parent department. There are 18 core courses including a project work. **Complementary courses** cover two disciplines that are related to the core subject and are distributed in the first four semesters. There shall be one **open course** in the 5$^{th}$ semester. Students can opt one open course of their choice offered by any department in the institution other than their parent department. **Audit courses** are courses which are mandatory for a programme but not conducted for the calculation of SGPA or CGPA. There shall be one audit course each in the first 4 semesters. Audit courses are not meant for class room study. The students can attain only pass (Grade P) for these courses. At the end of each semester there shall be examination conducted by the college from a pool of questions (Question Bank).

Each course shall have certain credits. **Credit** is a unit of academic input measured in terms of weekly contact hours/course contents assigned to a course. A student is required to acquire a minimum of 140 credits for the completion of the UG programme, of which 120 credits are to be acquired from class room study and shall only be counted for SGPA and CGPA. Out of the 120 credits, 38 (22 for common (English) courses + 16 for common languages other than English) credits shall be from common courses, 55 credits for core courses (including 2 credits each for project work and Elective), 24 credits for complementary courses (12 credits each) and 3 credits for the open course. Audit courses shall have 4 credits per course and a total of 16 credits in the entire programme.

**Extra credits** are mandatory for the programme. Extra credits will be awarded to students who participate in activities like NCC, NSS and Swatch Bharath. Those students who could not join in any of the above activities have to undergo Calicut University Social Service Programme (CUSSP). Extra credits are not counted for SGPA or CGPA. The maximum credit acquired under extra credit shall be 4. If more Extra credit activities are done by a student that may be mentioned in the Grade card.

Each course shall have a unique alphanumeric **code number**, which includes abbreviation of the subject in three letters, the semester number (1 to 6) in which the course is offered, the code of the course (A: Common course, B: Core course, C: Complementary course, D: Open course and E: Audit course) and the serial number of the course (01, 02, *etc.*). For example, CHE5B06 represents a core course of serial number 06 offered in 5$^{th}$ semester in B.Sc. Chemistry Programme.

# UNDERGRADUATE PROGRAMME IN CHEMISTRY

## PREAMBLE

Science education is central to the development of any society. This can be achieved only by revamping the undergraduate programme to make it effective and meaningful. The development of scientific temper in society necessitates proper education and guidance. In order to achieve this, one must update the developments in the field of science. An effective science education can be imparted at the undergraduate level only by revamping the present curriculum. To achieve this goal, the curriculum should be restructured by emphasising various aspects such as the creativity of students, knowledge of current developments in the discipline, awareness of environmental impacts due to the development of science and technology, and the skills essential for handling equipments and instruments in laboratories and industries.

Chemistry, being an experimental science, demands testing theories through practical laboratory experiences for a thorough understanding of the subject. Nowadays, chemistry laboratories in academic institutions use large amounts of chemicals. The awareness and implementation of eco-friendly experiments becomes a global necessity. It is essential to ensure that laboratory chemicals are used at a minimal level without affecting the skill and understanding aimed through laboratory sessions. This creates an environmental awareness among the students and pollution free atmosphere in the campus.

During the preparation of the syllabus, the existing syllabus, the syllabi of $XI^{th}$ & $XII^{th}$ standards, UGC model curriculum and the syllabi of other universities have been referred. Care has been taken to ensure that the syllabus is compatible with the syllabi of other universities at the same level. Sufficient emphasis is given in the syllabus for training in laboratory skills and instrumentation.

The units of the syllabus are well defined. The number of contact hours required for each unit is given which excludes prerequisites. The pre requisites provided at the beginning of the units guides the students to what he/she should know before exploring the topic. This can be assessed by the teacher either before delivering the particular topic or as a bridge course at the beginning of each semester. **These shall not be considered for external evaluation**. A list of references and further readings are provided at the end of each unit.

## AIMS

This curriculum has been prepared with the objective of giving sound knowledge and understanding of chemistry to undergraduate students. The goal of the syllabus is to make the study of chemistry stimulating, relevant and interesting. It has been prepared with a view to equip students with the potential to contribute to academic and industrial environments. This curriculum will expose students to various fields in chemistry and develop interest in related disciplines. Chemistry, being a border science to biology, physics and engineering, has a key role to play in the understanding of these disciplines. The updated syllabus is based on an interdisciplinary approach to understand the application of the subject in daily life.

**BROAD OBJECTIVES**

To enable the students

- To understand basic facts and concepts in chemistry.
- To apply the principles of chemistry.
- To appreciate the achievements in chemistry and to know the role of chemistry in nature and in society.
- To familiarize with the emerging areas of chemistry and their applications in various spheres of chemical sciences and to apprise the students of its relevance in future studies.
- To develop skills in the proper handling of instruments and chemicals.
- To familiarize with the different processes used in industries and their applications.
- To develop an eco-friendly attitude by creating a sense of environmental awareness.
- To be conversant with the applications of chemistry in day-to-day life.

## PROGRAMME STRUCTURE

| *Semester* | *Common course* | | *Core course* | *Complementary course* | | *Open course* | *Total* |
|---|---|---|---|---|---|---|---|
| | *English* | *Additional Language* | | *Mathematics* | *Physics* | | |
| I | 4+3 | 4 | 2 | 3 | 2 | - | 18 |
| II | 4+3 | 4 | 2 | 3 | 2 | - | 18 |
| III | 4 | 4 | 3 | 3 | 2 | - | 16 |
| IV | 4 | 4 | 3+4* | 3 | 2+4* | - | 24 |
| V | - | - | 3+3+3 | - | - | 3 | 12 |
| VI | - | - | 3+3+3+3+2# +4*+4*+4*+ 4*+2** | - | - | - | 32 |
| **Total** | **22** | **16** | **55** | **12** | **12** | **3** | **120** |

*Practical **Project #Elective

### Mark and Indirect Grading System

Mark system is followed instead of direct grading for each question. After external and internal evaluations marks are entered in the answer scripts. All other calculations, including grading, will be done by the university using the software. Indirect Grading System in 10 point scale is followed. Each course is evaluated by assigning marks with a letter grade (O, $A^+$, A, $B^+$, B, C, P, F, I or Ab) to that course by the method of indirect grading.

### Mark Distribution

| *Sl. No.* | *Course* | *Marks* |
|---|---|---|
| 1 | English | 550 |
| 2 | Additional Language | 400 |
| 3 | Core course: Chemistry | 1475 |
| 4 | Complementary course: Mathematics | 300 |
| 5 | Complementary course: Physics/Food Science/Computer science | 400 |
| 6 | Open Course | 75 |
| | ***Total Marks*** | 3200 |

**Ten point Indirect Grading System**

| *% of Marks (Both Internal & external put together)* | *Grade* | *Interpretation* | *Grade Point Average* | *Range of Grade points* | *Class* |
|---|---|---|---|---|---|
| 95 and above | O | Outstanding | 10 | 9.5 - 10 | First Class with distinction |
| 85 to below 95 | $A^+$ | Excellent | 9 | 8.5 - 9.49 | |
| 75 to below 85 | A | Very good | 8 | 7.5 – 8.49 | |
| 65 to below 75 | $B^+$ | Good | 7 | 6.5 – 7.49 | First Class |
| 55 to below 65 | B | Satisfactory | 6 | 5.5 – 6.49 | |
| 45 to below 55 | C | Average | 5 | 4.5 – 5.49 | Second Class |
| 35 to below 45 | P | Pass | 4 | 3.5 – 4.49 | Third class |
| Below 35 | F | Failure | 0 | 0 | Fail |
| Incomplete | I | Incomplete | 0 | 0 | Fail |
| Absent | Ab | Absent | 0 | 0 | Fail |

## CREDIT AND MARK DISTRIBUTION IN EACH SEMESTER

**Total Credits: 120**

| ***Semester*** | *Course* | *Credit* | *Mark* |
|---|---|---|---|
| **I** | Common course: English | 4 | 100 |
| | Common course: English | 3 | 75 |
| | Common course: Additional Language | 4 | 100 |
| | Core Course I: Theoretical and Inorganic Chemistry- I | 2 | 75 |
| | Complementary course: Mathematics | 3 | 75 |
| | Complementary course: Physics | 2 | 75 |
| | **Total** | **18** | **500** |
| **II** | Common course: English | 4 | 100 |
| | Common course: English | 3 | 75 |
| | Common course: Additional Language | 4 | 100 |
| | Core Course II: Theoretical and Inorganic Chemistry- II | 2 | 75 |
| | Complementary course: Mathematics | 3 | 75 |
| | Complementary course: Physics | 2 | 75 |
| | **Total** | **18** | **500** |
| **III** | Common course: English | 4 | 100 |
| | Common course: Additional Language | 4 | 100 |
| | Core Course III: Physical Chemistry-I | 3 | 75 |
| | Complementary course: Mathematics | 3 | 75 |
| | Complementary course: Physics | 2 | 75 |
| | **Total** | **16** | **425** |
| **IV** | Common course: English | 4 | 100 |
| | Common course: Additional Language | 4 | 100 |
| | Core Course IV: Organic Chemistry-I | 3 | 75 |
| | Core Course V: Inorganic Chemistry Practical-I | 4 | 100 |
| | Complementary course: Mathematics | 3 | 75 |
| | Complementary course: Physics | 2 | 75 |
| | Complementary course: Physics Practical | 4 | 100 |
| | **Total** | **24** | **625** |
| **V** | Core Course VI: Inorganic Chemistry-III | 3 | 75 |
| | Core Course VII: Organic Chemistry-II | 3 | 75 |
| | Core Course VIII: Physical Chemistry-II | 3 | 75 |
| | Open course | 3 | 75 |
| | **Total** | **12** | **300** |
| **VI** | Core Course IX: Inorganic Chemistry-IV | 3 | 75 |
| | Core Course X: Organic Chemistry-III | 3 | 75 |
| | Core Course XI: Physical Chemistry-III | 3 | 75 |
| | Core Course XII: Advanced and Applied Chemistry | 3 | 75 |
| | Core Course XIII: Elective | 2 | 75 |
| | Core Course XIV: Physical Chemistry Practical | 4 | 100 |
| | Core Course XV: Organic Chemistry Practical | 4 | 100 |
| | Core Course XVI: Inorganic Chemistry Practical-II | 4 | 100 |
| | Core Course XVII: Inorganic Chemistry Practical-III | 4 | 100 |
| | Core Course XVIII: Project Work | 2 | 75 |
| | **Total** | **32** | **850** |

**SYLLABUS**

**FOR**

# CORE COURSE

## Core Course Structure - Total Credits: 55 (Internal: 20%; External: 80%)

| *Semester* | *Code No* | *Course Title* | | *Hrs/ Week* | *Total Hrs* | *Credit* | *Marks* |
|---|---|---|---|---|---|---|---|
| **I** | CHE1B01 | Core Course I: Theoretical and Inorganic Chemistry- I | | 2 | 32 | 2 | 75 |
| | - | Core Course V : Inorganic Chemistry Practical-I | | 2 | 32 | -* | - |
| **II** | CHE2B02 | Core Course II: Theoretical and Inorganic Chemistry- II | | 2 | 32 | 2 | 75 |
| | - | Core Course V : Inorganic Chemistry Practical-I | | 2 | 32 | -* | - |
| **III** | CHE3B03 | Core Course III: Physical Chemistry-I | | 3 | 48 | 3 | 75 |
| | - | Core Course V : Inorganic Chemistry Practical-I | | 2 | 32 | -* | - |
| **IV** | CHE4B04 | Core Course IV: Organic Chemistry-I | | 3 | 48 | 3 | 75 |
| | CHE4B05(P) | Core Course V : Inorganic Chemistry Practical-I | | 2 | 32 | 4 | 100 |
| **V** | CHE5B06 | Core Course VI: Inorganic Chemistry-III | | 3 | 48 | 3 | 75 |
| | CHE5B07 | Core Course VII: Organic Chemistry-II | | 4 | 64 | 3 | 75 |
| | CHE5B08 | Core Course VIII: Physical Chemistry-II | | 3 | 48 | 3 | 75 |
| | - | Core Course XIV: Physical Chemistry Practical | | 5 | 80 | -** | - |
| | - | Core Course XV: Organic Chemistry Practical | | 5 | 80 | -** | - |
| | - | Core Course XVIII: Project Work | | 2 | 32 | -** | - |
| **VI** | CHE6B09 | Core Course IX: Inorganic Chemistry-IV | | 3 | 48 | 3 | 75 |
| | CHE6B10 | Core Course X: Organic Chemistry-III | | 3 | 48 | 3 | 75 |
| | CHE6B11 | Core Course XI: Physical Chemistry-III | | 3 | 48 | 3 | 75 |
| | CHE6B12 | Core Course XII: Advanced and Applied Chemistry | | 3 | 48 | 3 | 75 |
| | CHE6B13(E1) | Core Course XIII: Elective*** | 1. Industrial Chemistry | 3 | 48 | 2 | 75 |
| | CHE6B13(E2) | | 2. Polymer Chemistry | | | | |
| | CHE6B13(E3) | | 3. Medicinal and Environmental Chemistry | | | | |
| | CHE6B14(P) | Core Course XIV: Physical Chemistry Practical | | - | - | 4** | 100 |
| | CHE6B15(P) | Core Course XV: Organic Chemistry Practical | | - | - | 4** | 100 |
| | CHE6B16(P) | Core Course XVI: Inorganic Chemistry Practical-II # | | 5 | 80 | 4 | 100 |
| | CHE6B17(P) | Core Course XVII: Inorganic Chemistry Practical-III | | 5 | 80 | 4 | 100 |
| | CHE6B18(Pr) | Core Course XVIII: Project Work | | - | - | 2** | 75 |
| **Total** | | | | | | **55** | 1475 |

* Exam will be held at the end of 4th semester

** Exam will be held at the end of 6th semester

***An institution can choose any one among the three courses.

#Includes industrial visit also. Marks: 85 (Inorganic Chemistry Practical–II) + 15 (Industrial visit).

# SEMESTER I

### Course Code: CHE1B01

## Core Course I: Theoretical and Inorganic Chemistry- I

Total Hours: 32; Credits: 2; Hours/Week: 2; Total Marks 75 (Internal 15 & External 60)

| CHE1B01 | Theoretical and Inorganic Chemistry-I | L* | T** | P*** | C# |
|---|---|---|---|---|---|
| | | 2 | 0 | 0 | 2 |
| Objective (s) | To gain detailed knowledge of the principle of volumetric analysis and properties of *s* and *p* block elements. To provide the basic groundwork for a research project. Students will be able to analyse basic theory of acid base concept. | | | | |
| Course outcome (s) | | | | | |
| CO1 | To apply the methods of a research project. | | | | |
| CO2 | To understand the principles behind volumetry. | | | | |
| CO3 | To analyse the characteristics of different elements. | | | | |
| CO4 | To distinguish between different acid base concepts. | | | | |
| CO5 | To analyse the stability of different nuclei. | | | | |

*Lecture, **Tutorial, ***Practical, #Credit

**Module I: Chemistry as a discipline of science (5 hrs)**

[Prerequisites: Evolution of chemistry – early form of chemistry: the *panch tatvas* and alchemy, idea of some technologies that eventually formed the basis of the various branches of chemistry, ancient speculations to particulate nature of matter, laws of chemical combination. Scope of chemistry, branches of chemistry, interdisciplinary areas involving Chemistry.]

What is science? Scientific statements - scientific methods - observation - posing a question - formulation of hypothesis - experiment - theory - law - revision of scientific theories and laws. Scientific research: selecting a topic for research, design of an experiment, sampling, use of controls, experimental bias, analysis, results and discussion of results, statistical analysis of experimental data, preparation of seminar papers, major publishers in chemical science, author citation, reviews and keywords.

Publishing a research work: Introduction, review of literature, scope, materials and methods, results and discussion, conclusions and bibliography.

**References**

1. J. A. Lee, *The Scientific Endeavor: A Primer on Scientific Principles and Practice*, Pearson Education, 1999.

2. C. N. R. Rao, *Understanding Chemistry*, Universities Press India Ltd., Hyderabad, 1999.
3. George Gamow, *One, Two, Three...Infinity: Facts and Speculations of Science*, Dover Publications, 1988.
4. *Resonance – Journal of Science Education*, Indian Academy of Sciences.
5. *Nature Chemistry*, Nature Publishing Group.
6. *Chemistry: A Volatile History*, BBC documentary.
7. http://www.vlab.co.in
8. http://nptel.iitm.ac.in

**Further reading**

1. T. F. Gieryn, *Cultural Boundaries of Science*, University of Chicago Press, Chicago, 1999.
2. H. Collins, T. Pinch, *The Golem: What Everyone Should Know about Science*, Cambridge University Press, Cambridge, 1993.
3. C.R. Kothari, *Research Methodology: Methods and Techniques*, 2nd Revised Edition, New Age International Publishers, New Delhi, 2004.

**Module II: Analytical Principles – I (10 hrs)**

[Prerequisites: Awareness on nature of experiments performed in chemical laboratories. The health risks and hazards associated with chemicals. Concentrated and dilute solutions. Acids and bases, Organic and Inorganic chemicals]

*Laboratory Hygiene and Safety:* Awareness of Material Safety Data Sheet (MSDS). Storage and handling of chemicals. Simple first aids: Electric shocks, fire, cut by glass and inhalation of poisonous gases - Accidents due to acids and alkalies - Burns due to phenol and bromine. Disposal of sodium and broken mercury thermometer - Use of calcium chloride and silica gel in desiccators. – R & S Phrases (elementary idea only) – Safe laboratory practices – Lab safety signs. Personal Protective Equipment (PPE).

Accuracy, precision, types of error - absolute and relative error, methods of eliminating or minimizing errors. Methods of expressing precision: mean, median, deviation, average deviation and coefficient of variation. Significant figures and its application.

Mole concept. Equivalent mass. Methods of expressing concentration: Weight percentage, molality, molarity, normality, mole fraction, ppm and millimoles. Numerical Problems related to basic concepts.

*Volumetric Analysis:* Introduction - Primary and secondary standards – Standard solutions - Theory of titrations involving acids and bases, $KMnO_4$, $K_2Cr_2O_7$, $I_2$ and liberated $I_2$ - Complexometric titrations. Indicators: Theory of acid-base, redox, adsorption and complexometric indicators. Double burette method of titration: Principle and advantages.

**References**

1. B. R. Puri, L. R. Sharma, K. C. Kalia, *Principles of Inorganic Chemistry*, 31st Edn., Milestone Publishers and Distributors, New Delhi, 2013.
2. Satya Prakash, *Advanced Inorganic Chemistry*, Vol. 1, 5th Edn., S. Chand and Sons, New Delhi, 2012.
3. J. Mendham, R. C. Denney, J. D. Barnes, M. Thomas, *Vogel's Text Book of Quantitative Chemical Analysis*, 6th Edn., Pearson Education, Noida, 2013.

**Further reading**

1. *Guidance in a Nutshell - Compilation of Safety Data Sheets*, European Chemicals Agency, Finland, Version 1.0, December 2013.
2. D. A. Skoog, D. M. West, F. J. Holler, S. R. Crouch, *Fundamentals of Analytical Chemistry*, 8th Edn., Brooks/Cole, Thomson Learning, Inc., USA, 2004.
3. R. H. Hill, D. Finster, *Laboratory Safety for Chemistry Students*, 1st Edn., Wiley, Hoboken, NJ, 2010.
4. M. C. Day, J. Selbin, *Theoretical Inorganic Chemistry*, East West Press, New Delhi, 2002.

**Module III: Periodic Properties (3 hrs)**

[Prerequisites: Name and symbol of elements, Law of triads, octaves, X-ray studies of Henrry Mosley, Mosleys periodic law - Modern periodic law – Long form periodic table. Periodicity in properties: Atomic and ionic radii.]

Ionization enthalpy - Electron affinity (electron gain enthalpy) – Electronegativity: Pauling and Mullikan scales. Effective nuclear charge – Slater rule and its applications – Polarising power – Fajans rule.

**Module IV: Representative Elements (6 hrs)**

[Prerequisites: Comparative study of *s* and *p* block elements based on electronic configuration, size, melting point, boiling point, density, ionization energy, electronegativity and oxidation state.]

Standard electrode potential, flame colour of s block elements, diagonal relationships - Inert pair effect.

Ionic compounds: Lattice energy of ionic compounds - BornLande equation (derivation not expected) - Solvation enthalpy and solubility of ionic compounds - Born-Haber cycle and its applications - Properties of ionic compounds.

Polarity in covalent compounds - Percentage of ionic character - Dipole moment and molecular structure, Polarising power - Fajans rule.

Comparison of Lewis acidity of boron halides - Preparation, properties, structure and uses of Diborane, Boric acid, Borazine and Boron nitride - Structure of $AlCl_3$.

Structures of oxides of N and P, oxy acids of N and P, structure of $SO_2$ and $SO_3$. Structure and acidic strength of oxy and peroxy acids of sulphur, oxy acids of chlorine. Preparation, properties and uses of ammonia, nitric acid, ozone, hydrogen peroxide, sulphuric acid and hydrochloric acid.

**References**

1. B. R. Puri, L. R. Sharma, K. C. Kalia, *Principles of Inorganic Chemistry*, 31st Edn., Milestone Publishers and Distributors, New Delhi, 2013.
2. Satya Prakash, *Advanced Inorganic Chemistry,* Vol. 1, 5th Edn., S. Chand and Sons, New Delhi, 2012.
3. W. U. Malik, G. D. Tuli, R. D. Madan, *Selected Topics in Inorganic Chemistry,* S. Chand and Co., New Delhi, 2010.
4. J. D. Lee, *Concise Inorganic Chemistry*, 5th Edn., Oxford University Press, New Delhi, 2008.

**Further reading**

1. D. F. Shriver, P. W. Atkins, *Inorganic Chemistry*, 5rd Edn., Oxford University Press, New York, 2010.
2. M. C. Day, J. Selbin, *Theoretical Inorganic Chemistry*, East West Press, New Delhi, 2002.
3. J. E. Huheey, E. A. Keitler, R. L. Keitler, *Inorganic Chemistry – Principles of Structure and Reactivity,* 4th Edn., Pearson Education, New Delhi, 2013.

**Module V: Acid Base Concepts (3 hrs)**

[Prerequisites: Arrhenius definition, Bronsted-Lowry definition and conjugate acid-base pairs, lewis concept, ionization of acids and bases.]

Lux-Flood, Solvent system and Usanovich concepts.

Metal and nonmetal hydroxy compounds, acid anhydrides, amphoteric oxides and hydroxides.

Hard and soft acids and bases: Classification of acids and bases as Hard and Soft. Applications of HSAB concept, limitations of HSAB concept.

**References**

1. W. U. Malik, G. D. Tuli, R. D. Madan, *Selected Topics in Inorganic Chemistry*, S. Chand and Co., New Delhi, 2010 (Reprint).
2. J. D. Lee, *Concise Inorganic Chemistry*, 5th Edn., Oxford University Press, New Delhi, 2008.
3. D. F. Shriver, P. W. Atkins, *Inorganic Chemistry*, 5rd Edn., Oxford University Press,New York, 2010.

**Further reading**

1. J. E. Huheey, E. A. Keitler, R. L. Keitler, *Inorganic Chemistry – Principles of Structure and Reactivity*, 4th Edn., Pearson Education, New Delhi, 2013.
2. M. C. Day, J. Selbin, *Theoretical Inorganic Chemistry*, East West Press, New Delhi, 2002.
3. O.W. Hand, H. L. Blewitt, *Acid Base Chemistry*, Macmillan USA, 1986.

**Module VI: Nuclear Chemistry (5 hrs)**

[Prerequisites: Nuclear stability – N/P ratio – Packing fraction – Mass defect – Binding energy - Nuclear fission - Atom bomb – Nuclear fusion – Hydrogen bomb.]

Nuclear forces - Exchange theory and nuclear fluid theory - Nuclear reactors. Decay series – group displacement law - Isotopes: Detection – Aston's mass spectrograph – Separation of isotopes by gaseous diffusion method and thermal diffusion method – Application of radioactive isotopes – $^{14}C$ dating – Rock dating – Isotopes as tracers – Study of reaction mechanism (ester hydrolysis) – Radio diagnosis and radiotherapy.

**References**

1. H. J. Arnikar, *Essentials of Nuclear Chemistry*, 4th Edn., New Age International (P) Ltd., New Delhi, 1995.

**Further reading**

1. S. Glasstone, *Source Book on Atomic Energy*, 3rd Edn., East-West Press Pvt. Ltd., NewDelhi, 1967.
2. J. B. Rajam, L. D. Broglie, *Atomic Physics*, 7th Edn., S. Chand and Co. Pvt. Ltd., New Delhi, 1999.

| Mark Distribution | |
|---|---|
| Module I | 10 Marks |
| Module II | 24 Marks |
| Module III | 8 Marks |
| Module IV | 15 Marks |
| Module V | 8 Marks |
| Module VI | 14 Marks |

# SEMESTER II

### Course Code: CHE2B02

## Core Course II: Theoretical and Inorganic Chemistry- II

Total Hours: 32; Credits: 2; Hours/Week: 2; Total Marks 75 (Internal 15 & External 60)

| CHE2B02 | Theoretical and Inorganic Chemistry- II | L | T | P | C |
|---|---|---|---|---|---|
| | | 2 | 0 | 0 | 2 |
| Objective(s) | Module I – To introduce the students to the failures of classical physics theories in explaining many experiments and the emergence of quantum theory with which all of them could be satisfactorily explained. Module II – To enablethe students to understand the the basic postulates of quantum mechanics and how to solve the time-independent Schrödinger wave equation of different systems including H atom. Module III – To introduce the quantum mechanical treatment of chemical bonding in diatomic molecules using VB and MO theories. Module IV - To introduce the students to the quantum mechanical treatment of hybridisation and bonding in polyatomic systems. | | | | |
| Course outcome (s) | | | | | |
| CO1 | To understand the importance and the impact of quantum revolution in science. | | | | |
| CO2 | To understand and apply the concept that the wave functions of hydrogen atom are nothing but atomic orbitals. | | | | |
| CO3 | To understand that chemical bonding is the mixing of wave functions of the two combining atoms. | | | | |
| CO4 | To understand the concept of hybridization as linear combination of orbitals of the same atom. | | | | |
| CO5 | To inculcate an atomic/molecular level philosophy in the mind. | | | | |

[Pre-requisites: Early atom models – John Dalton's atomic theory, the discharge tube experiment and discovery of electron, the plum-pudding model, the gold foil experiment and the invention of the nucleus. The nuclear model. Failures of the nuclear model.]

**Module I: The Quantum revolution and its early impact in atomic structure (6 hrs)**

Experiments which led to the development and generalisation of quantum theory – black body radiation, Planck's quantum hypothesis, photoelectric effect, Einstein's generalisation of quantum theory.

Atomic model partly based on quantum theory – Bohr's theory of the atom, calculation of Bohr radius, velocity and energy of an electron. Atomic spectra of hydrogen and hydrogen like systems. Limitations of Bohr's theory. Louis de Broglie's matter waves – wave-particle duality. Electron diffraction.

**Module II: Introductory Quantum Chemistry and the quantum mechanical model of the atom (10 hrs)**

Operator algebra – linear and Hermitian operators, Laplacian and Hamiltonian operators, eigen functions and eigen values of an operator. Non-commuting operators and the Heisenberg's uncertainty principle.

Postulates of quantum mechanics. Well behaved functions. Time independent Schrödinger wave equation for conservative systems. Application to particle in a one dimensional box – normalization of wave function. Particle in a three dimensional box – separation of variables, degeneracy.

Application of Schrödinger wave equation to hydrogen atom. The wave equation in spherical polar coordinates. Separation of variables. Wave functions or atomic orbitals, radial and angular parts of atomic orbitals. Quantum numbers (*n, l, m*). Radial functions, Radial distribution functions and their plots, Angular functions and their plots (1s, 2s and $2p_z$ only).

The Stern-Gerlach experiment and the concept of electron spin, spin quantum number, spin orbitals (elementary idea only). Pauli's exclusion principle.

**Module III: Bonding in diatomic molecules (10 hrs)**

Need for approximation methods in multi-electron systems. Born-Oppenheimer approximation. Variation theorem (elementary idea only).

Quantum mechanical concept of bonding – (mixing of wave functions of different atoms). Valence bond theory of $H_2$ molecule (derivation not required). Molecular orbital theory of $H_2^+$ ion $H_2$ molecule - linear combination of atomic orbitals (LCAO) and coefficients in the linear combination (derivation not required). Potential energy diagram of $H_2$ molecule formation – equilibrium geometry. Bonding and antibonding molecular orbitals, bond order. MO diagrams of homonuclear and heteronuclear diatomic molecules – $He_2$, $Li_2$, $Be_2$, $B_2$, $C_2$, $N_2$, $O_2$, $F_2$, CO and NO. Comparison of VB and MO theories.

**Module IV: Bonding in polyatomic molecules (6 hrs)**

[Prerequisite: VSEPR theory: Postulates – applications.]

Concept of Hybridization: Need of hybridization, Definition (mixing of wave functions of the same atom), LCAO of the central atom – coefficients of atomic orbitals in the linear combination of sp ($BeH_2$), $sp^2$ ($BH_3$) and $sp^3$ ($CH_4$) hybridization (derivation not required). Other examples of hybridization – Geometry of molecules like $PCl_5$, $SF_6$ and $IF_7$.

**Reference**

1. D. A. McQuarrie, J. D. Simon, *Physical Chemistry – A Molecular Approach*, Viva, 2001.

2. A. K. Chandra, *Introductory Quantum Chemistry*, 4th Edn., Tata McGraw Hill Publishing Company, Noida, 1994.

3. R. K. Prasad, *Quantum Chemistry*, 3rd Edn., New Age International, 2006.

**Further reading**

1. N. Levine, *Quantum Chemistry*, 6th Edn., Pearson Education Inc., 2009.

2. P. W. Atkins, R. S. Friedman, *Molecular Quantum Mechanics*, 4th Edn., Oxford University Press, 2005.

| **Mark Distribution** | |
|---|---|
| Module I | 15 Marks |
| Module II | 25 Marks |
| Module III | 24 Marks |
| Module IV | 15 Marks |

# SEMESTER III

## Course Code: CHE3B03

## Core Course III: PHYSICAL CHEMISTRY - I

Total Hours: 48; Credits: 3; Hours/Week: 3; Total Marks 75 (Internal 15 & External 60)

| **CHE3B03** | **PHYSICAL CHEMISTRY - I** | L | T | P | C |
|---|---|---|---|---|---|
| | | 3 | 0 | 0 | 3 |
| Objective (s) | To introduce the concepts of chemical thermodynamics, equilibria and group theory. | | | | |
| Course outcome (s) | | | | | |
| CO1 | To understand the properties of gaseous state and how it links to thermodynamic systems. | | | | |
| CO2 | To understand the concepts of thermodynamics and it's relation to statistical thermodynamics. | | | | |
| CO3 | To apply symmetry operations to categorize different molecules. | | | | |

**Module I: Gaseous State (8 hrs)**

[Prerequisites: Fundamentals of gaseous state. Postulates of kinetic theory of gases - Derivation of kinetic gas equation - Maxwell's distribution of molecular velocities - Root mean square, average and most probable velocities.]

Collision number - Mean free path - Collision diameter - Deviation from ideal behavior - Compressibility factor – van der Waals equation of state (derivation required) - Virial equation - Expression of van der Waals equation in virial form and calculation of Boyle temperature - PV isotherms of real gases - Continuity of states - Isotherm of van der Waals equation - Critical phenomena - Critical constants and their determination - Relationship between critical constants and van der Waals constants.

**References**

1. B. R. Puri, L. R. Sharma, M. S. Pathania, *Principles of Physical Chemistry*, 46th Edn., Vishal Publishing Company, New Delhi, 2013.

2. P. W. Atkins, J. de Paula, *Atkin's Physical Chemistry*, 8th Edn., Oxford University Press, 2006.

3. D. A. McQuarrie, J. D. Simon, *Physical Chemistry: A Molecular Approach*, University Science Books: Sausalito, CA, 1997.

4. K. L. Kapoor, *Physical Chemistry*, Vol. II and III, Macmillan Publishers, Noida, 2004.

**Further reading**

1. G. M. Barrow, *Physical Chemistry*, 5th Edn., Tata McGraw Hill Education, New Delhi, 2006.

2. S. Glasstone, D.H. Lewis, *Elements of Physical Chemistry*, 2nd Edn., Macmillan & Company, UK, 1962.

3. F. Daniels, R. A. Alberty, *Physical Chemistry*, 5th Edn., John Wiley and Sons, Canada, 1980.

4. P. Atkins, J. de Paula, *The Elements of Physical Chemistry* 7th Edn., Oxford University Press, Oxford, 2016.

**Module II: Chemical Thermodynamics – I (16 hrs)**

[Prerequisites: Fundamentals of Chemical Thermodynamics. Path function and state function - Thermodynamic terms for defining System - Surroundings - Types of systems - intensive and extensive properties - Steady state and equilibrium state. Concept of thermal equilibrium - Zeroth law of thermodynamics.]

First law of thermodynamics – Concept of heat, work, internal energy and enthalpy - Heat capacities at constant volume and at constant pressure & their relationship - Expansion of an ideal gas under isothermal and adiabatic conditions - Work done in isothermal expansion and reversible isothermal expansion - Joule-Thomson effect- significance of term $(\delta U/\delta V)_T$ - Liquefaction of gases - Derivation of the expression for Joule Thomson coefficient – Inversion temperature. Maxwell's relations.

Thermochemistry: Heat changes during physicochemical processes. Kirchoff's relations. Bond dissociation energies. Resonance energy from thermochemical data. Changes of thermodynamic properties with respect to different chemical changes.

Second law of thermodynamics - Need for the law - Kelvin, Planck and Clausius statements and equivalence of the two statements with entropic formulation. Calculation of entropy change for reversible and irreversible processes. Entropy change of systems and surroundings for various processes and transformations. Entropy change during the isothermal mixing of ideal gases. Entropy and unavailable work. free energy functions (G and A) and their variation with T, P and V. Criteria for spontaneity and equilibrium. Carnot's theorem - Carnot's cycle and its efficiency.

**Module III: Chemical Thermodynamics – II (8 hrs)**

[Prerequisites: Module II: Chemical Thermodynamics - I, idea of permutation and combination]

Gibbs-Helmholtz equation - Partial molar free energy - Concept of chemical potential - Gibbs-Duhem equation. Maxwell relations.

Fundamental concepts of Statistical Thermodynamics - Probability - Partition function - ensembles - Boltzmann distribution derivation - Relation between entropy and probability - Stirling's approximation - Residual entropy and absolute entropy. Third law of thermodynamics - Nernst heat theorem - Statement of third law.

**References**

1. B. R. Puri, L. R. Sharma, M. S. Pathania, *Principles of Physical Chemistry*, 46th Edn., Vishal Publishing Company, New Delhi, 2013.

2. P. W. Atkins, J. de Paula, *Atkin's Physical Chemistry*, 8th Edn., Oxford University Press, 2006.

3. D. A. McQuarrie, J. D. Simon, *Physical Chemistry: A Molecular Approach*, University Science Books: Sausalito, CA; 1997.

4. K. L. Kapoor, *Physical Chemistry*, Vol. II and III, Macmillan Publishers, Noida, 2004.

**Further reading**

1. G. M. Barrow, *Physical Chemistry*, 5th Edn., Tata McGraw Hill Education, New Delhi, 2006.

2. S. Glasstone, D. H. Lewis, *Elements of Physical Chemistry*, 2nd Edn., Macmillan & Company, UK, 1962.

3. F. Daniels, R. A. Alberty, *Physical Chemistry*, 5th Edn., John Wiley and Sons, Canada, 1980.

4. P.W. Atkins, J. de Paula, *The Elements of Physical Chemistry*, 7th Edn., Oxford University Press, Oxford, 2016.

5. T. Engel, P. Reid, *Thermodynamics, Statistical Thermodynamics & Kinetics*, Pearson Education, Inc: New Delhi, 2007.

6. D. A. McQuarrie, *Statistical Mechanics*, University Science Books, 2000.

7. J. Rajaram, J. C. Kuriacose, *Chemical Thermodynamics*, Pearson Education, New Delhi, 2013.

**Module IV: Chemical Equilibria (8 hrs)**

Law of mass action, thermodynamic derivation of law of chemical equilibrium. Relation between Gibbs free energy of reaction and reaction quotient. Equilibrium constants and their quantitative dependence on temperature, pressure and thermodynamic derivation of relations between the various equilibrium constants Kp, Kc and Kx (using chemical potential). Van't

Hoff's equation - Le Chatelier principle (quantitative treatment). Homogeneous and heterogenous equilibria.

**References**

1. B. R. Puri, L. R. Sharma, M. S. Pathania, *Principles of Physical Chemistry*, 46th Edn., Vishal Publishing Company, New Delhi, 2013.

2. P. W. Atkins, J. de Paula, *Atkin's Physical Chemistry*, 8th Edn., Oxford University Press, 2006.

3. D. A. McQuarrie, J. D. Simon, *Physical Chemistry: A Molecular Approach*, University Science Books: Sausalito, CA; 1997.

**Further reading**

1. G. M. Barrow, *Physical Chemistry*, 5th Edn., Tata McGraw Hill Education, New Delhi, 2006.

2. K. L. Kapoor, *Physical Chemistry*, Vol. II and III, Macmillan Publishers, Noida, 2004.

3. S. Glasstone, D. H. Lewis, *Elements of Physical Chemistry*, 2nd Edn., Macmillan & Company, UK, 1962.

4. F. Daniels, R. A. Alberty, *Physical Chemistry*, 5th Edn., John Wiley and Sons, Canada, 1980.

5. P. W. Atkins, J. de Paula, *The Elements of Physical Chemistry*, 7th Edn., Oxford University Press, Oxford, 2016.

6. J. Rajaram, J. C. Kuriacose, *Chemical Thermodynamics*, Pearson Education, New Delhi, 2013.

**Module V: Molecular Symmetry and Group Theory (8 hrs)**

Elements of symmetry of molecules (Identity, proper axis of rotation, plane of symmetry, centre of symmetry and improper axis of rotation) – corresponding symmetry operations – Schoenflies notation – binary combinations of symmetry operations.

Rules for a set of elements to form a mathematical group - point group classification of simple molecules – $C_{nv}$, $C_{nh}$, $D_{nh}$. Group multiplication table for $C_{2v}$ and $C_{2h}$.

**References**

1. B. R. Puri, L. R. Sharma, M. S. Pathania, *Principles of Physical Chemistry*, 46th Edn., Vishal Publishing Company, New Delhi, 2013.

2. P. W. Atkins, J. de Paula, *Atkin's Physical Chemistry*, 8th Edn., Oxford University Press 2006.

3. D. A. McQuarrie, J. D. Simon, *Physical Chemistry: A Molecular Approach*, University Science Books: Sausalito, CA; 1997.

4. K. L. Kapoor, *Physical Chemistry*, Vol. II and III, Macmillan Publishers, Noida, 2004.

5. B. S. Garg, *Chemical Applications of Molecular Symmetry and Group Theory*, Macmillan Publishers India Ltd., 2012.

**Further reading**

1. G. M. Barrow, *Physical Chemistry*, 5th Edn., Tata McGraw Hill Education, New Delhi, 2006.

2. S. Glasstone, D. H. Lewis, *Elements of Physical Chemistry*, 2nd Edn., Macmillan & Company, UK, 1962.

3. F. Daniels, R. A. Alberty, *Physical Chemistry*, 5th Edn., John Wiley and Sons, Canada, 1980.

4. P. W. Atkins, J. de Paula, *The Elements of Physical Chemistry*, 7th Edn., Oxford University Press, Oxford, 2016.

5. P. K. Bhattacharya, *Group Theory and its Chemical Applications*, Himalaya Publishing House, New Delhi, 1986.

6. F. A. Cotton, *Chemical Applications of Group Theory*, 3rd Edn., John Wiley & Sons, New York, 1990.

| **Mark Distribution** | |
|---|---|
| Module I | 14 Marks |
| Module II | 25 Marks |
| Module III | 14 Marks |
| Module IV | 12 Marks |
| Module V | 14 Marks |

# SEMESTER IV

## Course Code: CHE4B04

## Core Course IV: ORGANIC CHEMISTRY– I

Total Hours: 48; Credits: 3; Hours/Week: 3; Total Marks 75 (Internal 15 & External 60)

| CHE4B04 | ORGANIC CHEMISTRY– I | L | T | P | C |
|---|---|---|---|---|---|
| | | 3 | 0 | 0 | 3 |
| Objective (s) | To enable the students to analyse basic theory and concepts of organic chemistry and appreciate different organic reaction mechanism and their stereochemistry. | | | | |
| Course outcome (s) | | | | | |
| CO1 | To apply the concept of stereochemistry to different compounds. | | | | |
| CO2 | To understand the basic concepts of reaction mechanism. | | | | |
| CO3 | To analyse the mechanism of a chemical reaction. | | | | |
| CO4 | To analyse the stability of different aromatic systems. | | | | |

**Module I: Reaction Mechanism: Basic Concepts (10 hrs)**

[Prerequisites: Homolytic and heterolytic bond breaking – Curved arrow notation, drawing electron movements with arrows, half-headed and double headed arrows. Types of reagents: Electrophiles and nucleophiles.]

Electron Displacement Effects: Inductive effect: Definition – Characteristics - +I and –I groups. Applications: Comparison of acidity of (i) formic acid and acetic acid (ii) chlorobutanoic acids. Mesomeric effect: Definition – Characteristics - +M and –M groups. Applications: Comparison of basicity of aniline, *p*-nitroaniline and *p*-anisidine. Hyperconjugation: Definition – Characteristics. Examples: Propene, ethyl carbocation and ethyl free radical. Applications: relative stability of alkenes, comparison of stabilities of (i) 1-butene and 2-butene (ii) toluene, ethyl benzene and tert-butyl benzene. Electromeric effect: Definition – Characteristics - +E effect (addition of $H^+$ to ethene) and -E effect (addition of $CN^-$ to acetaldehyde). Comparison of electron density in benzene, toluene, phenol, chlorobenzene and nitrobenzene. Steric effect: Definition, reason and examples.

Reaction intermediates: Carbocations, carbanions, free radicals and carbenes (hybridization, structure, formation and stability).

Intermolecular Forces: Introduction. Hydrogen bond: Intra and intermolecular hydrogen bonds - Effect on physical properties. Induction forces and dispersion forces: van der Waals forces, ion-dipole, dipole-dipole, ion-induced dipole, dipole-induced dipole and induced dipole-induced dipole interactions.

**References**

1. Peter Sykes, *A Guide book to Mechanism in Organic Chemistry*, 6th Edn., Pearson Education, New Delhi, 2013.

2. S. M. Mukherjee, S. P. Singh, *Reaction Mechanism In Organic Chemistry*, Macmillan, 1984.

2. P. S. Kalsi, *Organic Reactions, Stereochemistry and Mechanisms*, 4th Edn., New Age International Publishers, New Delhi, 2006.
3. K. S. Tewari, N. K. Vishnoi, S. N. Mehrotra, *A Textbook of Organic Chemistry*, 2nd Edn., Vikas Publishing House, New Delhi, 2004.
4. M. K. Jain, S. C. Sharma, *Modern Organic Chemistry*, 3rd Edn., Vishal Publishing Company Co., 2010.
5. R. T. Morrison, R. N. Boyd, *Organic Chemistry*, 7th Edn., Pearson Education, New Delhi, 2013.
6. I. L. Finar, *Organic Chemistry*, Vol. I, 5th Edn., Pearson Education, New Delhi, 2013.

**Further Reading**

1. Jerry March, *Advanced Organic Chemistry*, 5th Edn., John Wiley & Sons, NewYork, 2004.
2. Reinhard Bruckner, *Advanced Organic Chemistry*, Elsevier, 2002.
4. J. Clayden, N. Greeves, S. Warren, P. Wothers, *Organic Chemistry*, 2nd Edn., Oxford University Press, New York, 2012.
5. V. K. Ahluwalia, *Green Chemistry*, Ane Books India, 2009.

**Module II: Stereochemistry (13 hrs)**

[Prerequisites: *Concept of isomerism*: Types of isomerism - constitutional isomerism (chain, position and functional) and stereoisomerism. *Stereoisomerism*: Classification into conformational isomerism and configurational isomerism. Elements of symmetry of molecules (Identity, proper axis of rotation, plane of symmetry, centre of symmetry and improper axis of rotation).]

Representation of organic molecules: Fischer, Flying wedge, Sawhorse and Newman projections. Inter conversion of different representations.

*Conformational Isomerism*: Conformations – Conformational analysis of ethane and *n*-butane including energy diagrams. Baeyer's strain theory. Conformations of cyclohexane (chair, half chair, boat and twist) - Axial and equatorial bonds - diaxial and flagpole interactions.

Configurational isomerism: Optical isomerism and Geometrical isomerism.

*Optical Isomerism*: Optical activity – Concept of chirality – Chirality in organic molecules: Enantiomers, Diastereomers and Meso compounds. Optical isomerism in glyceraldehyde, lactic acid and tartaric acid. Relative and absolute configuration - DL system, RS system of nomenclature for acyclic optical isomers with one and two asymmetric carbon atoms – sequence rules. Erythro and threo representations (basic idea only). Racemic mixture – Resolution methods – Enantiomeric excess. Asymmetric synthesis (partial and absolute).

*Geometrical Isomerism*: Definition, condition, geometrical isomerism in but-2-ene, fumaric & maleic acid. Cis-trans, syn-anti and E-Z notations with examples.

**References:**

1. D. Nasipuri, *Stereochemistry of Organic Compounds: Principles and Applications*, 3rd Edn., New Age International Publishers, New Delhi, 2011.
2. P. S. Kalsi, *Stereochemistry, Conformation and Mechanisms*, New Age International Publishers, 2005.
3. R. T. Morrison, R. N. Boyd, *Organic Chemistry*, 7th Edn., Pearson Education, New Delhi, 2013.
4. I. L. Finar, *Organic Chemistry*, 5th Edn., Vol. I, Pearson Education, New Delhi, 2013.
5. M. K. Jain, S. C. Sharma, *Modern Organic Chemistry*, 3rd Edn., Vishal Publishing Company Co., 2010.
6. K. S. Tewari, N. K. Vishnoi, S. N. Mehrotra, *A Textbook of Organic Chemistry*, 2nd Edn., Vikas Publishing House, New Delhi, 2004.

**Further Reading**

1. C. N. Pillai, *Organic Chemistry*, Universities Press, 2008.
2. P. Y. Bruice, *Essential Organic Chemistry*, 3rd Edn., Pearson Education, 2015.
3. J. Clayden, N. Greeves, S. Warren, P. Wothers, *Organic Chemistry*, 2nd Edn., Oxford University Press, New York, 2012.

**Module III: Aliphatic Hydrocarbons and alkyl halides (16 hrs)**

[Prerequisites: Nomenclature of hydrocarbons and alkyl halides.]

Alkanes: Preparation from alkyl halides (Reduction of alkyl halides, Wurtz reaction and Corey-House synthesis), from carbonyl compounds (Clemmensen reduction, Wolf-kishner reduction and Kolbe electrolysis). Chemical reactions: Halogenation - Mechanism of free radical chlorination.

Alkenes: Preparation: dehalogenation of dihalides (stereochemistry expected) and dehydration of alcohols. Dehydrohalogenation of alkyl halides (Saytzeff's rule). Chemical reactions: Addition of halogens (electrophilic addition with mechanism), addition of hydrogen halides (Markownikov and Anti-Markownikov addition with mechanism) and addition of water (mechanism expected) – conversion to alcohol (oxymercuration-reduction and hydroboration-oxidation) – Oxidation of alkenes – Epoxidation, dihydroxylation (cis and trans hydroxylation) and oxidative cleavage (permanganate cleavage and ozonolysis).

Alkynes: Preparation from dihalides and acetylides. Chemical reactions: Addition of hydrogen using Lindlar's catalyst and Na/liquid ammonia – Electrophilic addition of halogens and hydrogen halides – Acidity of alkynes – test for terminal alkynes – Oxidation – (Ozonolysis and reaction with alkaline $KMnO_4$). Chemistry of the test for unsaturation: Bromine water and Baeyer's reagent.

Alkyl halides: Preparation – From alkenes and alcohols. Reactions – Types of aliphatic nucleophilic substitution reactions – $S_N1$and $S_N2$ mechanisms with stereochemical aspects

and effects of substrate structure, solvent, nucleophile and leaving group. Elimination reactions: E1 & E2 mechanisms.

**References**

1. Peter Sykes, *A Guide book to Mechanism in Organic Chemistry*, 6th Edn., Pearson Education, New Delhi, 2013.
2. K. S. Tewari, N. K. Vishnoi, S. N. Mehrotra, *A Textbook of Organic Chemistry*, 2nd Edn., Vikas Publishing House, New Delhi, 2004.
3. M. K. Jain, S. C. Sharma, *Modern Organic Chemistry*, 3rd Edn., Vishal Publishing Company Co., 2010.
4. R. T. Morrison, R. N. Boyd, *Organic Chemistry*, 7th Edn., Pearson Education, New Delhi, 2013.
5. I. L. Finar, *Organic Chemistry*, Vol. I, 5th Edn., Pearson Education, New Delhi, 2013.

**Further Reading**

1. Jerry March, *Advanced Organic Chemistry*, 5th Edn., John Wiley & Sons, NewYork, 2004.
2. J. Clayden, N. Greeves, S. Warren, P. Wothers, *Organic Chemistry*, 2nd Edn., Oxford University Press, New York, 2012.
3. V. K. Ahluwalia, *Green Chemistry*, Ane Books India, 2009.

**Module IV: Aromaticity (3 hrs)**

[Prerequisites: Structure of benzene – Huckel's (4n+2)π electron rule.]

Applications of Huckel's rule to aromatic – anti-aromatic – non-aromatic compounds. Aromaticity of benzenoid (benzene, naphthalene and anthracene) nonbenzenoid (furan, thiophene, pyrrole, pyridine) and other cyclic systems – cyclopropene and cyclopropenyl ions, cyclopentadiene and cyclopentadienyl ions, cycloheptatriene and tropylium ion, cyclooctatetraene, azulene and annulenes.

**References:**

1. R. T. Morrison, R. N. Boyd, *Organic Chemistry*, 7th Edn., Pearson Education, New Delhi, 2013.
2. I. L. Finar, *Organic Chemistry*, Vol. I, 5th Edn., Pearson Education, New Delhi, 2013.
3. M. K. Jain, S. C. Sharma, *Modern Organic Chemistry*, 3rd Edn., Vishal Publishing Company Co., 2010.
4. K. S. Tewari, N. K. Vishnoi, S. N. Mehrotra, *A Textbook of Organic Chemistry*, 2nd Edn., Vikas Publishing House, New Delhi, 2004.
5. Peter Sykes, *A Guide book to Mechanism in Organic Chemistry*, 6th Edn., Pearson Education, New Delhi, 2013.

**Further Reading**

1. P. S. Kalsi, *Organic Reactions and their Mechanisms*, New Age International Publishers, 2009.
2. S. H. Pine, *Organic Chemistry*, 5th Edn., McGraw Hill, 1987.
3. Jerry March, *Advanced Organic Chemistry*, 5th Edn., John Wiley & Sons, NewYork, 2004.
4. P. Y. Bruice, *Essential Organic Chemistry*, 3rd Edn., Pearson Education, 2015.
5. J. Clayden, N. Greeves, S. Warren, P. Wothers, *Organic Chemistry*, 2nd Edn., Oxford University Press, New York, 2012.

**Module V: Aromatic Hydrocarbons and Aryl halides (6 hrs)**

[Prerequisites: Module IV: Aromaticity. Electrophile and nucleophile, transition state, intermediate and activation energy.]

Nomenclature of benzene derivatives – Structure and stability of benzene (Kekule, Resonance and Molecular Orbital concepts). Aromatic Electrophilic substitution. Mechanism of nitration, halogenations, sulphonation, Friedel-Craft's alkylation and acylation. Orientation of aromatic substitution – Ring activating and deactivating groups with examples – ortho, para and meta directing groups. Birch reduction of benzene.

Aryl halides: Aromatic nucleophilic substitutions – bimolecular displacement mechanism, elimination-addition (benzyne intermediate) mechanism.

**References:**

1. R. T. Morrison, R. N. Boyd, *Organic Chemistry*, 7th Edn., Pearson Education, New Delhi, 2013.
2. I. L. Finar, *Organic Chemistry*, Vol. I, 5th Edn., Pearson Education, New Delhi, 2013.
3. M. K. Jain, S. C. Sharma, *Modern Organic Chemistry*, 3rd Edn., Vishal Publishing Company Co., 2010.
4. K. S. Tewari, N. K. Vishnoi, S. N. Mehrotra, *A Textbook of Organic Chemistry*, 2nd Edn., Vikas Publishing House, New Delhi, 2004.
5. Peter Sykes, *A Guide book to Mechanism in Organic Chemistry*, 6th Edn., Pearson Education, New Delhi, 2013.

**Further Reading**

1. P. S. Kalsi, *Organic Reactions and their Mechanisms*, New Age International Publishers, 2009.
2. S. H. Pine, *Organic Chemistry*, 5th Edn., McGraw Hill, 1987.
3. Jerry March, *Advanced Organic Chemistry*, 5th Edn., John Wiley & Sons, NewYork, 2004.
4. P. Y. Bruice, *Essential Organic Chemistry*, 3rd Edn., Pearson Education, 2015.

5. J. Clayden, N. Greeves, S. Warren, P. Wothers, *Organic Chemistry*, 2nd Edn., Oxford University Press, New York, 2012.

| **Mark Distribution** | |
|---|---|
| Module I | 16 Marks |
| Module II | 20 Marks |
| Module III | 22 Marks |
| Module IV | 6 Marks |
| Module V | 15 Marks |

# SEMESTER IV

## Course Code: CHE4B05(P)

## Core Course V: INORGANIC CHEMISTRY PRACTICAL – I

Total Hours: 128; Credits: 4; Hours/Week: 2 (I, II, III & IV Semesters); Total Marks 100
(Internal 20 & External 80)

| **CHE4B05 (P)** | **INORGANIC CHEMISTRY PRACTICAL – I** | L | T | P | C |
|---|---|---|---|---|---|
| | | 0 | 0 | 2 | 4 |
| Objective (s) | To enable the students to gain skills in preparation of standard solutions and quantitative volumetric analysis. | | | | |
| Course outcome (s) | | | | | |
| CO1 | To enable the students to develop skills in quatitative analysis and preparing inorganic complexes. | | | | |
| CO2 | To understand the principles behind quantitative analysis. | | | | |
| CO3 | To apply appropriate techniques of volumetric quantitative analysis in estimations. | | | | |
| CO4 | To analyse the strength of different solutions. | | | | |

**General Instructions**

*1. Use safety coat, goggles, shoes and gloves in the laboratory.*

*2. For weighing electronic balance may be used.*

*3. Double burette titration method may be used for acid base titrations in Module III. Single burette method can be followed for other titrations (Module IV- VII).*

*4. Experiments may be selected in such a way that preference may be given for Modules from IV to VII.*

*5. A minimum number of, 1 experiment from module III, 14 experiments covering Modules IV to VII and 4 inorganic preparations must be done to appear for the examination.*

*6. Practical examination will be conducted at the end of semester IV.*

**Module I: Introduction to Volumetric Analysis**

1. Weighing using electronic balance.

2. Preparation of standard solutions.

**Module II: Technique of Quantitative Dilution**

1. Preparation of 100 mL 0.2 M $H_2SO_4$ from commercial acid.

2. Preparation of 250 mL 0.025 M thiosulphate from 0.1 M thiosulphate.

**Module III: Neutralization Titrations**

1. Strong acid – strong base titration.

2. Strong acid – weak base titration.

3. Weak acid – strong base titration.

4. Estimation of $NH_3$ by indirect method.

5. Titration of HCl + $CH_3COOH$ mixture *Vs* NaOH using two different indicators to determine the composition.

6. Estimation of borax.

**Module IV: Redox Titrations**

***a) Permanganometry***

1. Estimation of oxalic acid.

2. Estimation of $Fe^{2+}$/$FeSO_4.7H_2O$/Mohr's salt.

3. Estimation of hydrogen peroxide.

4. Estimation of calcium.

***b) Dichrometry***

1. Estimation of $Fe^{2+}$/$FeSO_4.7H_2O$/Mohr's salt using internal indicator.

2. Estimation of $Fe^{2+}$/$FeSO_4.7H_2O$/Mohr's salt using external indicator.

3. Estimation of ferric iron (after reduction with stannous chloride) using internal indicator.

***c) Iodimetry and Iodometry***

1. Estimation of iodine.

2. Estimation of copper.

3. Estimation of chromium.

**Module V: Precipitation Titration (using adsorption indicator)**

1. Estimation of chloride in neutral medium.

**Module VI: Complexometric Titrations**

1. Estimation of zinc.

2. Estimation of magnesium.

3. Estimation of calcium.

4. Determination of hardness of water.

**Module VII: Some Estimations of Practical Importance**

1. Determination of acetic acid content in vinegar by titration with NaOH.

2. Determination of alkali content in antacid tablets by titration with HCl.

3. Determination of available chlorine in bleaching powder.

4. Determination of COD of water samples.

5. Estimation of citric acid in lemon or orange.

**Module VIII: Inorganic Preparations**

1. Ferric alum
2. Potash alum
3. Mohr's salt
4. Nickel(II) dimethylglyoximate
5. Potassium trisoxalatoferrate(III)
6. Potassium trioxalatochromate(III)
7. Tris(thiourea)copper(I) sulphate
8. Tetraamminecopper(II) sulphate
9. Microcosmic salt
10. Sodium nitroprusside

**References**

1. J. Mendham, R. C. Denney, J. D. Barnes, M. Thomas, *Vogel's Textbook of Quantitative Chemical Analysis*, 6th Edn., Pearson Education, Noida, 2013.
2. D. A. Skoog, D. M. West, F.J. Holler, S. R. Crouch, *Fundamentals of Analytical Chemistry*, 8th Edn., Brooks/Cole, Thomson Learning, USA, 2004.
3. G. D. Christian, *Analytical Chemistry*, 7th Edn., John Wiley and Sons, New York, 2013.
4. A. L. Underwood, *Quantitative Analysis*, 6th Edn., Prentice Hall of India Pvt. Ltd, New Delhi, 1999.
5. D. N. Bajpai, O. P. Pandey, S. Giri, *Practical Chemistry; For I, II & III B. Sc. Students*, S. Chand & Company Ltd., New Delhi, 2012.
6. W.G. Palmer, *Experimental Inorganic Chemistry*, Cambridge University Press, 1970.

# SEMESTER V

## Course Code: CHE5B06

## Core Course VI: INORGANIC CHEMISTRY – III

Total Hours: 48; Credits: 3; Hours/Week: 3; Total Marks 75 (Internal 15 & External 60)

| **CHE5B06** | **INORGANIC CHEMISTRY – III** | L | T | P | C |
|---|---|---|---|---|---|
| | | 3 | 0 | 0 | 3 |
| Objective (s) | To enable the students to gain detailed knowledge of the chemistry of different analytical principles and to develop concerns for environment. To give a basic understanding of different metallurgical processes, interhalogen compounds and inorganic polymers. | | | | |
| Course outcome (s) | | | | | |
| CO1 | To understand the principles behind quanlitative and quantitative analysis. | | | | |
| CO2 | To understand basic processes of metallurgy and to analyse the merits of different alloys. | | | | |
| CO3 | To understand the applications of different inorganic polymers. | | | | |
| CO4 | To analyse different polluting agents. | | | | |
| CO5 | To apply the principles of solid waste management. | | | | |

**Module I: Analytical Principles II (6 hrs)**

Qualitative Analysis: Applications of solubility product and common ion effect in the precipitation of cations – Interfering acid radicals and their elimination (oxalate, fluoride, borate, phosphate, chromate, arsenite and arsenate) – Introduction of micro scale experiments in inorganic and organic qualitative analysis & their advantages. Preparation of $Na_2CO_3$ extract for inorganic qualitative analysis and it's advantages.

Gravimetric analysis – Mechanism of precipitate formation. Factors affecting stability of precipitates. Co-precipitation and post precipitation. Effects of digestion, washing, drying and ignition of precipitates.

**References**

1. Jeffrey A. Lee, *The Scientific Endeavor: A Primer on Scientific Principles and Practice*, Pearson Education, 1999.

2. J. Mendham, R.C. Denney, J. D. Barnes, M. Thomas, *Vogel's Text Book of Quantitative Chemical Analysis*, 6th Edn., Pearson Education, Noida, 2013.

**Further reading**

1. D. A. Skoog, D. M. West, F. J. Holler, S. R. Crouch, *Fundamentals of Analytical Chemistry*, 8th Edn., Brooks/Cole, Thomson Learning, USA, 2004.
2. A. I. Vogel, *A Textbook of Quantitative Inorganic Analysis*, 3rd Edn., Longmans, Green, London, 1962.

**Module II: Metallurgy (10 hrs)**

[Prerequisites: Occurrence of metals based on standard electrode potential – Concentration of ores – Calcination and roasting – Reduction to free metal.]

Electrometallurgy – Hydrometallurgy. Refining of metals: Electrolytic refining, ion exchange method, zone refining, vapour phase refining and oxidative refining – Ellingham diagrams for metal oxides – Extractive metallurgy of Al, Fe, Ni, Cu, Ti and U. Alloys: Definition – Composition and uses of German silver, brass, bronze, gunmetal and alnico. Steel: Open hearth process – classification of steel – Composition and uses of alloy steels – Composition, properties and applications of industrially important stainless steel types: *Austenitic*, *Martensitic* and *Ferritic stainless steels*, Aerospace and automotive applications of stainless steel. Intramedullary rods (a brief study).

**References**

1. B. R. Puri, L. R. Sharma, K. C. Kalia, *Principles of Inorganic Chemistry*, 31st Edn., Milestone Publishers, New Delhi, 2010.
2. S. Prakash, G. D. Tuli, S. K. Basu, R. D. Madan, *Advanced Inorganic Chemistry*, 5th Edn., Vol. I, S Chand, 2012.

**Further reading**

1. A. Cottrel, *An introduction to metallurgy*, 2nd Edn., University press, 1990.
2. Jonathan Beddoes, J. Gordon Parr, *Introduction to stainless steels*, 3rd Edn., ASM International, 1999.

**Module III: Interhalogen compounds (5 hrs)**

[Prerequisites: Halogens, properties, electronic configuration, electronegativity, electron affinity.]

Electropositive character of iodine – General preparation and properties of interhalogen compounds (study of individual members not required) – Structure, hybridization and reactivity of $ClF_3$, $ICl_3$, $IF_5$ and $IF_7$ - Comparison of properties of halogens and pseudohalogens (cyanogens as example) – Structure of polyhalide ions.

**References**

1. B. R. Puri, L. R. Sharma, K. C. Kalia, *Principles of Inorganic Chemistry*, Shoban Lal Nagin Chand and Co., Delhi, 1996.
2. D. F. Shriver, P. W. Atkins, *Inorganic Chemistry*, 3rd Edn., Oxford University Press, 2006.

**Further reading**

1. J. E. Huheey, E. A. Keiter, R. L. Keiter, O. K. Medhi, *Inorganic Chemistry*, 4th Edn., Pearson. 2006.
2. F. A. Cotton, G. Wilkinson, C. Murillo, M. Bochman, *Advanced Inorganic Chemistry*, 6th Edn., John Wiley, New York, 1999.
3. F. A. Cotton, G. Wilkinson, P. L. Gaus, *Basic Inorganic Chemistry*, 3rd Edn., John Wiley, New York, 2008.

**Module IV: Noble Gases (3 hrs)**

[Prerequisites: Why the name noble gas? electronic configuration.]

Discovery – Occurrence – Separation by charcoal adsorption method – Structure of oxides, fluorides and oxy fluorides of xenon – Reaction of xenon fluorides with water – Uses of noble gases.

**References**

1. B. R. Puri, L. R. Sharma, K. C. Kalia, *Principles of Inorganic Chemistry*, Shoban Lal Nagin Chand and Co., Delhi, 1996.
2. D. F. Shriver, P. W. Atkins, *Inorganic Chemistry*, 3rd Edn., Oxford University Press, 2006.
3. M. N. Greenwood, A. Earnshaw, *Chemistry of the elements*, 2nd Edn., Butterworth, 1997.

**Further reading**

1. J. E. Huheey, E. A. Keiter, R. L. Keiter, O. K. Medhi, *Inorganic Chemistry*, 4th Edn., Pearson, 2006.
2. F. A. Cotton, G. Wilkinson, C. Murillo, M. Bochman, *Advanced Inorganic Chemistry*, 6th Edn., John Wiley, New York, 1999.
3. F. A. Cotton, G. Wilkinson, P. L. Gaus, *Basic Inorganic Chemistry*, 3rd Edn., John Wiley, New York, 2008.

**Module V: Inorganic Polymers & Non-aqueous Solvents (8 hrs)**

[Prerequisites: Catenation, Self ionization of water.]

*Inorganic Polymers:* Heterocatenation. Structure and applications of silicones and silicates. Phosphazenes: Preparation, properties and structure of di and tri phosphonitrilic chlorides. SN compounds: Preparation, properties and structure of $S_2N_2$, $S_4N_4$ and (SN)x.

*Non-aqueous Solvents:* Classification – General properties – Self ionization and leveling effect – Reactions in liquid ammonia, liquid $N_2O_4$, liquid $SO_2$ and liquid HF.

**References**

1. B. R. Puri, L. R. Sharma, K. C. Kalia, *Principles of Inorganic Chemistry*, 31st Edn. Milestone Publishers, New Delhi, 2010.
2. S. Prakash, G. D. Tuli, S. K. Basu, R. D. Madan, Advanced Inorganic Chemistry,Vol. I, S Chand, 2006.
3. J. E. Huheey, E. A. Keiter, R. L. Keiter, O. K. Medhi, *Inorganic Chemistry*, 4th Edn., Pearson, 2006.
4. Christian Reichardt, Thomas Welton, Solvents and solvent effect in organic chemistry, Wiley-VCH Verlag GmbH & Co., 2002.

**Further reading**

1. M. Clyde Day, J. Selbin, *Theoretical Inorganic Chemistry*, Reinhold Book Corp., 1962.
2. Sisler, Harry Hall, *Chemistry in non-aqueous solvents*, Reinhold, New York, 1961.

**Module VI: Environmental Pollution (12 hrs)**

[Prerequisites: What is Pollution? quality of drinking water.]

Air pollution: Major air pollutants – Oxides of carbon, nitrogen and sulphur – Particulates – London smog and photochemical smog. Effects of air pollution: Acid rain, greenhouse effect and depletion of ozone. Control of air pollution – Alternate refrigerants. Bhopal Tragedy (a brief study).

Water pollution: Water pollution due to sewage and domestic wastes – Industrial effluents – Agricultural discharge – Eutrophication. Quality of drinking water – Indian standard and WHO standard. Water quality parameters: DO, BOD and COD – Determination of BOD and COD. Toxic metals in water (Pb, Cd and Hg) – Minamata disaster (a brief study). Control of water pollution – Need for the protection of water bodies.

Thermal pollution, noise pollution and radioactive pollution (Sources, effects and consequences). Pollution due to light.

Hiroshima, Nagasaki and Chernobyl accidents (a brief study). Local environmental movements: Silent Valley, Plachimada, Narmada. Air pollution in Indian cities (Delhi, Agra and Kanpur).

**References**

1. S. S. Dara, *A Textbook of Environmental Chemistry and Pollution Control*, 8th Edn., S. Chand and Sons, New Delhi, 2008.
2. A. K. De, *Environmental Chemistry*, 6th Edn., New Age International (P) Ltd., New Delhi, 2006.
3. A. K. Ahluwalia, *Environmental Chemistry*, Ane Books India, New Delhi, 2008.

**Further reading**

1. M. L. Davis, D. A. Cornwell, *Introduction to Environmental Engineering*, 3rd Edn., McGraw Hill, New Delhi, 1998.
2. S. E. Manahan, *Environmental Chemistry*, 8th Edn., CRC Press, Florida, 2004.
3. G. M. Masters, *Introduction to Environmental Engineering and Science*, 3rd Edn., Prentice-Hall Inc., New Delhi, 2007.
4. B. K. Sharma, H. Kaur, *Environmental Chemistry*, Goel Publishing House, Meerut, 1996.
5. M. N. Rao, A. K. Datta, *Waste Water treaement*, Ofxord & IBH Publ, Co. Pvt. Ltd., 1987.

**Module VII: Solid Waste Management (4 hrs)**

[Prerequisites: Aerobic and anaerobic degradation.]

House hold, municipal and industrial solid waste – Non-degradable, degradable and biodegradable waste – Hazardous waste – Pollution due to plastics. Solid waste management: Recycling, digestion, dumping, incineration, land treatment and composting. Impacts of medical waste and *e-waste* and their disposal. Energy production from waste.

**References**

1. R. C. Brunner, *Hazardous Waste Incineration*, McGraw Hill Inc., 1989.
2. A. K. De, *Environmental Chemistry*, 6th Edn., New Age International (P) Ltd., New Delhi, 2006.

| **Mark Distribution** | |
|---|---|
| Module I | 8 Marks |
| Module II | 15 Marks |
| Module III | 10 Marks |
| Module IV | 6 Marks |
| Module V | 14 Marks |
| Module VI | 18 Marks |
| Module VII | 8 Marks |

# SEMESTER V

## Course Code: CHE5B07

## Core Course VII: ORGANIC CHEMISTRY – II

Total Hours: 64; Credits: 3; Hours/Week: 4; Total Marks 75 (Internal 15 & External 60)

| CHE5B07 | ORGANIC CHEMISTRY – II | L | T | P | C |
|---|---|---|---|---|---|
| | | 4 | 0 | 0 | 3 |
| Objective (s) | To give the students a thorough knowledge about the chemistry of selected functional groups and their applications in organic preparations. | | | | |
| Course outcome (s) | | | | | |
| CO1 | To understand the difference between alcohols and phenols. | | | | |
| CO2 | To understand the importance of ethers and epoxides. | | | | |
| CO3 | To apply organometallic compounds in the preparation of different functional groups. | | | | |
| CO4 | To apply different reagents for the inter conversion of aldehydes, carboxylic acids and acid derivatives. | | | | |
| CO5 | To apply active methylene compounds in organic preparations. | | | | |

**Module I: Alcohols and Phenols (14 hrs)**

[Prerequisites: Monohydric alcohols – Nomenclature, hydrogen bonding.]

Methods of formation of alcohols by reduction of carbonyl compounds. Reaction of carbonyl compounds with Grignard reagent. From alkenes (hydration, hydroboration oxidation and oxymercuration-demercuration reactions). Reactions of alcohols: Acidic and basic nature of alcohols, formation of ester, reaction with hydrogen halides (Lucas test), oxidation (with PCC and $KMnO_4$) – pinacol-pinacolone rearrangement (mechanism expected). Victor Meyer's test.

Phenols - Nomenclature, preparation of phenols (from cumene and aromatic sulphonic acid) and acidity of phenol (substituent effects). Reactions of phenols – electrophilic aromatic substitution (bromination, nitration and sulphonation) and carboxylation (Kolbe Schmitt reaction). Riemer-Tiemann reaction (mechanism expected), Liebermann's nitroso reaction and Hauben-Hoesch reaction. Preparation of phenolphthalein and fluorescein and colour change of phenolphthalein with pH.

**References**

1. R. T. Morrison, R. N. Boyd, *Organic Chemistry*, 7th Edn., Pearson Education, New Delhi, 2013.

2. I. L. Finar, *Organic Chemistry*, Vol. I, 5th Edn., Pearson Education, New Delhi, 2013.

3. M. K. Jain, S. C. Sharma, *Modern Organic Chemistry*, 3rd Edn., Vishal Publishing Company Co., 2010.

4. K. S. Tewari, N. K. Vishnoi, S. N. Mehrotra, *A Textbook of Organic Chemistry*, 2nd Edn., Vikas Publishing House, New Delhi, 2004.

**Further reading**

1. B. S. Bahl, *Advanced organic Chemistry*, 3rd Edn., S. Chand, 2002.
2. John McMurry, *Organic Chemistry*, 5th Edn., Thompson Asia Pvt. Ltd., 2000.
3. C. N. Pillai, *Organic Chemistry*, Universities Press, 2008.

**Module II: Ethers and Epoxides (5 hrs)**

[Prerequisites: Ethers - Nomenclature – Isomerism – Preparation by Williamson's synthesis.]

Reactions of ethers: Acidic cleavage and Claisen rearrangement (mechanism expected) – Zeisel's method of estimation of methoxy groups. Crown ethers: Nomenclature – importance in organic synthesis and phase transfer catalysis (PTC).

Epoxides: Synthesis from alkenes – acid catalyzed ring opening of epoxides, orientation of epoxide ring opening, reactions of Grignard and organolithium reagents with epoxides.

**References**

1. R. T. Morrison, R. N. Boyd, *Organic Chemistry*, 7th Edn., Pearson Education, New Delhi, 2013.
2. I. L. Finar, *Organic Chemistry*, Vol. I, 5th Edn., Pearson Education, New Delhi, 2013.
3. M. K. Jain, S. C. Sharma, *Modern Organic Chemistry*, 3rd Edn., Vishal Publishing Company Co., 2010.
4. K. S. Tewari, N. K. Vishnoi, S. N. Mehrotra, *A Textbook of Organic Chemistry*, 2nd Edn., Vikas Publishing House, New Delhi, 2004.

**Further reading**

1. B. S. Bahl, *Advanced organic Chemistry*, 3rd Edn., S. Chand, 2002.
2. John McMurry, *Organic Chemistry*, 5th Edn., Thompson Asia Pvt Ltd., 2000.
3. C. N. Pillai, *Organic Chemistry*, Universities Press, 2008.

**Module III: Organometallic Compounds (2 hrs)**

Preparation and synthetic applications of Grignard reagent and organozinc compounds.

**References**

1. R. T. Morrison, R. N. Boyd, *Organic Chemistry*, 7th Edn., Pearson Education, New Delhi, 2013.
2. I. L. Finar, *Organic Chemistry*, Vol. I, 5th Edn., Pearson Education, New Delhi, 2013.
3. M. K. Jain, S. C. Sharma, *Modern Organic Chemistry*, 3rd Edn., Vishal Publishing Company Co., 2010.
4. K. S. Tewari, N. K. Vishnoi, S. N. Mehrotra, *A Textbook of Organic Chemistry*, 2nd Edn., Vikas Publishing House, New Delhi, 2004.

5. B. S. Bahl, *Advanced organic Chemistry*, 3rd Edn., S. Chand, 2002.

**Further reading**

1. P. Y. Bruice, *Essential Organic Chemistry*, 3rd Edn., Pearson Education, 2015.
2. John McMurry, *Organic Chemistry*, 5th Edn., Thompson Asia Pvt Ltd., 2000.

**Module IV: Aldehydes and Ketones (11 hrs)**

[Prerequisites: Nomenclature – Isomerism. Preparation: From alcohols, cyanides, acid chlorides and Etard's reaction.]

Nucleophilic addition reactions – Carbon nucleophiles (addition of HCN, Wittig reaction), Oxygen nucleophiles ($H_2O$, alcohols,), Nitrogen nucleophiles ($NH_3$, hydroxyl amine, hydrazine, semicarbazide and DNP reagent) and Sulfur nucleophiles (sodium bisulfate). Oxidation – acidified $K_2Cr_2O_7$, $KMnO_4$, $CrO_3$; Oppenauer oxidation. Distinguishing aldehydes and ketones (Tollen's reagent, Fehling's solution); Reduction – Catalytic hydrogenation, Wolf-Kishner, Clemmensen, metal hydride ($LiAlH_4$ and $NaBH_4$) and MPV reduction. Reactions involving $\alpha$ carbons of carbonyl compounds – Aldol condensation, Cannizzaro reaction Benzoin condensation and Perkin's reactions. Haloform reaction (mechanism expected). Synthetic utility of Wittig reaction, Reformatsky reaction and Beckmann rearrangement.

**References**

1. R. T. Morrison, R. N. Boyd, *Organic Chemistry*, 7th Edn., Pearson Education, New Delhi, 2013.
2. I. L. Finar, *Organic Chemistry*, Vol. I, 5th Edn., Pearson Education, New Delhi, 2013.
3. M. K. Jain, S. C. Sharma, *Modern Organic Chemistry*, 3rd Edn., Vishal Publishing Company Co., 2010.
4. K. S. Tewari, N. K. Vishnoi, S. N. Mehrotra, *A Textbook of Organic Chemistry*, 2nd Edn., Vikas Publishing House, New Delhi, 2004.
5. B. S. Bahl, *Advanced organic Chemistry*, 3rd Edn., S. Chand, 2002.

**Further reading**

1. P. Y. Bruice, *Essential Organic Chemistry*, 3rd Edn., Pearson Education, 2015.
2. John McMurry, *Organic Chemistry*, 5th Edn., Thompson Asia Pvt. Ltd., 2000.
3. C. N. Pillai, *Organic Chemistry*, Universities Press, 2008.

**Module V: Carboxylic Acids and Sulphonic Acids (14 hrs)**

[Prerequisites: Carboxylic Acids: Nomenclature – Isomerism. Preparation.]

Carboxylic acids – Hydrolysis of nitrile and carboxylation of Grignard reagent. Chemical properties: Acidity (effect of substituent on the acidity of aliphatic and aromatic carboxylic acids). Reactions of carboxylic acids – conversion to acid chlorides, esters, amides and acid

anhydrides. Relative reactivity of carboxylic acid derivatives (acid chlorides, esters, amides and acid anhydrides). Fischer esterification (mechanism expected), HVZ reaction – Decarboxylation – Kolbe electrolysis (mechanism expected). Hydroxy acids – Citric acid – preparation by Reformatsky reaction and uses. Lactic acid, Malic acid and Tartaric acid (structure only). Methods of formation and chemical reactions of unsaturated monocarboxylic acids (cinnamic acid and crotonic acid). Ascend and descend in carboxylic acid series.

Sulphonic Acids: Preparation and properties of benzene sulphonic acid – Tosylation.

Comparison of acidity of alcohols, phenols, carboxylic acids and sulphonic acids.

**References**

1. R. T. Morrison, R. N. Boyd, *Organic Chemistry*, 7th Edn., Pearson Education, New Delhi, 2013.

2. I. L. Finar, *Organic Chemistry*, Vol. I, 5th Edn., Pearson Education, New Delhi, 2013.

3. M. K. Jain, S. C. Sharma, *Modern Organic Chemistry*, 3rd Edn., Vishal Publishing Company Co., 2010.

4. K. S. Tewari, N. K. Vishnoi, S. N. Mehrotra, *A Textbook of Organic Chemistry*, 2nd Edn., Vikas Publishing House, New Delhi, 2004.

5. B. S. Bahl, *Advanced organic Chemistry*, 3rd Edn., S. Chand, 2002.

**Further reading**

1. R. K. Bansal, *A Textbook of Organic Chemistry*, New Age International, 2010.

2. John McMurry, *Organic Chemistry*, 5th Edn., Thompson Asia Pvt. Ltd., 2000.

3. C. N. Pillai, *Organic Chemistry*, Universities Press, 2008.

**Module VI: Nitrogen Compounds (14 hrs)**

[Prerequisites: Nitro-aci tautomerism – Difference between alkyl nitrites and nitro alkanes. Diazotization and coupling.]

Nitro Compounds: Ketones from nitro compounds – Nef reaction (mechanism not required) – Reduction products of nitrobenzene in acidic, neutral and alkaline media.

Amines: Nomenclature – Isomerism. Preparation: From alkyl halides, nitro compounds, nitriles, isonitriles and amides – Hofmann's bromamide reaction, Schmidt reaction and Gabriel phthalmide synthesis. Chemical properties: Basicity (effect of substituents on the basicity of aliphatic and aromatic amines), carbylamine reaction, conversion of amine to alkene (Hofmann's elimination with mechanism and stereochemistry), acylation and reaction with nitrous acid. Electrophilic substitution reactions of aniline: Halogenation, nitration and sulphonation. Preparation and uses sulpha drugs – Structural formula of sulphapyridine, sulphadiazine, sulphathiazole and sulphaguanidine. Separation of amines by Hinsberg's method.

Synthetic transformations of aryl diazonium salts, azo coupling. Preparation of methyl orange – Reason for its colour change with pH.

Carbonic Acid Derivatives: Preparation and properties of urea – Estimation of urea (hypobromite method and urease method) – preparation and basicity of guanidine.

**References**

1. R. T. Morrison, R. N. Boyd, *Organic Chemistry*, 7th Edn., Pearson Education, New Delhi, 2013.

2. I. L. Finar, *Organic Chemistry*, Vol. I, 5th Edn., Pearson Education, New Delhi, 2013.

3. M. K. Jain, S. C. Sharma, *Modern Organic Chemistry*, 3rd Edn., Vishal Publishing Company Co., 2010.

4. K. S. Tewari, N. K. Vishnoi, S. N. Mehrotra, *A Textbook of Organic Chemistry*, 2nd Edn., Vikas Publishing House, New Delhi, 2004.

5. B. S. Bahl, *Advanced organic Chemistry*, 3rd Edn., S. Chand, 2002.

**Further Reading**

1. P. Y. Bruice, *Essential Organic Chemistry*, 3rd Edn., Pearson Education, 2015.

2. John McMurry, *Organic Chemistry*, 5th Edn., Thompson Asia Pvt Ltd, 2000.

3. C. N. Pillai, *Organic Chemistry*, Universities Press, 2008.

4. J. Clayden, N. Greeves, S. Warren, P. Wothers, *Organic Chemistry*, Oxford University Press, New York, 2012.

**Module VII: Heterocyclic & Active Methylene Compounds (4 hrs)**

Heterocyclic Compounds: Classification – Nomenclature – Preparation and properties of furan and pyridine. Indole – Fischer indole synthesis and resonance structures.

Active Methylene Compounds: Examples – Preparation of ethyl acetoacetate by Claisen condensation (mechanism expected) – Tautomerism – Synthetic applications of ethylacetoacetate.

**References**

1. R. T. Morrison, R. N. Boyd, *Organic Chemistry*, 7th Edn., Pearson Education, New Delhi, 2013.

2. I. L. Finar, *Organic Chemistry*, Vol. I, 5th Edn., Pearson Education, New Delhi, 2013.

3. M. K. Jain, S. C. Sharma, *Modern Organic Chemistry*, 3rd Edn., Vishal Publishing Company Co., 2010.

4. K. S. Tewari, N. K. Vishnoi, S. N. Mehrotra, *A Textbook of Organic Chemistry*, 2nd Edn., Vikas Publishing House, New Delhi, 2004.

**Further reading**

1. John McMurry, *Organic Chemistry*, 5th Edn., Thompson Asia Pvt Ltd, 2000.

2. C. N. Pillai, *Organic Chemistry*, Universities Press, 2008.

| **Mark Distribution** | |
|---|---|
| Module I | 16 Marks |
| Module II | 8 Marks |
| Module III | 4 Marks |
| Module IV | 14 Marks |
| Module V | 15 Marks |
| Module VI | 16 Marks |
| Module VII | 6 Marks |

# SEMESTER V

## Course Code: CHE5B08

## Core Course VIII: PHYSICAL CHEMISTRY – II

Total Hours: 48; Credits: 3; Hours/Week: 3; Total Marks 75 (Internal 15 & External 60)

| **CHE5B08** | **PHYSICAL CHEMISTRY – II** | L | T | P | C |
|---|---|---|---|---|---|
| | | 3 | 0 | 0 | 3 |
| Objective (s) | To familiarise the students with the concepts of kinetics, catalysis and photochemistry and to familiarize the applications of molecular spectroscopy and phase equilibrium. | | | | |
| Course outcome (s) | | | | | |
| CO1 | To apply the concept of kinetics, catalysis and photochemistry to various chemical and physical processes. | | | | |
| CO2 | To characterise different molecules using spectral methods. | | | | |
| CO3 | To understand various phase transitions and its applications. | | | | |

**Module I: Kinetics (10 hrs)**

[Prerequisites: Fundamentals of Kinetics – Introduction – Derivation of rate constants for first, second (with same and different reactants), third (with same reactants only) and zero order reactions with examples (graphical representations needed) – Half life period (derivation for first and $n^{th}$ order reactions).]

Factors affecting the rate of reactions - Methods to determine the order of a reaction – Steady state approximation – Parallel reactions, opposing reactions, consecutive reactions and chain reactions with examples (elementary idea only) – Arrhenius equation – Effect of temperature on reaction rates. Determination and significance of Arrhenius parameters – Theories of reaction rates – Collision theory – Derivation of rate equation for bimolecular reactions using collision theory – Transition state theory – Expression for rate constant based on equilibrium constant and thermodynamic aspects (derivation not required) – Unimolecular reactions – Lindemann mechanism.

**Module II: Adsorption and Catalysis (6 hrs)**

[Prerequisites: Physical and chemical adsorption, factors affecting adsorption.]

Adsorption isotherms: Freundlich and Langmuir isotherms (derivation required) – Multilayer adsorption – BET equation (derivation not needed) and its applications to surface area measurements. Applications of adsorption.

*Catalysis:* Homogeneous and heterogenous catalysis – Theories of homogenous and heterogenous catalysis – Enzyme catalysis – Michaelis-Menten equation (derivation not required).

**References**

1. B. R. Puri, L. R. Sharma, M. S. Pathania, *Principles of Physical Chemistry*, 46th Edn., Vishal Publishing Company, New Delhi, 2013.

2. P. W. Atkins, J. de Paula, *Atkin's Physical Chemistry*, 8th Edn., Oxford University Press, 2006.

3. Donald A. McQuarrie, John D. Simon, *Physical Chemistry: A Molecular Approach*, University Science Books: Sausalito, CA; 1997.

4. K. Laidler, *Chemical Kinetics*, 3rd Edn., Pearson Education, New Delhi, 2004.

5. P. L. Soni, O. P. Dharmarha, U. N. Dash, *Textbook of Physical Chemistry*, 23rd Edn., Sultan Chand & Sons, New Delhi, 2011.

6. K. L. Kapoor, *Physical Chemistry*, Vol. II and III, Macmillan Publishers, Noida, 2004.

**Further reading**

1. Gordon M. Barrow, *Physical Chemistry*, 5th Edn., Tata McGraw Hill Education, New Delhi, 2006.

2. S. Glasstone, D. H. Lewis, *Elements of Physical Chemistry*, 2nd Edn., Macmillan & Company, UK, 1962.

3. F. Daniels, R. A. Alberty, *Physical Chemistry*, 5th Edn., John Wiley and Sons, Canada, 1980.

4. P. W. Atkins, J. de Paula, *The Elements of Physical Chemistry*, 7th Edn., Oxford University Press, Oxford, 2016.

**Module III: Phase Equilibria (10 hrs)**

[Prerequisites: Concept of phase - solid, liquid and gas - homogeneous and heterogeneous phase - component and degree of freedom.]

Gibbs phase rule and its derivation. Clausius-Clapeyron equation and its applications to solid-liquid, liquid-vapour and solid-vapour equilibria, phase diagram for one component systems, with applications. One component systems: Water and sulphur systems. Two component systems: Simple eutectic system (lead - silver system) – Pattinson's process – Two component systems involving formation of compounds with congruent melting points (zinc-magnesium system and ferric chloride-water system) – Two component systems involving formation of compounds with incongruent melting points (sodium sulphate-water system). Freezing mixtures – Thermal analysis – Cooling curve method – Deliquescence and efflorescence.

Liquid-liquid equilibria – Partially miscible and immiscible liquid systems – CST – Upper CST and lower CST – Steam distillation. Nernst distribution law: Derivation and applications.

**References**

1. B. R. Puri, L. R. Sharma, M. S. Pathania, *Principles of Physical Chemistry*, 46th Edn., Vishal Publishing Company, New Delhi, 2013.

2. P. W. Atkins, J. de Paula, *Atkin's Physical Chemistry*, 8th Edn., Oxford University Press, 2006.

3. Donald A. McQuarrie, John D. Simon, *Physical Chemistry: A Molecular Approach*, University Science Books: Sausalito, CA; 1997.

4. P. L. Soni, O. P. Dharmarha, U. N. Dash, *Textbook of Physical Chemistry*, 23rd Edn., Sultan Chand & Sons, New Delhi, 2011.

**Further reading**

1. Gordon M. Barrow, *Physical Chemistry*, 5th Edn., Tata McGraw Hill Education, New Delhi, 2006.

2. K. L. Kapoor, *Physical Chemistry*, Vol. II and III, Macmillan Publishers, Noida, 2004.

3. S. Glasstone, D. H. Lewis, *Elements of Physical Chemistry*, 2nd Edn., Macmillan & Company, UK, 1962.

4. F. Daniels, R. A. Alberty, *Physical Chemistry*, 5th Edn., John Wiley and Sons, Canada, 1980.

5. P. W. Atkins, J. de Paul,a *The Elements of Physical Chemistry*, 7th Edn., Oxford University Press, Oxford, 2016.

**Module IV: Molecular Spectroscopy I (12 hrs)**

[Prerequisites: Electromagnetic spectrum - wavelength, frequency, wavenumber.]

Interaction of electromagnetic radiation with matter – Qualitative aspects, Einstein, absorption-emission and factors affecting line width and intensity of signal (elementary idea) - Energy levels in molecules – Born-Oppenheimer approximation.

*Rotational Spectroscopy:* Introduction – Rigid rotor – Expression for energy – Selection rules – Intensities of spectral lines – Determination of bond lengths of diatomic molecules.

*Vibrational Spectroscopy:* Simple harmonic oscillator – Energy levels – Force constant – Selection rules - Anharmonicity – Fundamental frequencies – Overtones – Fingerprint

region – Group frequency concept – Degree of freedom for polyatomic molecules – Modes of vibrations of $CO_2$ and $H_2O$.

*Raman Spectroscopy:* Basic principles – Qualitative treatment of rotational Raman effect – Vibrational Raman spectra – Stokes & anti-stokes lines and their intensity difference – Selection rules – Mutual exclusion principle.
*Electronic Spectroscopy:* Basic principles – Frank-Condon principle – Electronic transitions – Beer Lamberts law - Dissociation energy of diatomic molecules – Chromophore and auxochrome – Bathochromic and hypsochromic shifts.

**Module V: Molecular Spectroscopy II (4 hrs)**

[Prerequisites: Electromagnetic spectrum – energy range and frequency.]

*Nuclear Magnetic Resonance (NMR) Spectroscopy:* Proton NMR and $^{13}C$ NMR – Principle – Number and position of signals – Chemical shift – Different scales – Spin-spin coupling (qualitative idea). NMR spectra of simple molecules.
*Electron Spin Resonance (ESR) Spectroscopy:* Principle – Hyperfine structure – ESR of methyl, phenyl and cycloheptatrienyl radicals.

**References**

1. B. R. Puri, L. R. Sharma, M. S. Pathania, *Principles of Physical Chemistry*, 46th Edn., Vishal Publishing Company, New Delhi, 2013.

2. P. W. Atkins, J. de Paula, *Atkin's Physical Chemistry*, 8th Edn., Oxford University Press 2006.

3. Donald A. McQuarrie, John D. Simon, *Physical Chemistry: A Molecular Approach*, University Science Books: Sausalito, CA; 1997.

4. C. N. Banwell, *Fundamentals of molecular spectroscopy*, McGraw-Hill, 1994.

5. G. M. Barrow, *Introduction to Molecular Spectroscopy*, McGraw Hill, London, 1962.

**Further reading**

1. G. M. Barrow, *Physical Chemistry*, 5th Edn., Tata McGraw Hill Education, New Delhi, 2006.

2. K. L. Kapoor, *Physical Chemistry*, Vol. II and III, Macmillan Publishers, Noida, 2004.

3. S. Glasstone, D. H. Lewis, *Elements of Physical Chemistry*, 2nd Edn., Macmillan & Company, UK, 1962.

4. F. Daniels, R. A. Alberty, *Physical Chemistry*, 5th Edn., John Wiley and Sons, Canada, 1980.

5. Peter Atkins, J. de Paula, *The Elements of Physical Chemistry*, 7th Edn., Oxford University Press, Oxford, 2016.

6. P. R. Singh, S. K. Dixit, *Molecular Spectroscopy: Principles and Chemical Applications*, S. Chand & Company, New Delhi 1980.

7. P. K. Bhattacharya, *Group Theory and its Chemical Applications*, Himalaya Publishing House, New Delhi, 1986.

8. F. A. Cotton, *Chemical Applications of Group Theory*, 3rd Edn., John Wiley & Sons, New Delhi.

**Module VI: Photochemistry (6 hrs)**

[Prerequisites: Introduction – Difference between thermal and photochemical processes – Beer Lambert's law.]

Laws of photochemistry: Grothus-Draper law and Stark-Einstein's law of photochemical equivalence. Quantum yield and its explanation – Photophysical processes: Jablonski diagram – Fluorescence – Phosphorescence. Non-radiative processes: Internal conversion and inter system crossing. Photosensitization – Chemiluminescence – Photochemical reactions (hydrogen-chlorine and hydrogen-bromine).

**References**

1. B. R. Puri, L. R. Sharma, M. S. Pathania, *Principles of Physical Chemistry*, 46th Edn., Vishal Publishing Company, New Delhi, 2013.

2. P. W. Atkins, J. de Paula, *Atkin's Physical Chemistry*, 8th Edn., Oxford University Press, 2006.

3. Donald A. McQuarrie, John D. Simon, *Physical Chemistry: A Molecular Approach*, University Science Books: Sausalito, CA; 1997.

4. K. K. Rohatgi-Mukherjee, *Fundamentals of Photochemistry*, New Age International, 1978.

**Further reading**

1. G. M. Barrow, *Physical Chemistry*, 5th Edn., Tata McGraw Hill Education, New Delhi, 2006.

2. K. L. Kapoor, *Physical Chemistry*, Vol. II and III, Macmillan Publishers, Noida, 2004.

3. S. Glasstone, D. H. Lewis, *Elements of Physical Chemistry*, 2nd Edn., Macmillan & Company, UK, 1962.

4. F. Daniels, R. A. Alberty, *Physical Chemistry*, 5th Edn., John Wiley and Sons, Canada, 1980.

5. Peter Atkins, Julio de Paula, *The Elements of Physical Chemistry*, 7th Edn., Oxford University Press, Oxford, 2016.

6. K. Laidler, *Chemical Kinetics*, 3rd Edn., Pearson Education, New Delhi, 2004.

| **Mark Distribution** | |
|---|---|
| Module I | 17 Marks |
| Module II | 10 Marks |
| Module III | 17 Marks |
| Module IV | 18 Marks |
| Module V | 7 Marks |
| Module VI | 10 Marks |

**SEMESTER VI**

**Course Code: CHE6B09**

**Core Course IX: INORGANIC CHEMISTRY – IV**

Total Hours: 48; Credits: 3; Hours/Week: 3; Total Marks 75 (Internal 15 & External 60)

| **CHE6B09** | **INORGANIC CHEMISTRY – IV** | L | T | P | C |
|---|---|---|---|---|---|
| | | 3 | 0 | 0 | 3 |
| Objective (s) | To gain detailed knowledge of the electronic configuration and properties of transition and inner transition elements and their role in biological systems. To introduce the importance of different instruments used in analysis. | | | | |
| Course outcome (s) | | | | | |
| CO1 | To understand the principles behind different instrumental methods. | | | | |
| CO2 | To distinguish between lanthanides and actinides. | | | | |
| CO3 | To appreciate the importance of CFT. | | | | |
| CO4 | To understand the importance of metals in living systems. | | | | |
| CO5 | To distinguish geometries of coordination compounds. | | | | |

**Module I: Instrumental Methods of Analysis (10 hrs)**

[Prerequisites: laws of spectrophotometry - Beer-Lambert's law.]

Atomic Absorption Spectroscopy (AAS), Flame Emission Spectroscopy – Colorimetry – Spectrophotometry, Atomic Force Microscopy (AFM), Scanning Electron Microscopy (SEM), Transmission Electron Microscopy (TEM), Thermogravimetry (TGA), Differential Scanning Calorimetry (DSC) and Cyclic Voltammetry (CV). [Principle and applications only.]

**References**

1. D. A. Skoog, F. James Holler, S. R. Crouch, *Principles of Instrumental Analysis*, 6th Edn., Cengage Learning; Noida, 2004.
2. H. H. Willard, L. L. Merritt, J. A. Dean, F. A Settle, *Instrumental methods of Analysis*, CBS Publishers & Distributors, Delhi, 1996.
3. H. H. Willard, L. L. Merritt, J. A. Dean, F. A. Steptoe, *Instrumental Methods of Analysis*, 7th Edn., Wadsworth Publishing Co. Ltd., Belmont, California, USA, 1988.

**Further reading**

1. D. A. Skoog, D. M. West, F. J. Holler, *Fundamentals of Analytical Chemistry*, 6th Edn., Saunders College Publishing, Fort Worth, 1992.
2. D. C. Harris, Quantitative Chemical Analysis, 5th Edn., W. H. Free-man and Company, NewYork, 1999.

**Module II: Transition and Inner Transition Elements (8 hrs)**

[Prerequisites: *Transition Metals:* General characteristics: Metallic character, oxidation states, size, density, melting point, boiling point. *Lanthanides:* Electronic configuration and general characteristics.]

*Transition Metals*: 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.

Explanation of metallic properties of transition metals based on theories of Metallic Bonding: Free electron theory, valence bond theory and band theory (qualitative treatment only).

*Lanthanides:* Occurrence of lanthanides – Importance of beach sands of Kerala – Isolation of lanthanides from monazite sand – Separation by ion exchange method. Lanthanide contraction: Causes and consequences. Industrial importance of lanthanides.

*Actinides:* Electronic configuration and general characteristics – Comparison with lanthanides.

**References**

1. J. D. Lee, *Concise Inorganic Chemistry*, 5th Edn., Wiley India Pvt. Ltd., 2008.
2. B. R. Puri, L. R. Sharma, K. C. Kalia, *Principles of Inorganic Chemistry*, Milestone Publishers, New Delhi, 2010.
3. J. E. Huheey, E. A. Keiter, R. L. Keiter, O. K. Medhi, *Inorganic Chemistry*, Pearson, 2006.

**Further reading**

1. F. A. Cotton, G. Wilkinson, *Advanced Inorganic Chemistry*, 6th Edn., John Wiley, New York. 1999.
2. D. F. Shriver, P. W. Atkins, *Inorganic Chemistry*, 3rd Edn., Oxford University Press, 2009.

**Module III: Coordination Chemistry (16 hrs)**

[Prerequisites: Coordinate bond, postulates of Werner's theory, ligand, coordination number, homoleptic and heteroleptic complex, isomerism in coordination compounds, difference between double salt and complex.]

Bonding theories: Review of Werner's theory and Sidgwick's concept of coordination – EAN rule – Valence Bond theory – Geometries of coordination numbers 4 and 6 – Limitations of VBT. Crystal filed theory – Splitting of *d*-orbitals in octahedral, tetrahedral, tetragonal and square planar complexes – Factors affecting crystal field splitting – CFSE of low spin and high spin octahedral complexes – Spectrochemical series – Explanation of geometry, magnetism and colour – Distorted octahedral complexes - Jahn-Teller Theorem, CFSE – calculation and its applications. Merits and demerits of Crystal field theory.

Molecular orbital theory for octahedral complexes (with sigma bonds only). Stability of complexes: Inert and labile complexes – Factors influencing stability. Application of complexes in qualitative and quantitative analysis.

**References**

1. R. Gopalan, V. Ramalingam, *Concise Coordination Chemistry*, 1st Edn., Vikas Publishing House, New Delhi, 2001.
2. R. Puri, L. R. Sharma, K. C. Kalia, *Principles of Inorganic Chemistry*, 31st Edn., Milestone Publishers, New Delhi, 2010.
3. J. D. Lee, *Concise Inorganic Chemistry*, 5th Edn., Wiley India Pvt. Ltd., 2008.

**Further reading**

1. F. A. Cotton, G. Wilkinson, *Advanced Inorganic Chemistry*, 6th Edn., Wiley India Pvt. Ltd., New Delhi, 2009.
2. J. E. Huheey, E. A. Keitler, R. L. Keitler, *Inorganic Chemistry – Principles of Structure and Reactivity*, 4th Edn., Pearson Education, New Delhi, 2013.
3. D. F. Shriver, P. Atkins, *Inorganic Chemistry*, 5th Edn., Oxford University Press, New York, 2010.
4. F. Basolo, R. C. Johnson, *Coordination Chemistry*, 2nd Edn., Science Reviews, Wilmington, 1986.
5. G. L. Meissler, D. A. Tarr, *Inorganic Chemistry*, 3rd Edn., Pearson Education, 2004.

**Module IV: Organometallic Compounds (6 hrs)**

[Prerequisites: Uniqueness of carbon, covalent bond, coordinate bond, bonding in carbon monoxide.]

Definition – Classification based on the nature of metal-carbon bond – Zeise's salt. 18-electron rule. Metal carbonyls - Mononuclear and Polynuclear carbonyls of Fe, Co and Ni (structure only) – Bonding in metal carbonyls.

Ferrocene: Preparation, properties and bonding (VBT only).

Catalysis: Zeigler Natta catalyst in the polymerization and Wilkinson catalyst in the hydrogenation of alkene.

**References**

1. P. Powell, *Principles of Organometallic Compounds*, 2nd Edn., Chapman and Hall, London, 1988.
2. B. R. Puri, L. R. Sharma, K. C. Kalia, *Principles of Inorganic Chemistry*, 31st Edn., Milestone Publishers, New Delhi 2010.
3. G. L. Meissler, D. A. Tarr, *Inorganic Chemistry*, 3rd Edn., Pearson Education, 2004.
4. J. E. Huheey, E. A. Keiter, R. L. Keiter, O. K. Medhi, *Inorganic Chemistry*, Pearson, 2006.

**Further reading**

1. R. C. Mehrothra, A. Singh, *Organometallic chemistry*, New age publishers, 1991.

**Module V: Bioinorganic Chemistry (8 hrs)**

[Prerequisites: Metal ions in biological system – Trace and bulk metal ions.]

Haemoglobin and Myoglobin (elementary idea of structure and oxygen binding mechanism) – Chlorophyll and photosynthesis (mechanism not expected) – Sodium-potassium pump – Biochemistry of Ca, Zn and Co – Toxicity of metal ions (Pb, Hg and As). Anticancer drugs: *Cis*-platin, oxaliplatin, carboplatin and auranofin – Structure and significance.

**References**

1. B. R. Puri, L. R. Sharma, K. C. Kalia, *Principles of Inorganic Chemistry*, Milestone Publishers, New Delhi, 2010.
2. G. L. Meissler, D. A. Tarr, *Inorganic Chemistry*, 3rd Edn. Pearson Education, 2004.
3. J. E. Huheey, E. A. Keiter, R. L. Keiter, O. K. Medhi, *Inorganic Chemistry*, 5th Edn. Pearson, 2009.
4. F. A. Cotton, G. Wilkinson, P. L. Gaus, *Basic Inorganic Chemistry*, 3rd Edn., John Wiley, 1995.

**Further reading**

1. B. Douglas, D. Mc Daniel, J. Alexander, *Concepts and models of Inorganic Chemistry*, 3rd Edn., John Wiley, 1994.
2. I. Bertini, H. B. Gray, S. J. Lippard, J. Selvertone Valentine, *Bioinorganic Chemistry*, Viva Books Pvt. Ltd., 2007.

| Mark Distribution | |
|---|---|
| Module I | 15 Marks |
| Module II | 14 Marks |
| Module III | 24 Marks |
| Module IV | 12 Marks |
| Module V | 14 Marks |

## SEMESTER VI

## Course Code: CHE6B10

## Core Course X: ORGANIC CHEMISTRY – III

Total Hours: 48; Credits: 3; Hours/Week: 3; Total Marks 75 (Internal 15 & External 60)

| CHE6B10 | ORGANIC CHEMISTRY – III | L | T | P | C |
|---|---|---|---|---|---|
| | | 3 | 0 | 0 | 3 |
| Objective(s) | To gain detailed knowledge of the chemistry of different bio molecules. To provide a basic understanding of different spectral techniques and their application in simple molecules. To differentiate diverse pericyclic reactions. | | | | |
| Course outcome (s) | | | | | |
| CO1 | To elucidate the structure of simple organic compounds using spectral techniques. | | | | |
| CO2 | To understand the basic structure and tests for carbohydrates. | | | | |
| CO3 | To understand the basic components and importance of DNA. | | | | |
| CO4 | To understand the basic structure and applications of alkaloids and terpenes. | | | | |
| CO5 | To distinguish different pericyclic reactions. | | | | |

### Module I: Structure Elucidation Using Spectral Data (11 hrs)

[Prerequisites: Electromagnetic spectrum- wavelength, frequency and energy relation. Beer-Lambert's law - chromophore and auxochrome, functional groups.]

Applications of spectral techniques in the structural elucidation of organic compounds.

UV-Visible Spectroscopy: Electronic transitions in molecules ($\sigma\rightarrow\sigma^*$, $n\rightarrow\sigma^*$, $\pi\rightarrow\pi^*$ and $n\rightarrow\pi^*$) – Chromophore and auxochrome. Study of the UV spectra of butadiene, acetone, methyl vinyl ketone and benzene. $\lambda_{max}$ calculation for dienes and $\alpha,\beta$-unsaturated carbonyl compounds.

IR Spectroscopy: Concept of group frequencies – fingerprint region – IR spectra of alcohols, phenols, amines, ethers, aldehydes, ketones, carboxylic acids, esters and amides.

$^1$H NMR: Chemical shift – Spin-spin splitting – Interpretation of $^1$H NMR spectra of simple organic molecules such as ethyl bromide, ethanol, acetaldehyde, acetone, 1, 1, 2-tribromoethane, propanoic acid, ethyl acetate, toluene and acetophenone.

Structure elucidation of simple organic compounds using UV, IR and $^1$H NMR spectroscopic techniques (ethanol, acetone, acetophenone, acetaldehyde, acetic acid, propanoic acid and ethyl acetate).

Purification of organic compounds: Column, paper and thin layer chromatography. Gas Chromatography.

**References**

1. R. M. Silverstein, F. X. Webster, *Spectrometric Identification of Organic Compounds*, 6th Edn., John Wiley and Sons, New York, 2004.
2. Y. R. Sharma, *Elementary Organic Spectroscopy*, 5th Edn., S. Chand & Company Ltd., New Delhi, 2013.
3. D. L. Pavia, G. M. Lampman, G. S. Kriz, *Introduction to Spectroscopy*, 5th Edn., Thomson Brooks Cole, 2015.
4. Paula Y. Bruice, *Organic Chemistry*, 7rd Edn., Pearson Education, Asia, 2013.

**Further reading**

1. P. S. Kalsi, *Applications of Spectroscopic Techniques in Organic Chemistry*, 6th Edn., New Age International (P) Ltd., New Delhi, 2004.
2. William Kemp, *Organic Spectroscopy*, 2nd Edn., Macmillan, New York, 1987.
3. R. T. Morrison, R. N. Boyd, *Organic Chemistry*, 7th Edn., Pearson Education, New Delhi, 2013.
4. I. L. Finar, *Organic Chemistry*, 5th Edn., Vol. I, Pearson Education, New Delhi, 2013.

**Module II: Carbohydrates (8 hrs)**

[Prerequisites: Classification. Monosaccharides: Fischer projection – D, L configuration. Cyclic structure of ribose, deoxy ribose, glucose and fructose.]

Epimers and anomeres – Mutarotation – Reactions of glucose – Killiani-Fischer synthesis and Ruff degradation – Conversion of aldoses to ketoses and *vice versa* – Osazone formation. Disaccharides: Cyclic structure of maltose, lactose and sucrose – Inversion of cane sugar. Reducing and non-reducing sugars. Polysaccharides: Structure of cellulose, starch and glycogen (structure elucidation not required). Test for carbohydrates: Chemistry of Tollen's test, Fehling's test, Benedict's test and Molisch's test – Tests for urine sugar and blood sugar.

**References**

1. I. L. Finar, *Organic Chemistry*, Vol. I & II, Pearson Education.
2. M. K. Jain, S. C. Sharma, *Modern Organic Chemistry*, 3rd Edn., Vishal Publishing Company Co., 2010.
3. K. S. Tewari, N. K. Vishnoi, S. N. Mehrotra, *A Textbook of Organic Chemistry*, 2nd Edn., Vikas Publishing House, New Delhi, 2004.
4. R. T. Morrison, R. N. Boyd, *Organic Chemistry*, 7th Edn., Pearson Education, New Delhi, 2013.

**Further reading**

1. J. F. Robyt, *Essentials of Carbohydrate Chemistry*, Springer, 1998.
2. S. P. Bhutani, *Chemistry of Biomolecules*, Ane Books Pvt. Ltd., 2009.

**Module III: Proteins and Nucleic acids (11 hrs)**

[Prerequisites: Amino acids – Classification – Structure of amino acids – Zwitter ion formation – Isoelectric point.]

Amino acids: Synthesis (Strecker synthesis and amino malonate synthesis). Peptides and Proteins – Structure determination of peptides: Edmann degradation and Sanger's methods. Peptide synthesis: Solid phase synthesis. Denaturation of proteins. Enzymes – characteristics and examples. Tests for proteins: Chemistry of Xanthoprotein test, Biuret test and Ninhydrin test.

Nucleic acids: Introduction, constituents of nucleic acids – nitrogenous bases, nucleosides and nucleotides. Double helical structure of DNA. Codon and genetic code – DNA replication – Difference between DNA & RNA – DNA finger printing and its applications. Polymerase chain reaction.

**References**

1. I. L. Finar, *Organic Chemistry*, Vol. I & II, Pearson Education.

2. M. K. Jain, S. C. Sharma, *Modern Organic Chemistry*, 3rd Edn., Vishal Publishing Company Co., 2010.

3. K. S. Tewari, N. K. Vishnoi, S. N. Mehrotra, *A Textbook of Organic Chemistry*, 2nd Edn., Vikas Publishing House, New Delhi, 2004.

4. R. T. Morrison, R. N. Boyd, *Organic Chemistry*, 7th Edn., Pearson Education, New Delhi, 2013.

**Further reading**

1. O. P. Agarwal, *Chemistry of Organic Natural Products*, 30th Edn., Goel Publications, 2006.

**Module IV: Biomolecules (5 hrs)**

Lipids: Classification – Fats and oils – Hydrogenation – Analysis of fats and oils – Acid value, Saponification value and Iodine value. Phospholipids: Structure of Lecithin. Biological functions of lipids.

Steroids: Classification – Structure and biological functions of cholesterol, testosterone, estradiol and progesterone – Elementary idea of HDL and LDL.

Hormones: Definition, examples and functions of steroid, peptide and amine hormones.

Vitamins: Classification – Sources and deficiency diseases – Structure of vitamin C.

Note: Structural elucidation not expected in any case.

**References**

1. I. L. Finar, *Organic Chemistry*, Vol. I & II, Pearson Education.

2. M. K. Jain, S. C. Sharma, *Modern Organic Chemistry*, 3rd Edn., Vishal Publishing Company Co., 2010.
3. K. S. Tewari, N. K. Vishnoi, S. N. Mehrotra, *A Textbook of Organic Chemistry*, 2nd Edn., Vikas Publishing House, New Delhi, 2004.

**Further reading**

1. John McMurry, *Organic Chemistry*, 5th Edn., Thompson Asia Pvt. Ltd., 2000.
2. C. N. Pillai, *Organic Chemistry*, Universities Press, 2008.
3. S. P. Bhutani, *Chemistry of Biomolecules*, Ane Books Pvt Ltd., 2009.
4. O. P. Agarwal, *Chemistry of Organic Natural Products*, 30th Edn., Goel Publications, 2006.
5. R. T. Morrison, R. N. Boyd, *Organic Chemistry*, 7th Edn., Pearson Education, New Delhi, 2013.

**Module V: Natural products (5 hrs)**

[Prerequisites: Heterocyclic systems - nitrogen heterocycles.]

Alkaloids: Extraction. Classification based on structure of heterocyclic ring. Physiological actions of nicotine, quinine, coniine.

Terpenes: Classification – Isoprene rule – Essential oils – Isolation of essential oils by steam distillation and Enfleurage process – Uses of lemongrass oil, eucalyptus oil – Isolation of terpenes from essential oils (elementary idea) – Source, structure and uses of citral, geraniol, limonene and menthol. Structure of natural rubber – Vulcanization and its advantages.

Note: Structural elucidation not expected in any case.

**References**

1. I. L. Finar, *Organic Chemistry*, Vol. I & II, Pearson Education.
2. K. S. Tewari, N. K. Vishnoi, S. N. Mehrotra, *A Textbook of Organic Chemistry*, 2nd Edn., Vikas Publishing House, New Delhi, 2004.
3. M. K. Jain, S. C. Sharma, *Modern Organic Chemistry*, 3rd Edn., Vishal Publishing Company Co., 2010.
4. R. T. Morrison, R. N. Boyd, *Organic Chemistry*, 7th Edn., Pearson Education, New Delhi, 2013.

**Further reading**

1. S. P. Bhutani, *Chemistry of Biomolecules*, Ane Books Pvt. Ltd., 2009.
2. O. P. Agarwal, *Chemistry of Organic Natural Products*, 30th Edn., Goel Publications, 2006.

**Module VI: Pericyclic Reactions (8 hrs)**

[Prerequisites: Formation of molecular orbitals - bonding and antibonding MOs, nodes. Conjugated, cumulated and isolated double bonds.]

Introduction – Molecular orbitals of conjugated π systems (C2, C3, C4, C5 and C6 systems). Frontier Molecular Orbitals (FMOs). Types of pericyclic reactions. Electrocyclic reactions: Butadiene↔cyclobutene and hexatriene↔cyclohexadiene interconversions. *Dis* and *con* rotation. Cycloaddition reactions: Dimerisation of ethylene and Diel's-Alder reaction. Supra-supra and supra-antara interactions. Sigmatropic reactions: [1,3], [1,5] and [3,3] rearrangements. FMO explanations and Woodward-Hoffmann selection rules for the above reactions. Cope and Claisen rearrangements (mechanism expected). Pericyclic reactions in human body – Vitamin D from cholesterol (elementary idea).

**References**

1. Peter Sykes, *A Guide book to Mechanism in Organic Chemistry*, 6th Edn., Pearson Education, New Delhi, 2013.

2. P. S. Kalsi, *Organic Reactions, Stereochemistry and Mechanisms*, 4th Edn., New Age International Publishers, New Delhi, 2006.

3. M. K. Jain, S. C. Sharma, *Modern Organic Chemistry*, 3rd Edn., Vishal Publishing Company Co., 2010.

4. P. Y. Bruice, *Essential Organic Chemistry*, 3rd Edn., Pearson Education, 2015.

5. Jagdamba Singh, Jaya Singh, *Photochemistry and Pericyclic Reactions*, 3rd Edn., New Age Science Ltd., New Delhi, 2009.

**Further Reading**

1. R. Bruckner, *Advanced Organic Chemistry*, Elsevier, 2002.

2. Jerry March, *Advanced Organic Chemistry*, 5th Edn., John Wiley & Sons, NewYork, 2004.

3. S. H. Pine, *Organic Chemistry*, McGraw Hill, 2006.

4. J. Clayden, N. Greeves, S. Warren, P. Wothers, *Organic Chemistry*, 2nd Edn., Oxford University Press, New York, 2012.

| Mark Distribution | |
|---|---|
| Module I | 18 Marks |
| Module II | 13 Marks |
| Module III | 16 Marks |
| Module IV | 8 Marks |
| Module V | 8 Marks |
| Module VI | 16 Marks |

# SEMESTER VI

## Course Code: CHE6B11

## Core Course XI: PHYSICAL CHEMISTRY – III

Total Hours: 48; Credits: 3; Hours/Week: 3; Total Marks 75 (Internal 15 & External 60)

| **CHE6B11** | **PHYSICAL CHEMISTRY – III** | L | T | P | C |
|---|---|---|---|---|---|
| | | 3 | 0 | 0 | 3 |
| Objective (s) | To get a thorough knowledge of electrochemistry, colligative properties and solid state. | | | | |
| Course outcome (s) | | | | | |
| CO1 | To understand the basic concepts of electrochemistry. | | | | |
| CO2 | To understand the importance of colligative properties. | | | | |
| CO3 | To relate the properties of materials/solids to the geometrical properties and chemical compositions. | | | | |

**Module I: Electrochemistry – I (12 hrs)**

[Prerequisites: Fundamentals of Electrochemistry. Introduction (Faradays law, types of conductance) – Measurement of equivalent conductance – Variation of conductance with dilution – Kohlrausch's law – Arrhenius theory of electrolyte dissociation and its limitations.]

Weak and strong electrolytes – Ostwald's dilution law, its uses and limitations – Debye-Huckel-Onsager's equation for strong electrolytes (elementary treatment only, derivation is not required) – Debye-Falkenhagen and Wein effects – Migration of ions and Transport number and its determination by Hittorf's and moving boundary methods. Applications of conductivity measurements: Determination of degree of dissociation, ionic product of water and solubility product of sparingly soluble salts (work out problems) – Conductometric titrations, strong acid-strong base, weak acid-strong base, strong acid-weak base and weak acid-weak base.

**Module II: Electrochemistry – II (10 hrs)**

[Prerequisites: Module I – Electrochemistry. Basics of thermodynamics. Types of cell and electrodes (Reversible - SHE, calomel and quinhydrone electrode) – Standard electrode potential – Electrochemical series.]

Nernst equation for electrode potential and EMF of a cell – Relationship between free energy and electrical energy.

Gibbs Helmholtz equation to galvanic cells. Concentration cells: Concentration cells with and without transference – Liquid junction potential (LJP). Application of EMF measurements: Solubility of sparingly soluble salts – Determination of pH – pH

measurement using glass electrode – Potentiometric titrations – Hydrogen-oxygen fuel cell – Electrochemical theory of corrosion of metals.

**References**

1. B. R. Puri, L. R. Sharma, M. S. Pathania, *Principles of Physical Chemistry*, 46th Edn., Vishal Publishing Company, New Delhi, 2013.

2. P. W. Atkins, J. de Paula, *Atkin's Physical Chemistry,* 8th Edn., Oxford University Press, 2006.

3. Donald A. McQuarrie, John D. Simon, *Physical Chemistry: A Molecular Approach* University Science Books: Sausalito, CA; 1997.

4. S. Glasstone, *An Introduction to Electrochemistry*, East-West Press Pvt. Ltd., New Delhi, 2007.

**Further reading**

1. G. M. Barrow, *Physical Chemistry*, 5th Edn., Tata McGraw Hill Education, New Delhi, 2006.

2. K. L. Kapoor, *Physical Chemistry*, Vol. II and III, Macmillan Publishers, Noida, 2004.

3. S. Glasstone, D. H. Lewis, *Elements of Physical Chemistry*, 2nd Edn., Macmillan & Company, UK, 1962.

4. F. Daniels, R. A. Alberty, *Physical Chemistry*, 5th Edn., John Wiley and Sons, Canada, 1980.

5. Peter Atkins, Julio de Paula, *The Elements of Physical Chemistry*, 7th Edn., Oxford University Press, Oxford, 2016.

6. J. Bockris, A. K. N. Reddy, *Modern Electrochemistry*, Kluwer Academic/Plenum Publishers, New York, 2000.

**Module III: Solutions (10 hrs)**

[Prerequisites: Fundamentals of solutions. Solute, solvent, kinds of solutions – Vapour pressure - Solubility of gases in liquids – Henry's law and its applications – Raoult's law – Ideal and non ideal solutions – Dilute solutions.]

Colligative properties – Qualitative treatment of colligative properties – Relative lowering of vapour pressure – Elevation of boiling point – Depression in freezing point – Osmotic pressure – Reverse osmosis and its applications – Application of colligative properties in finding molecular weights (thermodynamic derivation not needed) – Abnormal molecular mass – Van't Hoff factor. Surface tension: Explanation and its determination. Viscosity:

Determination of molecular mass from viscosity measurements. Refraction: Refractive index – Molar refraction and optical exaltation – application.

**References**

1. B. R. Puri, L. R. Sharma, M. S. Pathania, *Principles of Physical Chemistry*, 46th Edn., Vishal Publishing Company, New Delhi, 2013.

2. P. W. Atkins, J. de Paula, *Atkin's Physical Chemistry,* 8th Edn., Oxford University Press, 2006.

3. Donald A. McQuarrie, John D. Simon, *Physical Chemistry: A Molecular Approach*, University Science Books: Sausalito, CA; 1997.

4. P. L. Soni, O. P. Dharmarha, U. N. Dash, *Textbook of Physical Chemistry*, 23rd Edn., Sultan Chand & Sons, New Delhi, 2011.

**Further reading**

1. G. M. Barrow, *Physical Chemistry*, 5th Edn., Tata McGraw Hill Education, New Delhi, 2006.

2. K. L. Kapoor, *Physical Chemistry*, Vol. II and III, Macmillan Publishers, Noida, 2004.

3. S. Glasstone, D. H. Lewis, *Elements of Physical Chemistry*, 2nd Edn., Macmillan & Company, UK, 1962.

4. F. Daniels, R. A. Alberty, *Physical Chemistry*, 5th Edn., John Wiley and Sons, Canada, 1980.

**Module IV: Ionic Equilibria (3 hrs)**

[Prerequisites: Introduction to acid base theories – p$K_a$, p$K_b$ and pH – Buffer solutions.]
Mechanism of buffer action – Buffer index – Henderson equation – Applications of buffers - Hydrolysis of salts of all types – Degree of hydrolysis – Hydrolysis constant and its relation with $K_W$ - Solubility product and common ion effect.

**References**

1. B. R. Puri, L. R. Sharma, M. S. Pathania, *Principles of Physical Chemistry*, 46th Edn., Vishal Publishing Company, New Delhi, 2013.

2. P. W. Atkins, J. de Paula, *Atkin's Physical Chemistry,* 8th Edn., Oxford University Press, 2006.

3. Donald A. McQuarrie, John D. Simon, *Physical Chemistry: A Molecular Approach*, University Science Books: Sausalito, CA; 1997.

4. P. L. Soni, O. P. Dharmarha, U. N. Dash, *Textbook of Physical Chemistry*, 23rd Edn., Sultan Chand & Sons, New Delhi, 2011.

**Further reading**

1. G. M. Barrow, *Physical Chemistry*, 5th Edn., Tata McGraw Hill Education, New Delhi, 2006.

2. K. L. Kapoor, *Physical Chemistry*, Vol. II and III, Macmillan Publishers, Noida, 2004.

3. S. Glasstone, D. H. Lewis, *Elements of Physical Chemistry*, 2nd Edn., Macmillan & Company, UK, 1962.

4. F. Daniels, R. A. Alberty, *Physical Chemistry*, 5th Edn., John Wiley and Sons, Canada, 1980.

5. Peter Atkins, Julio de Paula, *The Elements of Physical Chemistry*, 7th Edn., Oxford University Press, Oxford, 2016.

**Module V: Solid State – I (10 hrs)**

[Prerequisites: Introduction - Amorphous and crystalline solids – Law of constancy of interfacial angles and rational indices – Space lattice and unit cell.]

Direct and reciprocal lattice (Miller indices) – Seven crystal systems and fourteen Bravais lattices – X-ray diffraction – Bragg's law (derivation required) – Planes - Simple account of rotating crystal method and powder pattern method – Analysis of powder patterns of NaCl, CsCl and KCl – Simple, face centered and body centered cubic systems – Identification of cubic crystals from inter-planar ratio – Close packing of spheres – Structure of simple ionic compounds of the type AB (NaCl and CsCl) and $AB_2$ ($CaF_2$).

**Module VI: Solid State – II (3 hrs)**

Band theory (qualitative idea) for Metals, Insulators and Semiconductors: Intrinsic and extrinsic conduction (elementary idea). Non-stoichiometric defects. Liquid crystals: Classification and applications (elementary idea).

**References**

1. B. R. Puri, L. R. Sharma, M. S. Pathania, *Principles of Physical Chemistry*, 46th Edn., Vishal Publishing Company, New Delhi, 2013.

2. P. W. Atkins, J. de Paula, *Atkin's Physical Chemistry*, 8th Edn., Oxford University Press, 2006.

3. Donald A. McQuarrie, John D. Simon, *Physical Chemistry: A Molecular Approach*, University Science Books: Sausalito, 1997.

4. Anthony R. West, *Solid State Chemistry and its Applications*, 2nd Edn., Wiley-Blackwell, 2014.

**Further reading**

1. Gordon M. Barrow, *Physical Chemistry*, 5th Edn., Tata McGraw Hill Education, New Delhi, 2006.

2. K. L. Kapoor, *Physical Chemistry*, Vol. II and III, Macmillan Publishers, Noida, 2004.

3. S. Glasstone, D. H. Lewis, *Elements of Physical Chemistry*, 2nd Edn., Macmillan & Company, UK, 1962.

4. F. Daniels, R. A. Alberty, *Physical Chemistry*, 5th Edn., John Wiley and Sons, Canada, 1980.

5. Peter Atkins, Julio de Paula, *The Elements of Physical Chemistry*, 7th Edn., Oxford University Press, Oxford, 2016.

6. L. V. Azaroff, *Introduction to Solids*, Tata McGraw Hill Publishing Company, New Delhi, 1960.

| **Mark Distribution** | |
|---|---|
| Module I | 17 Marks |
| Module II | 14 Marks |
| Module III | 14 Marks |
| Module IV | 8 Marks |
| Module V | 17 Marks |
| Module VI | 9 Marks |

# SEMESTER VI

## Course Code: CHE6B12

## Core Course XII: Advanced and Applied Chemistry

Total Hours: 48; Credits: 3; Hours/Week: 3; Total Marks 75 (Internal 15 & External 60)

| **CHE6B12** | **Advanced and Applied Chemistry** | L | T | P | C |
|---|---|---|---|---|---|
| | | 3 | 0 | 0 | 3 |
| Objective (s) | To initiate the students to the role and opportunities of chemistry as a discipline in modern civilization. | | | | |
| Course outcome (s) | | | | | |
| CO1 | To understand the importance of nanomaterials. | | | | |
| CO2 | To appreciate the importance of green approach in chemistry. | | | | |
| CO3 | To understand the uses and importance of computational calculations in molecular design. | | | | |
| CO4 | To understand the role of chemistry in human happiness index and life expectancy. | | | | |

**Module I: Colloids and Nanomaterials (6 hrs)**

[Prerequisites: Colloids: Definition – classification - Synthesis – nanometer, micrometer.]

Colloids: Stability – electrical double layer – *zeta* potential - Aggregation – flocculation – purification of colloids - Properties and applications of colloids.

Nanomaterials: Classification of nanomaterials (0D, 1D, 2D and 3D) – Top down and bottom up approaches in the synthesis – Size dependence of material properties (optical, electrical and catalytic). Variation in electronic and optical properties – Surface area to volume ratio (aspect ratio) and its significance – Metal and semiconductor nanoparticles and carbon nanotubes.

Characterization of nanomaterials. Applications of nanomaterials (general idea only).

**References**

1. M. A. Shah, Tokeer Ahmad, *Principles of Nanoscience and Nanotechnology*, Narosa Publishing House, New Delhi, 2010.

2. T. Pradeep, *A Textbook of Nanoscience and Nanotechnology*, McGrawhill, New Delhi, 2012.

3. P. N. Prasad, *Nanophotonics*, John Wiley & Sons, 2004.

4. P. W. Atkins, J. de Paula, *Atkin's Physical Chemistry*, 8th Edn., Oxford University Press, 2006.

**Further reading**

1. V. S. Muralidharan, A. Subramania, *Nano Science and Technology*, CRC Press, London.

2. V. R. Raghavan, *Materials Science and Engineering*, Prentice Hall (India) Ltd, 2001.

3. Jonathan W. Steed, David R. Turner, Karl J. Wallace, *Core Concepts in Supramolecular Chemistry and Nanochemistry*, John Wiley & Sons Ltd., 2007.

**Module II: New vistas in chemistry (8 hrs)**

Green Chemistry: Introduction – need of green chemistry approach – Twelve principles of green chemistry with explanations - Atom economy and microwave assisted reactions – Green solvents – Green synthesis of ibuprofen. Microwave and ultrasound assisted green synthesis: Diels-Alder reaction and Cannizzaro reaction.

Supramolecular chemistry: Introduction - types of non-covalent interactions – Molecular recognition – Host-guest interactions.

Combinatorial Chemistry: Introduction – combinatorial synthesis (elementary idea only). Applications of combinatorial synthesis (brief study).

**References**

1. V. K. Ahluwaliya, *Green Chemistry*, Narosa Publishing House, New Delhi, 2011.

2. P. S. Kalsi, J. P. Kalsi, *Bioorganic, Bioinorganic and Supramolecular Chemistry*, 1st Edn., New Age International Publishers (P) Ltd., New Delhi, 2007.

3. W. Bannwarth, B. Hinzen, *Combinatorial Chemistry – From Theory to Application*, 2nd Edn., Wiley-VCH, 2006.

4. Jonathan W. Steed, David R. Turner, Karl J. Wallace, *Core Concepts in Supramolecular Chemistry and Nanochemistry*, John Wiley & Sons Ltd., 2007.

**Further reading**

1. Paul T. Anastas, T. C. Williamson, *Green Chemistry – Designing Chemistry for the Environment*, 2nd Edn., 1998.

2. Andrew P. Dicks, *Green Organic Chemistry in Lecture and Laboratory*, CRC Press, University of Toronto, Ontario, Canada, 2011.

3. Helena Dodziuk, *Introduction to Supramolecular Chemistry*, Springer, New York, 2002.

**Module III: Introduction to Computational Chemistry (6 hours)**

Computational chemistry as a tool and its scope. Classification of computational chemistry methods – Molecular Mechanics methods (basic idea of force field and examples) and Electronic Structure methods (basic idea of *ab initio* and semi empirical methods), potential energy surface – local minima, global minima, saddle point and transition states. Geometry optimization. Softwares used in computational chemistry calculations.

**Reference**

1. I. N. Levine, Quantum Chemistry, 6th Edn., Pearson Education Inc., 2009.

2. Frank Jensen, *Introduction to Computational Chemistry*, John Wiley & Sons Ltd., 1999.

3. C. J. Cramer, *Essentials of Computational Chemistry: Theories and models*, John Wiley & Sons, 2002.

4. P. W. Atkins, *Molecular Quantum Mechanics*, Oxford University Press, New York, 2005.

5. R. K. Prasad, *Quantum Chemistry*, Oscar Publications, New Delhi, 2000.

**Further reading**

1. E. G. Lewars, *Computational Chemistry: Introduction to the theory and applications of molecular quantum mechanics*, 2nd Edn., Springer, 2011.

2. Andrew R. Leach, *Molecular Modelling: Principles and Applications*, 2nd Edn., Prentice Hall, 2001.

3. S. Wilson, *Chemistry by Computer: An Overview of the Applications of Computers in Chemistry*, Plenum Publishing, New York, 1986.

**Module IV: Synthetic polymers (4 hrs)**

Classification – Tacticity – Synthesis and applications of addition polymers (polyethene, polystyrene, PAN and PMMA) and condensation polymers (nylon 6, nylon 66, Bakelite, kevlar and terylene) – thermosets. Zeigler Natta polymerization - advantages. Plastic identification codes. Biodegradable polymers: PLA, PGA and PHBV.

**References**

1. V. R. Gowarikar, *Polymer Chemistry*, New Age International (P) Ltd., New Delhi, 2010.

2. Fred. W. Billmeyer, *Textbook of Polymer Science*, 3rd Edn., Wiley India, Delhi, 2008.

3. Jeol R. Fried, *Polymer Science and Technology*, Prentice Hall of India Pvt. Ltd., New Delhi, 1999.

4. M. S. Bhatnagar, *Polymer Chemistry*, S Chand and Company Pvt. Ltd., New Delhi, 2014 (Reprint).

**Further reading**

1. Premamoy Ghosh, *Polymer Science and Technology: Plastics, Rubbers, Blends and Composites*, 3rd Edn., McGraw Hill Education (India) Pvt. Ltd., 2011.

**Module V: Applied inorganic chemistry (8 hrs)**

Cement: Manufacture, composition and setting.

Glass: Manufacture, annealing, types of glasses and uses.

Refractory materials: borides and carbides.

Inorganic fertilizers: Essential nutrients for plants – nitrogeneous, phosphatic and potash fertilizers – examples with formula.

Rocket propellants: Classification with examples.

Tooth paste and Talcum powder: Composition and health effects.

Chemical industries in kerala: Location, raw materials, chemistry involved in the preparation and uses of the following, caustic soda and chlorine – Travancore Cochin Chemicals Ltd., $TiO_2$ pigment from ilmenite – Travancore Titanium Products Ltd.

**References**

1. E. Stocchi, *Industrial Chemistry*, Vol. I, Ellis Horwood Ltd., UK, 1990.

2. R. M. Felder, R. W. Rousseau, *Elementary Principles of Chemical Processes*, 3rd Edn., Wiley Publishers, New Delhi, 2010.

**Further reading**

1. W. D. Kingery, H. K. Bowen, D. R. Uhlmann, *Introduction to Ceramics*, 2nd Edn., Wiley Publishers, New Delhi, 1991.

2. J. A. Kent, *Riegel's Handbook of Industrial Chemistry*, CBS Publishers, New Delhi, 1997.

3. P. C. Jain, M. Jain, *Engineering Chemistry*, Dhanpat Rai & Sons, Delhi, 2015.

4. R. Gopalan, D. Venkatappayya, S. Nagarajan, *Engineering Chemistry*, Vikas Publications, New Delhi, 2005.

5. B. K. Sharma, *Engineering Chemistry*, Goel Publishing House, Meerut, 1997.

6. S. L. Tisdale, W. L. Nelson, J. D. Beaton, *Soil Fertility and Fertilizers*, Macmillan Publishing Company, New York, 1990.

**Module VI: Applied organic chemistry – I (8 hrs)**

Petroleum: Carbon range and uses of various fractions of petroleum distillation – Petrol – Knocking – Octane number – Anti-knocking compounds – Diesel oil – Cetane number – Flash point – Composition and uses of LPG and CNG.

Pharmaceuticals: Medicinal chemistry – Drugs (chemical, generic and trade names with examples).

Terminology: Prodrug, pharmacy, pharmacology, pharmacodynamics and pharmacokinetics (elementary idea only). Antipyretics, analgesics, antacids, antihistamines, antibiotics, antiseptics, disinfectants (definition and examples, structures not expected) – Preparation of paracetamol and aspirin.

Cleansing agents: Soaps and detergents: Preparation of soap by saponification of oils and fats, classification, advantages and disadvantages of soaps and detergents – TFM of soap – Cleaning action. Shampoos: Ingredients and functions.

Pesticides: Insecticides, rodenticides and fungicides (definition and examples) – Organo chlorine pesticides – Structure of Endosulfan, DDT and BHC. Organo phosphorus pesticides – malathion, parathion. Harmful effects of pesticides. Herbicides – glyphosate – side effects.

**References**

1. M. K. Jain, S. C. Sharma, *Modern Organic Chemistry*, 3rd Edn., Vishal Publishing Company Co., 2010.

2. K. S. Tewari, N. K. Vishnoi, S. N. Mehrotra, *A Textbook of Organic Chemistry*, 2nd Edn., Vikas Publishing House, New Delhi, 2004.

3. Jayashree Ghosh, *A Textbook of Pharmaceutical Chemistry*, 3rd Edn., S. Chand and Company Ltd., New Delhi, 1999.

4. A. W. A. Brown, *Insect Control by Chemicals*, New York, Wiley; London, Chapman & Hall, 1951.

**Further reading**

1. K. H. Buchel, *Chemistry of Pesticides*, John Wiley & Sons, New York, 1983.

2. G. Thomas, *Fundamentals of Medicinal Chemistry*, John Wiley & Sons Ltd., 2006.

**Module VII: Applied organic chemistry – II (8 hrs)**

Dyes: Definition – Requirements of a dye – Theories of colour and chemical constitution – Classification based on structure and mode of application to the fabric – Preparation and uses of Rosaniline and Indigo. Composition of hair dyes.

Food adulterants: Common food adulterants in various food materials and their identification: Milk, vegetable oils, tea, coffee powder and chilli powder.

Food additives: Food preservatives, artificial sweeteners and antioxidants (definition and examples, structures not required) – Structure of BHT, BHA and Ajinomoto – Common permitted and non-permitted food colours (structures not required) – Natural pigments in fruits and vegetables (carotenoids, chlorophylls and flavonoids). Artificial ripening of fruits. Composition of chocolate, milk powder and soft drinks.

**References**

1. K. S. Tewari, N. K. Vishnoi, S. N. Mehrotra, *A Textbook of Organic Chemistry*, 2nd Edn., Vikas Publishing House (Pvt.) Ltd., New Delhi, 2004.

2. B. Srilakshmi, *Food Science*, 5th Edn., New Age Publishers, New Delhi, 2010.

**Further reading**

1. B. Sivasankar, *Food processing and preservation*, Prentice – Hall of India Pvt. Ltd., New Delhi, 2002.

2. Srinivasan Damodaran, Kirk L. Parkin, Owen R. Fennema, *Food Chemistry*, 4th Edn., CRC Press, New York, 2007.

3. K. Singh, *Chemistry in Daily Life*, Prentice Hall of India, New Delhi, 2008.

| Mark Distribution | |
|---|---|
| Module I | 10 Marks |
| Module II | 14 Marks |
| Module III | 10 Marks |
| Module IV | 8 Marks |
| Module V | 12 Marks |
| Module VI | 13 Marks |
| Module VII | 12 Marks |

**SEMESTER VI**

**Course Code: CHE6B13(E1)**

**Core Course XIII: Elective 1. INDUSTRIAL CHEMISTRY**

Total Hours: 48; Credits: 2; Hours/Week: 3; Total Marks 75 (Internal 15 & External 60)

| **CHE6B13(E1)** | **INDUSTRIAL CHEMISTRY** | L | T | P | C |
|---|---|---|---|---|---|
| | | 3 | 0 | 0 | 2 |
| Objective (s) | To familiarise the students with the role and opportunities of chemistry as a discipline in modern civilization. To create awareness among the students about different chemical industries. | | | | |
| Course outcome (s) | | | | | |
| CO1 | To understand the importance of petrochemicals. | | | | |
| CO2 | To appreciate the importance and to familiarise the opportunities of pharmaceutical, leather and sugar industries. | | | | |
| CO3 | To analyse the role of catalysts in industrial processes. | | | | |

**Module I: Introduction (4 hrs)**

Requirements of an industry – location – water – industrial water treatment – safety measures – pilot plants – ISO certification.

**References**

1. B. K. Sharma, *Industrial chemistry*, 11th Edn., Goel publishing House, Meerut, 2000.
2. K. S. Tewari, N. K. Vishnoi, S. N. Mehrotra, *A Textbook of Organic Chemistry*, 2nd Edn., Vikas Publishing House (Pvt.) Ltd., New Delhi, 2004.

**Further reading**

1. Marshal Sittig, M. Gopala Rao, *Outlines of Chemical Technology for the 21st Century*, 3rd Edn., East-West Press Pvt. Ltd., New Delhi, 2010.
2. A. K. Ahluwalia, *Environmental Chemistry*, Ane Books India, New Delhi, 2008.
3. B. K. Sharma, H. Kaur, *Environmental Chemistry*, Goel Publishing House, Meerut, 1996.

**Module II: Petrochemical Industry (12 hrs)**

Introduction. Natural gas – CNG, LNG and LPG.

Coal: Classification based on carbon content – carbonisation of coal – composition and uses of various fractions.

Crude Oil: Constitution and distillation – composition and uses of different distillates – ignition point, flash point and octane number – cracking.

Catalysts used in Petroleum Industries: Structure, selectivity and applications.

Synthetic Petrol: Manufacture by Bergius and Fischer-Tropsch processes.

Manufacture of petrochemicals: Ethylene glycol, glycerine, acetone, phenol, vinyl acetate, toluene, linear alkyl benzenes and their sulphonates.

Usage and depletion of petroleum products – need for alternative fuel – hydrogen as the future fuel.

**References**

1. E. Stocchi, *Industrial Chemistry*, Vol. I, Ellis Horwood Ltd. UK, 1990.
2. P. C. Jain, M. Jain, *Engineering Chemistry*, Dhanpat Rai & Sons, Delhi, 2015.
3. B. K. Sharma, H. Gaur, *Industrial Chemistry*, Goel Publishing House, Meerut, 1996.

**Further reading**

1. B. K. B. Rao, *Modern Petroleum Refining Processes*, 4th Edn., Oxford & IBH Publishing Co. Pvt. Ltd., New Delhi, 2002.
2. R. A. Meyers, *Handbook of Petroleum Refining Processes*, 3rd Edn., McGraw-Hill, Noida, 2004.

**Module III: Pharmaceutical Industry (8 hrs)**

Drugs: Definition – History of drugs – Prodrug – Drug toxicity – Thalidomide tragedy (a brief study) – Routes of drug administration – Effective use of drugs – Over dosage – Prescription and non-prescription drugs – Drug abuse. Cancer: Definition – Lung cancer (causes, symptoms and treatment). Medical applications of nanomaterials.

**References**

1. G. L. Patrick, *Introduction to Medicinal Chemistry*, 6th Edn., Oxford University Press, UK, 2017.
2. Hakishan Singh, V. K. Kapoor, *Medicinal and Pharmaceutical Chemistry*, Vallabh Prakashan, Pitampura, New Delhi, 2005.
3. Thomas L. Lemke, David A. William, *Foye's Principles of Medicinal Chemistry*, 6th Edn., Wolters Kluwer Health, 2006.
4. Jayashree Ghosh, *A Text Book of Pharmaceutical Chemistry*, S. Chand and Co. Ltd, 1999.
5. O. Le. Roy, *Natural and synthetic organic medicinal compounds*, Ealemi, 1976.

**Further reading**

1. R. S. Satoskar, *Pharmacology and Pharmatherapeutics*, Vol. I and Vol. II, Popular Prakashan, 1973.
2. O. Kleiner, J. Martin, *Bio-Chemistry*, Prentice-Hall of India (P) Ltd, New Delhi, 1974.
3. Ashutosh Kar, *Medicinal Chemistry*, Wiley Eastern Limited, New Delhi, 1993.
4. Gurdeep R. Chatwal, *Synthetic Drugs*, Himalaya Publishing House, Bombay, 1995.
5. D. Sriram, P. Yogeeswari, *Medicinal Chemistry*, 2nd Edn., Pearson, 2011.

**Module IV: Industrial Catalysis (6 hrs)**

Types of catalysts: Homo catalysis and hetero catalysis – Applications of phase transfer catalysis and nano particle catalysts – Zeigler Natta catalyst and Wilkinson catalyst (mechanism not expected). Applications of raney nickel, platinum, palladium, ruthenium and $TiO_2$ based catalysts.

**References**

1. P. H. Groggins, *Unit Process in Organic Synthesis*, 5th Edn., McGraw Hill, New York, 2001.
2. L. K. Doraiswamy, *Organic Synthesis Engineering*, Academic Press, New York, 2001.
3. M. Gopalarao, M. Sitting, *Dryden's Outlines of Chemical Tech*., 2nd Edn., EastWest Pub., New Delhi, 1997.

**Further reading**

1. G. T. Austin, *Shreve's Chemical Process Industries*, 5th Edn., McGraw-Hill Pub., 1994.
2. J. A. Kent, *Riggel's Handbook of Industrial Chemistry*, Van Nostrant Reinhold, 1974.

**Module V: Leather and Sugar Industries (8 hrs)**

Leather Industry: Manufacture of leather: Preparatory stages, tanning (vegetable and chrome tanning), crusting and surface coating – Tannery effluent and byproduct problems.

Sugar Industry: Manufacture of sugar from cane sugar – Double sulphitation process – Refining and grading of sugar.

**References**

1. D. Woodroffe, *Fundamental of Leather Science*, 1st Edn., A Harvey, 1942.
2. N. J. Park Ridge, *Chemical treatment of hides and leather*, Noyes Publications, 1985.

**Further reading**

1. Jayashree Ghosh, *Fundamental concept of Applied Chemistry*, S. Chand & Company Ltd., 2012.

**Module VI: Textiles, Paints and Pigments (10 hrs)**

Textile Industry: Production of viscose fibre from cellulose – Properties and uses of nylon and polyester fibers – Introduction to dyeing – Chromophore, auxochrome and chromogen – Primary and secondary colours – Chromatic and achromatic colours – Dyeing of nylon with acid dyes.

Paints: Primary constituents – Binders and solvents – Requirements of a good paint – Oil based paints, latex paints, luminescent paints, fire retardant paints and heat resistant paints. Varnishes: Spirit varnishes and oleo resinous varnishes – Raw materials – Enamels and lacquers (brief study).

Pigments: Definition – white lead, lithopone, ultramarine, red lead, guignet's green and chrome yellow (composition and uses).

**References**

1. Sara J. Kadolph, Anna L. Langford, *Textiles*, 10th Edn., Pearson/Prentice-Hall, New Delhi, 2007.

2. A. A. Vidya, *Production of Synthetic Fibers*, Prentice-Hall of India, New-Delhi, 1988.

| **Mark Distribution** | |
|---|---|
| Module I | 4 Marks |
| Module II | 18 Marks |
| Module III | 13 Marks |
| Module IV | 12 Marks |
| Module V | 14 Marks |
| Module VI | 18 Marks |

**SEMESTER VI**

**Course Code: CHE6B13(E2)**

**Core Course XIII: Elective 2. POLYMER CHEMISTRY**

Total Hours: 48; Credits: 2; Hours/Week: 3; Total Marks 75 (Internal 15 & External 60)

| **CHE6B13(E2)** | **POLYMER CHEMISTRY** | L | T | P | C |
|---|---|---|---|---|---|
| | | 3 | 0 | 0 | 2 |
| Objective (s) | To gain detailed knowledge about the classification of polymers and various mechanisms and technology adopted for polymerisation. To give a basic understanding of the properties of polymers like glass transition temperature, molecular weight and degradation of polymers. To give a detailed idea about different commercial polymers. | | | | |
| Course outcome (s) | | | | | |
| CO1 | To understand various classification of polymers and types of polymerisation methods. | | | | |
| CO2 | To understand the important characteristics of polymers such as average molecular weight, glass transition temperature, viscoelasticity and degradation. | | | | |
| CO3 | To appreciate the importance of processing techniques. | | | | |
| CO4 | To characterise different commercial polymers and to understand the significance of recycling. | | | | |

**Module I: Introduction (4 hrs)**

Polymers and macromolecules – Monomers – Homo and hetero polymers – Copolymers – Classification based on origin (natural, semi synthetic and synthetic), synthesis (addition and condensation), structure (linear, branched chain and cross linked) and intermolecular forces (elastomeres, fibres, thermoplastics and thermosetting polymers) – Tacticity.

**Module II: Types of Polymerisation (10 hrs)**

Chain and step growth polymerizations – Free radical, ionic and coordination polymerizations with mechanism – Zeigler-Natta polymerization (mechanism expected) and its advantages – Ring-opening & group transfer polymerization (Mechanism not needed).

**Module III: Properties and Degradation of Polymers (10 hrs)**

Molecular weights of polymers: Average molecular weights – Number average, Weight average, Sedimentation average (Method of determination not required) and Viscosity average molecular weight – determination of viscosity average molecular weight; Poly

dispersity index and molecular weight distribution; Molecular weight and Degree of polymerization.

Glass transition temperature – definition, factors affecting Tg, importance of Tg.

Visco elasticity of polymers (Basic concepts only).

Polymer Degradation: Basic idea of thermal, photo and oxidative degradations of polymers.

**Module IV: Polymerisation Techniques (6 hrs)**

Polymerisation Techniques: Bulk, solution, suspension, emulsion, melt condensation and interfacial polycondensation polymerizations.

**Module V: Polymer Processing (6)**

Calendering, rotational moulding, compression, injection moulding, blow moulding and thermoforming.

**Module VI: Commercial Polymers (12 hrs)**

Preparation, Structure, properties and applications of: Polyolefins (HDPE, LDPE, PP and PS); Vinyl polymers (PVC, PVP and EVA, Saran); fluoro polymers (Teflon); Acrylic polymers (PAN and PMMA); Aliphatic polyamides (nylon 66 and nylon 6); Aromatic polyamides (kevlar); Polyester (terylene); Polycarbonate (lexan); Polyurethanes; Resins-Glyptal and formaldehyde resins (UF, MF and PF); Rubbers (natural rubber - Vulcanisation, EPDM, BR, SBR, nitrile rubber, Neoprene, Butyl rubber and silicone rubber); Conducting polymers - Dopping (conduction mechanism not required).

Pollution due to plastics – Recycling of plastics - Plastic identification codes.

**References**

1. F. W. Billmeyer Jr., *Textbook of Polymer Science*, John Wiley and Sons, New Delhi, 2007.

2. V. R. Gowarikar, *Polymer Chemistry*, New Age International Pvt. Ltd., New Delhi, 2010.

3. B. K. Sharma, *Polymer Chemistry*, Goel Publishing House, Meerut, 1989.

4. M. G. Arora, M. Singh, M. S. Yadav, *Polymer Chemistry*, 2nd Revised Edn., Anmolpublications Private Ltd., New Delhi, 1989.

5. K. J. Saunders, *Organic Polymer Chemistry*, 2nd Edn., Chapman and Hall, London, 1988.

6. Malcolm P. Stevens, *Polymer Chemistry: An Introduction*, 3rd Edn., Oxford University Press, USA, 1998.

7. Gowri Sankar Misra, *Introductory Polymer Chemistry*, New Age International, New Delhi, 1993.

8. M. S. Bhatnagar, *Polymer Chemistry*, S Chand and Company Pvt. Ltd., New Delhi, 2014 (Reprint).

**Further reading**

1. R. B. Seymour, C. E. Carraher, *Polymer Chemistry: An Introduction*, Marcel Dekker, Inc. New York, 1981.

2. G. Odian, *Principles of Polymerization*, 4th Edn., Wiley, 2004.

3. P. Ghosh, *Polymer Science & Technology*, Tata McGraw-Hill Education, 1991.

4. R. W. Lenz, *Organic Chemistry of Synthetic High Polymers*, Interscience Publishers, New York, 1967.

5. M. P. Stevens, *Polymer Chemistry: An Introduction*, 3rd Edn., Oxford University Press, 2005.

| **Mark Distribution** | |
|---|---|
| Module I | 4 Marks |
| Module II | 16 Marks |
| Module III | 17 Marks |
| Module IV | 12 Marks |
| Module V | 10 Marks |
| Module VI | 20 Marks |

**SEMESTER VI**

**Course Code: CHE6B13(E3)**

**Core Course XIII: Elective 3. MEDICINAL AND ENVIRONMENTAL CHEMISTRY**

Total Hours: 48; Credits: 2; Hours/Week: 3; Total Marks 75 (Internal 15 & External 60)

| **CHE6B13(E3)** | **MEDICINAL AND ENVIRONMENTAL CHEMISTRY** | L | T | P | C |
|---|---|---|---|---|---|
| | | 3 | 0 | 0 | 2 |
| Objective (s) | To introduce the students to the importance of chemistry in medicinal field and to get ideas about various diseases. To help the students to get information about various toxic substances in environment and their control. | | | | |
| Course outcome (s) | | | | | |
| CO1 | To understand the importance of drugs in human health. | | | | |
| CO2 | To understand the facts about common diseases and treatment. | | | | |
| CO3 | To identify the presence of toxic substances in atmosphere. | | | | |
| CO4 | To apply chemistry in treatment of water and sewage. | | | | |

**Module I: Health and Biochemical Analysis (6 hrs)**

Definition of health - WHO standard - Sterilization of surgical instruments - Biochemical analysis of urine and serum.

Blood: Composition, grouping and Rh factor - Blood transfusion.

**Module II: Drugs (4 hrs)**

Definition – History of drugs – Prodrug – Prescription and non-prescription drugs – Routes of drug administration - Drug dosage - Effective use of drugs – Over dosage - Drug toxicity – Thalidomide tragedy (a brief study) – Drug abuse. Assay of Drugs: Chemical, biological and immunological assays - LD50 and ED50 and therapeutic index.

**Module III: Common Diseases and Treatment (10 hrs)**

Diseases - Communicable and non-communicable diseases - Causes, symptoms and drugs used for the treatment of air-borne diseases (anthrax, chickenpox, influenza, measles and tuberculosis), water and food borne diseases (cholera, dysentery, typhoid fever and hepatitis A), bronchial asthma, kidney stone, diabetes – Drugs used in the treatment for systemic hypertension and hypercholesterolemia.

Cancer: Definition - Lung cancer (causes, symptoms and treatment) – Avenues for the treatment of terminal cancer.

**Module IV: Environmental Toxicology (6 hrs)**

Introduction – Threshold Limiting Value – Source and toxicological effects of inorganic compounds ($H_2S$, $Cl_2$ and asbestos), organic compounds ($CCl_4$, phenol, benzene, phenylene diamines, nitroso amines and *p*-dichlorobenzene), persistent organic pollutants (dioxins, TCDD, pesticides: Endosulphan, carbaryl and DDT), phthalates and heavy metals (As and Hg). Endosulfan disaster in Kerala (brief study).

**Module V: Control and Monitoring of Air Pollutants (12 hrs)**

Air Pollution Control Measures: Gravitational settling chamber, fabric filter, wet scrubber, catalytic converters, stacks and chimneys, cyclone collectors, Cottrell electrostatic precipitator, extraction ventilator, zoning and green belt.

Air Pollutant Monitoring: Sampling methods for particulate analysis - Filtration, sedimentation, electrostatic samplers, thermal precipitators and impingers. Sampling methods for gases and vapours – Cold trapping, absorption and adsorption. Analytical methods for the determination of CO, NOx, SOx, $H_2S$, hydrocarbons and particulate matter.

**Module VI: Water Treatment Processes (10 hrs)**

Types and characteristics of industrial waste water - Aerobic and anaerobic oxidation - Sedimentation, coagulation, filtration, disinfection, desalination and ion exchange. Primary treatment - Secondary treatment - Trickling filters, activated sludge process and sludge digestion - Tertiary treatment - USAB process and deep well injection. Sewage and sewage analysis - Total solids, settlable solids, suspended solids - Protection of surface waters from pollution with industrial sewage.

**References**

1. G. Thomas, *Fundamentals of Medicinal Chemistry*, John Wiley & Sons Ltd., London, 2003.

2. Arthur C. Guyton, John E. Hall, Textbook of Medical Physiology, 12th Edn., Saunders, US, 2010.

3. D. J. Abraham, *Burger's Medicinal Chemistry and Drug Discovery*, Vol.1-6, Wiley Interscience, Hoboken, NJ, 2003.

4. B. L. Oser, *Hawk's Physiological Chemistry*, Tata McGraw-Hill Publishing Co. Ltd., New Delhi, 1979.

5. S. C. Rastogi, *Biochemistry*, 2nd Edn., Tata McGraw Hill Publishing Co., New Delhi, 2007.

6. Gurdeep R. Chatwal, *Synthetic Drugs*, Himalaya Publishing House, Bombay, 1995.

7. Jayashree Ghosh, *A Textbook of Pharmaceutical Chemistry*, 3rd Edn., S. Chand and Company Ltd., New Delhi, 1999.

8. Rasheeduz Zafar, *Medicinal Plants of India*, 1st Edn., CBS Publishers & Distributors Pvt. Ltd., New Delhi, 2009.

9. A. K. De, *Environmental Chemistry*, 6th Edn., New Age International (P) Ltd., New Delhi, 2006.

10. M. L. Davis, D. A. Cornwell, *Introduction to Environmental Engineering*, 3rd Edn., McGraw Hill, New Delhi, 1998.

11. S. E. Manahan, *Environmental Chemistry*, 8th Edn., CRC Press, Florida, 2004.

12. G. M. Masters, *Introduction to Environmental Engineering and Science*, 3rd Edn., Prentice-Hall Inc., New Delhi, 2007.

13. A. K. Ahluwalia, *Environmental Chemistry*, Ane Books India, New Delhi, 2008.

14. B. K. Sharma, H. Kaur, *Environmental Chemistry*, Goel Publishing House, Meerut, 1996.

| **Mark Distribution** | |
|---|---|
| Module I | 6 Marks |
| Module II | 8 Marks |
| Module III | 17 Marks |
| Module IV | 12 Marks |
| Module V | 18 Marks |
| Module VI | 18 Marks |

# SEMESTER VI

## Course Code: CHE6B14(P)

## Core Course XIV: PHYSICAL CHEMISTRY PRACTICAL

Total Hours: 80; Credits: 4; Hours/Week: 5 (Semester V); Total Marks 100 (Internal 20 & External 80)

| **CHE6B14(P)** | **PHYSICAL CHEMISTRY PRACTICAL** | L | T | P | C |
|---|---|---|---|---|---|
| | | 0 | 0 | 5 | 4 |
| Objective (s) | To familiarise the students with the relation between physical properties and chemical composition used for analysis. To provide students an idea of designing experimental methods to analyse the physical properties of molecules or materials. | | | | |
| Course outcome (s) | | | | | |
| CO1 | To enable the students to develop analytical skills in determining the physical properties (physical constants). | | | | |
| CO2 | To develop skill in setting up an experimental method to determine the physical properties. | | | | |
| CO3 | To understand the principles of Refractometry, Potentiometry and Conductometry. | | | | |

**General Instructions**

*1. For weighing electronic balance may be used.*

*2. Use safety coat, goggles, shoes and gloves in the laboratory.*

*3. A minimum number of 10 experiments must be done, covering at least six modules, to appear for the examination.*

*4. The practical must be completed in the semester V. Practical examination will be conducted at the end of semester VI.*

**Module I: Viscosity and Surface tension**

1. Determination of viscosity of various liquids using Ostwald's viscometer.
2. Study of glycerine-water system and determination of percentage of glycerine using viscometer [plot composition (c) *versus* time of flow x density of the solution (td)].
3. Determination of the surface tension of a liquid or a dilute solution (NaCl / surfactant) using a stalagmometer (drop number method).

**Module II: Colligative properties** (Cooling curve method)

1. Determination of cryoscopic constant ($K_f$) of solid solvent using a solute of known molecular mass.

2. Determination of molecular mass of the solute using a solvent of known cryoscopic constant ($K_f$).

*Solid solvents: Naphthalene, biphenyl, camphor. Solutes: Naphthalene, biphenyl, 1,4 dichlorobenzene, diphenylamine, acetanilide, benzophenone.*

**Module III: Transition Temperature**

1. Determination of molal transition point depression constant ($K_t$) of salt hydrate using solute of known molecular mass.
2. Determination of molecular mass of the solute using a solvent of known molal transition point depression constant ($K_t$).

*Salt hydrates:* $Na_2S_2O_3.5H_2O$, $CH_3COONa.3H_2O$. *Solutes: Urea, Glucose*

**Module IV: Phase Equilibria**

1. Construction of phase diagram & determination of eutectic composition and eutectic temperature: *Naphthalene-biphenyl system, Naphthelene-diphenyl amine system, Biphenyl–diphenylamine system.*
2. Influence of KCl impurity on miscibility temperature of phenol-water system and determination of concentration of given KCl solution.

**Module V: Spectroscopy**

1. Determination of composition of glycerine-water mixture by refractive index method.
2. Determination of refractive indices of KCl solutions of different concentration and concentrations of unknown KCl solution.
3. Verify Lambert-Beer's law and determine molar extinction coefficient, concentration of any one, $CuSO_4$ / Ferric alum / $KMnO_4$ / $K_2Cr_2O_7$ in a solution. Find out the unknown concentration of the given solution. (Five standards may be prepared).

**Module VI: Conductometry and Potentiometry**

1. Conductometric titration of strong acid x strong base.
2. Potentiometric titration of strong acid x strong base.

**Module VII: pH metry**

1. Preparation of acidic / alkaline buffer solutions and measure the pH.
2. pH metric titration of strong acid with strong base.

**Module VIII: Kinetics**

1. Determination of specific reaction rate of the hydrolysis of methyl acetate catalysed by hydrogen ion at room temperature.
2. Determination of overall order of saponification of ethyl acetate.

**References**

1. A. Findlay, *Findlay's Practical Physical Chemistry,* 9th Edn., John Wiley and Sons, New York, 1972.
2. J. B. Yadav, *Advanced Practical Physical Chemistry,* Goel Publications, Meerut, 2008.
3. D. P. Shoemaker, C. W. Garland, *Experiments in Physical Chemistry*, McGraw-Hill Book Company, New York, 1962.
4. W. G. Palmer, *Experimental Physical Chemistry*, Cambridge University Press, Cambridge, 2009.
5. R. C. Das, B. Behra, *Experiments in Physical Chemistry*, Tata McGraw Hill, New Delhi, 1983.
6. D. A. Skoog, D. M. West, F. J. Holler, S. R. Crouch, *Fundamentals of Analytical Chemistry*, 8th Edn., Brooks/Cole, Thomson Learning, Inc., USA, 2004.
7. P. S. Sindhu, *Practicals in Physical Chemistry - A Modern Approach*, Macmillan India Ltd., 2006.

# SEMESTER VI

## Course Code: CHE6B15(P)

## Core Course XV: ORGANIC CHEMISTRY PRACTICAL

Total Hours: 80; Credits: 4; Hours/Week: 5 (Semester V); Total Marks 100 (Internal 20 & External 80)

| CHE6B15(P) | ORGANIC CHEMISTRY PRACTICAL | L | T | P | C |
|---|---|---|---|---|---|
| | | 0 | 0 | 5 | 4 |
| Objective (s) | To empower the students to prepare different compounds without compromising yield. Characterisation and analysis of different organic compounds based on functional groups. To develop skill in separation and purification of mixtures. | | | | |
| Course outcome (s) | | | | | |
| CO1 | To enable the students to develop analytical skills in organic qualitative analysis. | | | | |
| CO2 | To develop talent in organic preparations to ensure maximum yield. | | | | |
| CO3 | To apply the concept of melting or boiling points to check the purity of compounds. | | | | |
| CO4 | To analyse and characterise simple organic functional groups. | | | | |
| CO5 | To analyse individual amino acids from a mixture using chromatography. | | | | |

**General Instructions**

1. Semimicro analysis must be adopted for organic qualitative analysis.
2. Use safety coat, goggles, shoes and gloves in the laboratory.
3. Reactions must be carried out on tiles, wherever possible.
4. A minimum number of 7 organic analysis, 6 organic preparations and 1 chromatographic separation shall be done to appear for the examination.
5. The practical must be completed in semester V. Practical examination will be conducted at the end of semester VI.

**Module I: Reagent Preparation**

Preparation of Borshe's reagent, Schiff's reagent, Tollen's Reagent, Fehling's solution, phenolphthalein, methyl orange, *N*-Phenylanthranilic acid and neutral $FeCl_3$.

**Module II: Determination of Physical Constants**

1. Determination of boiling point.
2. Determination of melting point (capillary method and using melting point apparatus).

**Module III: Recrystallisation Techniques**

Recrystallise any four organic compounds using ethyl acetate, ethanol and water. Note the crystalline shape.

**Module IV: Solvent Extraction** (Use ether and record the yield recovery).

1. Aniline from water.
2. Methyl benzoate from water.

**Module V: Reactions of Organic Compounds**

Study of the reactions of functional groups from the following list (also prepare the derivatives).

1. Phenols (phenol, *α*-naphthol).
2. Nitro compounds (nitrobenzene, *o*-nitrotoluene).
3. Amines (aniline, *N*,*N*-dimethyl aniline).
4. Halogen compounds (chlorobenzene, benzyl chloride, *p*-dichlorobenzene).
5. Aldehydes and ketones (benzaldehyde, benzophenone).
6. Carboxylic acid (benzoic acid, cinnamic acid, phthalic acid, salicylic acid).
7. Carbohydrates (glucose, sucrose).
8. Amides (benzamide, urea).
9. Esters (ethyl benzoate, methyl salicylate).
10. Hydrocarbons (naphthalene, anthracene).

Analysis of about 10 organic compounds containing the above functional groups.

**Module VI: Organic Preparations**

1. Halogenation: *p*-bromoacetanilide from acetanilide, tribromoaniline from aniline.
2. Nitration: *p*-nitroacetanilide from acetanilide.
3. Oxidation: Benzoic acid from benzaldehyde, Benzoic acid from toluene.
4. Hydrolysis: Benzoic acid from ethyl benzoate, Benzoic acid from benzamide.
5. Diazo-coupling: Methyl orange from aniline, Phenylazo-*β*-naphthol from aniline.
6. Haloform reaction: Iodoform from acetone or ethyl methyl ketone.
7. Acylation: Acetylation of salicylic acid or aniline, Benzoylation of aniline or phenol.

Note: *Determine the yield. Calculate the theoretical yield and percentage conversion. Recrystallise the prepared compounds from appropriate solvents*.

**Module VII: Chromatography**

Paper chromatographic separation of mixture of two amino acids.

**References**

1. B. S. Furniss, A. J. Hannaford, P. W. G. Smith, A. R. Tatchell, *Vogel's Textbook of Practical Organic Chemistry*, 5th Edn., Pearson Education, Noida, 2014.
2. F. G. Mann, B. C. Saunders, *Practical Organic Chemistry*, 4th Edn., Pearson Education, Noida, 2011.

3. Arthur I. Vogel, *Elementary Practical Organic Chemistry- Small Scale Preparations*, 2nd Edn., Pearson Education, Noida, 2013.
4. V. K. Ahluwalia, S. Dhingra, *Comprehensive Practical Organic Chemistry*, Universities Press, Hyderabad, 2004.

## SEMESTER VI

### Course Code: CHE6B16(P)

### Core Course XVI: INORGANIC CHEMISTRY PRACTCAL-II

Total Hours: 80; Credits: 4; Hours/Week: 5; Total Marks 100 (Internal 20 & External 80)

| **CHE6B16(P)** | **INORGANIC CHEMISTRY PRACTCAL-II** | L | T | P | C |
|---|---|---|---|---|---|
| | | 0 | 0 | 5 | 4 |
| Objective (s) | To develop skill in quantitative analysis using gravimetric and colorimetric methods. | | | | |
| Course outcome (s) | | | | | |
| CO1 | To enable the students to develop analytical skills in inorganic quantitative analysis. | | | | |
| CO2 | To understand the principles behind gravimetry and to apply it in quantitative analysis. | | | | |
| CO3 | To understand the principles behind colorimetry and to apply it in quantitative analysis. | | | | |

**General Instructions**

*1. For weighing, electronic balance may be used.*

*2. Use safety coat, goggles, shoes and gloves in the laboratory.*

*3. A minimum number of 7 experiments must be done, covering the three modules, to appear for the examination.*

*4. The report of industrial visit must be submitted, along with the practical record, to appear for the examination.*

**Module I: Gravimetric Analysis – I (using silica crucible)**

1. Determination of water of hydration in crystalline barium chloride.
2. Determination of water of hydration in crystalline magnesium sulphate.
3. Estimation of $Ba^{2+}$ as $BaSO_4$
4. Estimation of $SO_4^{2-}$ as $BaSO_4$
5. Estimation $Fe^{3+}$ as $Fe_2O_3$
6. Estimation $Ca^{2+}$ as $CaCO_3$
7. Estimation $Al^{3+}$ as $Al_2O_3$

**Module II: Gravimetric Analysis – II (using sintered crucible)**

1. Estimation $Ni^{2+}$ as nickel dimethyl glyoximate.
2. Estimation $Cu^{2+}$ as cuprous thiocyanate.
3. Estimation $Mg^{2+}$ as magnesium oxinate.

**Module III: Colorimetry**

1. Verification of Beer-Lambert law for $KMnO_4$ and $K_2Cr_2O_7$ & determination of concentration of the given solution.
2. Estimation of iron.
3. Estimation of chromium.

4. Estimation of nickel.

**References**

1. J. Mendham, R. C. Denney, J. D. Barnes, M. Thomas, *Vogel's Textbook of Quantitative Chemical Analysis*, 6th Edn., Pearson Education, Noida, 2013.

2. D. N Bajpai, O. P. Pandey, S. Giri, *Practical Chemistry for I, II & III B. Sc. Students*, S. Chand & Company Ltd., New Delhi, 2012.

3. V. K. Ahluwalia, Sunita Dhingra, Adarsh Gulati, *College Practical Chemistry*, Universities Press (India) Pvt. Ltd., Hyderabad, 2008.

4. D. A. Skoog, D. M. West, F. J. Holler, S. R. Crouch, *Fundamentals of Analytical Chemistry*, 8th Edn., Brooks/Cole, Thomson Learning, USA, 2004.

# SEMESTER VI

## Course Code: CHE6B17(P)

## Core Course XVII: INORGANIC CHEMISTRY PRACTCAL-III

Total Hours: 80; Credits: 4; Hours/Week: 5; Total Marks 100 (Internal 20 & External 80)

| **CHE6B17(P)** | **INORGANIC CHEMISTRY PRACTCAL-III** | L | T | P | C |
|---|---|---|---|---|---|
| | | 0 | 0 | 5 | 4 |
| Objective (s) | To develop skill in quanlitative analysis of inorganic compounds. | | | | |
| Course outcome (s) | | | | | |
| CO1 | To enable the students to develop skills in inorganic quanlitative analysis. | | | | |
| CO2 | To understand the principles behind inorganic mixture analysis and to apply it in quanlitative analysis. | | | | |
| CO3 | To analyse systematically mixtures containing two cations and two anions. | | | | |

**General Instructions**

*1. Semimicro analysis must be adopted for inorganic qualitative analysis.*

*2. Mixtures containing more than one interfering anions must be avoided.*

*3. If interfering anions are not present, cations may be given from the same group.*

*4. Use safety coat, goggles, shoes and gloves in the laboratory.*

*5. A minimum of 7 inorganic mixtures must be done to appear for the examination.*

**Module I: Inorganic Qualitative Analysis**

1. Study of the reactions of following ions. *Anions:* Carbonate, sulphate, fluoride, chloride, bromide, iodide, acetate, borate, oxalate, phosphate and nitrate. *Cations:* Lead, bismuth, copper, cadmium, iron, aluminium, cobalt, nickel, manganese, zinc, barium, calcium, strontium, magnesium and ammonium.

2. Systematic analysis of mixtures containing two cations and two anions from the above list.

3. $Na_2CO_3$ extract procedure may be adopted.

**References**

1. G. Svehla, *Vogel's Qualitative Inorganic Analysis*, 7th Edn., Prentice Hall, New Delhi, 1996.

2. V. V. Ramanujam, *Inorganic Semi Micro Qualitative Analysis*, 3rd Edn., The National Publishing Company, Chennai, 1974.

3. W. G. Palmer, *Experimental Inorganic Chemistry*, Cambridge University Press, 1970.

# SEMESTER VI

## Course Code: CHE6B18(Pr)

## Core Course XVIII: PROJECT WORK

Total Hours: 32; Credits: 2; Hours/Week: 2 (Semester V); Total Marks 75 (Internal 15 & External 60)

| **CHE6B18(Pr)** | **PROJECT WORK** | L | T | P | C |
|---|---|---|---|---|---|
| | | 0 | 0 | 2 | 2 |
| Objective (s) | To develop skill in scientific research, critical thinking and reasoning. | | | | |
| Course outcome (s) | | | | | |
| CO1 | To understand the scientific methods of research project. | | | | |
| CO2 | To apply the scientific method in life situations. | | | | |
| CO3 | To analyse scientific problems systematically. | | | | |

**Guidelines**

1. Students shall undertake the project work related to chemistry only.
2. The UG level project work is a group activity, maximum number of students being limited to five. However, each student shall prepare and submit the project report separately.
3. Head of the department must provide the service of a teacher for supervising the project work of each group. A teacher can guide more than one group, if necessary.
4. The students must complete the project in semester V. However, the evaluation of the project report will be carried out at the end of semester VI.
5. Project work can be experimental, theoretical or both.
6. No two groups in the same institution are permitted to do project work on the same problem. Also the project must not be a repetition of the work done by students of previous batches.
7. Each group must submit a copy of the project report to be kept in the department.
8. The project report must be hard bound, spiral bound or paper back.
9. The project report shall be divided as, Chapter I: Introduction, Chapter II: Review of literature, Chapter III: Scope of the research problem, Chapter IV: Materials and methods, Chapter V: Results and discussion, Chapter VI: Conclusion and suggestions, if any, and Chapter VII: Bibliography.
10. Each student must present the project report before the external examiner during project evaluation.

# EVALUATION SCHEME

# FOR

# CORE COURSE

# CORE COURSE THEORY: EVALUATION SCHEME

The evaluation scheme for each course contains two parts: *viz.,* internal evaluation and external evaluation. 20% weightage shall be given to the internal assessment. The remaining 80% weightage shall be for the external evaluation.

## 1. INTERNAL EVALUATION

20% of the total marks in each course are for internal evaluation. The colleges shall send only the marks obtained for internal examination to the university. The internal assessment shall be based on a predetermined transparent system involving written test, class room participation based on attendance, assignment and seminar/viva in respect of theory courses. For practical courses it is based on lab involvement and records.

**Table 1: Components of Evaluation**

| *Sl. No.* | *Component* | *Marks* |
|---|---|---|
| 1 | Class room participation based on attendance (20%) | 3 |
| 2 | Test papers I (40%) | 6 |
| 3 | Assignment (20%) | 3 |
| 4 | Seminar/ Viva* (20%) | 3 |
| *Total Marks* | | 15 |

**Viva:* CHE1B01, CHE2B02, CHE3B03, CHE4B04, CHE5B06, CHE6B10, CHE6B11, CHE6B12 and elective course; *Seminar:* CHE5B07, CHE5B08 and CHE6B09.

**Table 2: Percentage of attendance based on class room participation and Eligible Marks**

| *% of attendance* | *Marks* |
|---|---|
| 85% and above | 3 |
| 75 - <85% | 2 |
| 50 - <75% | 1 |

**Table 3: Pattern of Test Papers**

| *Duration* | *Pattern* | *Total number* | *Number of questions to be answered* | *Marks for each question* | *Ceiling of Marks* |
|---|---|---|---|---|---|
| 1 Hour | Short answer | 6 | Up to 6 | 2 | 10 |
| | Paragraph | 4 | Up to 4 | 5 | 15 |
| | Essay | 2 | 1 | 10 | 10 |
| *Total Marks** | | | | | 35 |

*85% and above = 6, 65 to below 85% = 5, 55 to below 65% = 4, 45 to below 55% = 3, 35 to below 45% = 2, below 35% = 1

**2. EXTERNAL EVALUATION**

External evaluation carries 80% marks. University examinations will be conducted at the end of each semester. Duration of each external examination is two hours for 2/3 credit.

**Table 1: Pattern of Question Paper**

| *Duration* | *Pattern* | *Total number of questions* | *Number of questions to be answered* | *Marks for each question* | *Ceiling of Marks* |
|---|---|---|---|---|---|
| 2 Hours | Short answer | 12 | Up to 12 | 2 | 20 |
| | Paragraph | 7 | Up to 7 | 5 | 30 |
| | Essay | 2 | 1 | 10 | 10 |
| *Total Marks* | | | | | 60 |

## CORE COURSE PRACTICAL: EVALUATION SCHEME

The evaluation scheme for each course contains two parts: *viz.,* internal evaluation and external evaluation.

**1. INTERNAL EVALUATION**

20% of the total marks in each course are for internal evaluation. The colleges shall send only the marks obtained for internal examination to the university.

**Table 1: Components of Evaluation**

| *Sl. No.* | *Components* | *Marks* |
|---|---|---|
| 1 | Record (60%) | 12 |
| 2 | Lab involvement (40%) | 8 |
| *Total Marks* | | 20 |

**Table 2: Lab involvement**

| Component | Mark |
|---|---|
| Viva | 4 |
| Performance | 2 |
| Punctuality | 2 |
| Total | 8 |

**Table 3: Number of Experiments and Marks for Practical Records**

| *Number of Experiments (Marks in brackets)* | | | | | | |
|---|---|---|---|---|---|---|
| *Inorganic Chemistry Practical-I* | | *Physical Chemistry Practical* | *Organic Chemistry Practical* | | *Inorganic Chemistry Practical –II* | *Inorganic Chemistry Practical –III* |
| | | | *Analysis* | *Preparation* | | *Mixture* |
| Volumetry | *Preparation* | | | | | |
| 19-20 (9) | 6 (3) | 14 (12) | 10 (8) | 8 (4) | 10-11 (12) | 10 (12) |
| 18 (8) | 5 (2) | 13 (11) | 9 (7) | 7 (3) | 9 (11) | 9 (11) |
| 17 (7) | 4 (1) | 12 (10) | 8 (6) | 6 (2) | 8 (10) | 8 (10) |
| 16 (6) | | 11 (9) | 7 (5) | | 7 (9) | 7 (9) |
| 15 (5) | | 10 (8) | | | | |

## 2. EXTERNAL EVALUATION

External evaluation carries 80% marks. Practical examinations along with viva-voce will be conducted at the end of IV$^{th}$ and VI$^{th}$ semesters.

***PATTERN OF QUESTION PAPERS***

**Table 1: Inorganic Chemistry Practical – I**

| *Duration* | *Pattern* | *Marks* | *Total Marks* |
|---|---|---|---|
| 3 Hours | Question on volumetric analysis | 8 | 80 |
| | Procedure for volumetry | 8 | |
| | Procedure for inorganic preparation | 4 | |
| | Inorganic preparation | 5 | |
| | Result | 35 | |
| | Calculation | 4 | |
| | Record | 8 | |
| | Viva-Voce | 8 | |

*Guidelines*

1. *Valuation of Volumetric Procedure*: Eight points – 8 marks. 1. Correct intermediate; 2. Preparation of standard solution; 3. Standardisation of intermediate; 4. Indicator and end point of standardization; 5. Making up of given solution; 6. Titration of made up solution; 7. Indicator and end point of estimation; 8. Any other relevant points.

2. *Marks for Result:* For calculating the error percentage both theoretical value and skilled value are considered. The reported values (RV) of the students are compared with theoretical value (TV) and skilled value (SV) to calculate the error percentage. Up to 1.5% error: 35 marks; between 1.51 – 2%: 30 marks; between 2.1 – 2.5%: 25 marks; between 2.51– 3%: 15 marks; greater than 3%: 4 marks.

3. *Marks for Calculation:* Eight points – 4 marks. 1. Equivalent mass of the primary standard substance; 2. Calculation of normality of primary standard; 3. Table for standardization of intermediate with standard substance and indicator at the top; 4. Calculation of normality of the link solution; 5. Table for estimation including standard substance and indicator; 6. Calculation of normality of the given solution; 7. Equivalent mass of the compound/ion in the given solution; 8. Calculation of weight in the whole of the given solution.

4. Marks for inorganic preparation procedure: Six to seven points – 4 marks. 1) Balanced equation of the reaction; 2) Requirements; 3) Solvent used; 4) Reaction condition; 5) Precipitating agent; 6) Recrystallisation; 7) Solvent for recrystallisation.

5. Marks for inorganic preparation: The students shall exhibit the prepared compound for inspection. Yield: 3 marks; colour: 2 marks.

**Table 2: Physical Chemistry Practical**

| *Duration* | *Pattern* | *Marks* | *Total Marks* |
|---|---|---|---|
| 3 Hours | Principle and procedure | 4 + 4 | 80 |
| | Result | 40 | |
| | Graph | 8 | |
| | Duplicate/ other particulars | 4 | |
| | Calculation | 4 | |
| | Record | 8 | |
| | Viva-Voce | 8 | |

*Guidelines*

1. *Valuation of Principle and procedure:* 8 marks (4 marks for principle and 4 marks for procedure).

2. *Marks for Result:* The mark distribution may vary for different experiments.

**Table 3: Organic Chemistry Practical**

| *Duration* | *Pattern* | *Marks* | *Total Marks* |
|---|---|---|---|
| 3 Hours | Question on organic analysis & preparation | 8 | 80 |
| | Procedure for organic preparation | 8 | |
| | Organic Preparation | 12 | |
| | Organic Analysis | 36 | |
| | Record | 8 | |
| | Viva-Voce | 8 | |

*Guidelines*

1. *Procedure for Organic Preparation:* Eight points – 8 marks. 1) Type of reaction; 2) Balanced equation of the reaction; 3) Requirements; 4) Solvent used; 5) Reaction condition; 6) Precipitating agent; 7) Recrystallisation; 8) Solvent for recrystallisation.

2. *Organic Preparation:* The students shall exhibit the crude and recrystallized samples of the prepared organic compound for inspection. Yield: 3 marks; colour: 3 marks; dryness: 3 marks; crystalline shape: 3 marks.

3. *Organic Analysis:* Aliphatic/aromatic: 2 marks, saturated/unsaturated: 2 marks, detection of elements: 3 marks, identification test of functional group: 5 marks, chemistry of identification test: 3 marks, confirmation test of functional group: 5 marks, chemistry of confirmation test: 3 marks, suggestion of derivative: 1 mark, method of preparation of the derivative: 2 marks, preparation of derivative suggested by the examiner: 3 marks, chemistry of the derivative preparation: 3 marks, systematic procedure: 4 marks.

**Table 4: Inorganic Chemistry Practical – II**

| *Duration* | *Pattern* | *Marks* | *Total Marks* |
|---|---|---|---|
| 3 Hours | **Gravimetry and Colorimetry** | | 65 |
| | Procedure of colorimetry | 4 | |
| | Procedure of gravimetry | 8 | |
| | Result | 35 | |
| | Calculation | 2 | |
| | Record | 8 | |
| | Viva-Voce | 8 | |
| | **Industrial Visit** | | |
| | Report | 8 | 15 |
| | Viva-Voce | 7 | |

*Guidelines*

1. *Points for Evaluation of Colorimetry Procedure*: Four points – 4 marks. 1) Preparation of standard solutions; 2) Addition of appropriate reagents to develop colour; 3) Determination of absorbance using a colorimeter; 4) Plot the graph and find out the concentration of the unknown.

2. *Points for Evaluation of Gravimetry Procedure*: Eight points – 8 marks. 1) Making up of the given solution 2) Transferring a definite volume of the made up solution in to a

beaker 3) Addition of appropriate reagents 4) Dilution and heating to boiling 5) Precipitation by appropriate reagent and heating to make the precipitate granular 6) Allowing to settle and filtering through quantitative filter paper or previously weighed sintered crucible till the washings are free from ions 7) Incineration in a previously weighed silica crucible or drying the sintered crucible in an air oven 8) Repeating heating, cooling and weighing to constant weight 9) From the weight of precipitate the weight of metal in the given solution can be calculated.

3. *Marks for Gravimetry Result:* The reported value of the student is compared with theoretical value and one skilled value (closer to theoretical value) and error percentage is calculated. Up to 1.5% error: 35 marks; between 1.51 – 2%: 25 marks; between 2.1–2.5%: 15 marks; greater than 2.51%: 4 marks.

*4. Industrial Visit:* Good presentation of any one Chemical Factory / Research centre visit is considered for a maximum of 8 marks. Students are expected to make individual report. So variety must be appreciated. Viva-voce shall be conducted based on the industrial visit.

**Table 5: Inorganic Chemistry Practical – III**

| *Duration* | *Pattern* | *Marks* | *Total Marks* |
|---|---|---|---|
| 3 Hours | Question on qualitative analysis | 4 | 80 |
| | Identification tests for ions | 16 | |
| | Confirmation tests for ions | 16 | |
| | Identification of cation group | 4 | |
| | Chemistry of identification tests | 8 | |
| | Chemistry of confirmation tests | 8 | |
| | Systematic procedure | 8 | |
| | Record | 8 | |
| | Viva-Voce | 8 | |

*Guidelines*

1. *Identification Tests:* 4 Marks each for two anions two cations.
2. *Identification of Cation Group:* 2 Mark each.
3. *Confirmation Tests:* 4 Marks each for two anions and two cations.
4. *Chemistry of Identification Tests:* 2 Marks each for two anions and two cations.
5. *Chemistry of Confirmation Tests:* 2 Marks each for two anions and two cations.

**Table 6: Evaluation of Records**

| *Number of Experiments (Marks in brackets)* | | | | | | |
|---|---|---|---|---|---|---|
| *Inorganic Chemistry Practical – I* | | *Physical Chemistry Practical* | *Organic Chemistry Practical* | | *Inorganic Chemistry Practical –II* | *Inorganic Chemistry Practical –III* |
| Volumetry | Preparation | | *Analysis* | *Preparation* | | *Mixture* |
| 19-20 (6) | 6 (2) | 14 (8) | 10 (4) | 8 (4) | 10-11 (8) | 10 (8) |
| 18 (5) | 5 (1) | 13 (7) | 9 (3) | 7 (3) | 9 (7) | 9 (7) |
| 17 (4) | | 12 (6) | 8 (2) | 6 (2) | 8 (6) | 8 (6) |
| 16 (3) | | 11 (5) | | | 7 (5) | 7 (5) |
| | | | | | | 6 (4) |

**CORE COURSE PROJECT: EVALUATION SCHEME**

Project evaluation will be conducted at the end of sixth semester. Evaluation of the project report shall be done under mark system.

a) Supervising teachers will assess the project and award internal marks.

b) External evaluation by examiner appointed by university.

c) Grade for the project will be awarded to candidates, combining the internal and external marks.

**Table 1: Internal Evaluation**

| *Sl. No* | *Criteria* | *Marks* |
|---|---|---|
| 1 | Originality of content (20%) | 3 |
| 2 | Methodology of presentation (20%) | 3 |
| 3 | Organization of report and conclusion (30%) | 4.5 |
| 4 | Viva-voce (30%) | 4.5 |
| *Total Marks* | | 15 |

**Table 2: External Evaluation**

| *Sl. No* | *Criteria* | *Marks* |
|---|---|---|
| 1 | Content and relevance of the project (20%) | 12 |
| 2 | Presentation and quality of analysis (20%) | 12 |
| 3 | Findings and recommendations (30%) | 18 |
| 4 | Viva-voce (30%) | 18 |
| *Total Marks* | | 60 |

1) Submission of the project report and presence of the student for viva are compulsory for internal evaluation. No marks shall be awarded to a candidate if she/he fails to submit the project report for external evaluation

2) The student should get a minimum P grade in aggregate of external and internal.

3) There shall be no improvement chance for the marks obtained in the project report.

4) In the extent of student failing to obtain a minimum of pass grade, the project work may be re-done and a new internal mark may be submitted by the parent department. External examination may be conducted along with the subsequent batch.

# SYLLABUS

# FOR

# COMPLEMENTARY COURSES

# CHEMISTRY COMPLEMENTARY COURSE STRUCTURE

**Total Credits: 12 (Internal: 20%; External: 80%)**

| ***Semester*** | *Code No* | *Course Title* | *Hrs/ Week* | *Total Hrs* | *Credit* | *Marks* |
|---|---|---|---|---|---|---|
| **I** | CHE1C01 | Complementary Course I: General Chemistry | 2 | 32 | 2 | 75 |
| | - | Complementary Course V: Chemistry Practical | 2 | 32 | -* | - |
| **II** | CHE2C02 | Complementary Course II: Physical Chemistry | 2 | 32 | 2 | 75 |
| | - | Complementary Course V: Chemistry Practical | 2 | 32 | -* | - |
| **III** | CHE3C03 | Complementary Course III: Organic Chemistry | 3 | 48 | 2 | 75 |
| | - | Complementary Course V: Chemistry Practical | 2 | 32 | -* | - |
| **IV** | CHE4C04 | Complementary Course IV: Physical and Applied Chemistry | 3 | 48 | 2 | 75 |
| | CHE4C05(P) | Complementary Course V: Chemistry Practical | 2 | 32 | 4* | 100 |
| **Total** | | | | | **12** | 400 |

* Examination will be held at the end of semester IV.

**SEMESTER I**

**Course Code: CHE1C01**

**Complementary Course I: GENERAL CHEMISTRY**

Total Hours: 32; Credits: 2; Hours/Week: 2; Total Marks 75 (Internal 15 & External 60)

| **CHE1C01** | **GENERAL CHEMISTRY** | L | T | P | C |
|---|---|---|---|---|---|
| | | 2 | 0 | 0 | 2 |
| Objective(s) | To provide the students a thorough knowledge about the chemistry of quantitative and qualitative analysis and the theories of chemical bonding. It will also impart the ideas about atomic nucleus and the importance of metals in biological systems. | | | | |
| Course outcome (s) | | | | | |
| CO1 | To understand and to apply the theories of quantitative and qualitative analysis. | | | | |
| CO2 | To understand the theories of chemical bonding. | | | | |
| CO3 | To appreciate the uses of radioactive isotopes. | | | | |
| CO4 | To understand the importance of metals in biological systems. | | | | |

**Module I: Analytical Chemistry (10 hrs)**

Atomic mass - Molecular mass - Mole concept – Molar volume - Oxidation and reduction – Oxidation number and valency - Equivalent mass. Methods of expressing concentration: Molality, molarity, normality and mole fraction. Calculation of concentration on dilution of given solution (problems).

Theory of volumetric analysis – Acid-base, redox and complexometric titrations – Acid-base, redox and complexometric indicators. Double burette method of titration: Principle and advantages.

Principles in the separation of cations in qualitative analysis - Applications of common ion effect and solubility product - Microanalysis and its advantages.

Accuracy & Precision (mention only).

**References**

1. J. Mendham, R. C. Denney, J. D. Barnes, M. Thomas, *Vogel's Textbook of Quantitative Chemical Analysis*, 6th Edn., Pearson Education, Noida, 2013.

2. G. Svehla, *Vogel's Qualitative Inorganic Analysis*, 7th Edn., Prentice Hall, New Delhi, 1996.

**Module II: Atomic Structure and Chemical Bonding (10 hrs)**

*Atomic Structure:* Bohr atom model and its limitations, de Broglie equation - Heisenberg uncertainty principle - Schrödinger wave equation (mention only) - Atomic orbitals -

Quantum numbers and their significance - Pauli's Exclusion principle - Hund's rule of maximum multiplicity - Aufbau principle – Electronic configuration of atoms.

*Chemical Bonding:* Introduction – Type of bonds.

Ionic bond: Factors favouring the formation of ionic bonds - Lattice energy of ionic compounds and its application.

Covalent bond: Lewis theory – Coordinate bond.

VSEPR theory: Shapes of $BeCl_2$, $BF_3$, $SnCl_2$, $CH_4$, $NH_3$, $H_2O$, $NH_4^+$, $SO_4^{2-}$, $PCl_5$, $SF_4$, $ClF_3$, $XeF_2$, $SF_6$, $IF_5$, $XeF_4$, $IF_7$ and $XeF_6$.

Valence Bond theory - Hybridisation involving s, p and d orbitals: sp (acetylene), $sp^2$ (ethylene), $sp^3$ ($CH_4$), $sp^3d$ ($PCl_5$), $sp^3d^2$ ($SF_6$).

Molecular Orbital theory: LCAO – Electronic configuration of $H_2$, $B_2$, $C_2$, $N_2$, $O_2$ and CO – Calculation of bond order – determination of HOMO and LUMO – Explanation of bond length and bond strength.

Intermolecular forces - Hydrogen bonding in $H_2O$ - Dipole-dipole interactions.

**References**

1. C. N. R. Rao, *Understanding Chemistry*, Universities Press India Ltd., Hyderabad, 1999.

2. R. K. Prasad, *Quantum Chemistry*, 4th Edn., New Age International (P) Ltd., New Delhi, 2012.

3. Manas Chanda, *Atomic Structure and Chemical Bonding*, 4th Edn., Tata McGraw Hill Publishing Company, Noida, 2007.

4. R. Puri, L. R. Sharma K. C. Kalia, *Principles of Inorganic Chemistry*, 31st Edn., Milestone Publishers and Distributors, New Delhi, 2013.

**Module III: Nuclear Chemistry (6 hrs)**

Natural radioactivity – Modes of decay – Group displacement law.

Nuclear forces - n/p ratio - Nuclear stability - Mass Defect - Binding energy. Isotopes, isobars and isotones with examples.

Nuclear fission - Atom bomb - Nuclear fusion – Hydrogen bomb - Nuclear reactors

Application of radioactive isotopes – $^{14}C$ dating, Rock dating, Isotopes as tracers, Radio diagnosis, Radiotherapy.

**References**

1. H. J. Arnikar, *Essentials of Nuclear Chemistry*, 4th Edn., New Age International (P) Ltd., New Delhi, 2005.

2. R. Gopalan, *Elements of Nuclear Chemistry*, Vikas Publ. House, 2000.

**Module IV: Bioinorganic Chemistry (6 hrs)**

Metal ions in biological systems - Biochemistry of iron – Haemoglobin and myoglobin - $O_2$ and $CO_2$ transportation (mechanism not required) - Chlorophyll and photosynthesis (mechanism not expected) – Elementary idea of structure and mechanism of action of sodium potassium pump - Biochemistry of zinc and cobalt.

**References**

1. B. R. Puri, L. R. Sharma, K. C. Kalia, *Principles of Inorganic Chemistry*, Milestone Publishers, New Delhi, 2010.
2. G. L. Meissler, D. A. Tarr, *Inorganic Chemistry*, 3rd Edn. Pearson Education, 2004.
3. J. E. Huheey, E. A. Keiter, R. L. Keiter, O. K. Medhi, *Inorganic Chemistry*, 5th Edn., Pearson, 2009.
4. F. A. Cotton, G. Wilkinson, P. L. Gaus, *Basic Inorganic Chemistry*, 3rd Edn., John – Wiley, 1995.

| Mark Distribution | |
|---|---|
| Module I | 22 Marks |
| Module II | 25 Marks |
| Module III | 16 Marks |
| Module IV | 16 Marks |

**SEMESTER II**

**Course Code: CHE2C02**

**Complementary Course II: PHYSICAL CHEMISTRY**

Total Hours: 32; Credits: 2; Hours/Week: 2; Total Marks 75 (Internal 15 & External 60)

| **CHE2C02** | **PHYSICAL CHEMISTRY** | L | T | P | C |
|---|---|---|---|---|---|
| | | 2 | 0 | 0 | 2 |
| Objective(s) | To provide the students a thorough knowledge about different terminologies in thermodynamics and the continuity between different states of matter. To impart an idea about the basic principles of electrochemistry. | | | | |
| Course outcome (s) | | | | | |
| CO1 | To understand the importance of free energy in defining spontaneity. | | | | |
| CO2 | To realise the theories of different states of matter and their implication. | | | | |
| CO3 | To understand the basic principles of electrochemistry. | | | | |

**Module I: Thermodynamics (6 hrs)**

Definition of thermodynamic terms - System – Surroundings - Types of systems.
First law of Thermodynamics - Internal energy - Significance of internal energy change – Enthalpy. Second law of Thermodynamics - Entropy and spontaneity - Statement of second law based on entropy. Entropy change in phase transitions (derivation not required) - Entropy of fusion, vaporization and sublimation. The concept of Gibbs free energy - Physical significance of free energy - Conditions for equilibrium and spontaneity based on $\Delta G$ values - Effect of temperature on spontaneity of reaction. Third law of Thermodynamics.

**References**

1. B. R. Puri, L. R. Sharma, M. S. Pathania, *Principles of Physical Chemistry*, 46th Edn., Vishal Publishing Company, New Delhi, 2013.
2. J. Rajaram, J. C. Kuriacose, *Chemical Thermodynamics*, Pearson Education, New Delhi, 2013.

**Module II: Gaseous and Solid States (10 hrs)**

*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 behavior - van der Waals equation (derivation not required).

*Solid State:* Introduction - Isotropy and anisotropy - Symmetry elements in crystals - The seven crystal systems – Miller indices - Bravais lattices – Bragg's equation (derivation required) and its applications (mention only). Defects in crystals: Non-stoichiometric and stoichiometric defects - Extrinsic and intrinsic defects.

**References**

1. K. L. Kapoor, *A Textbook of Physical chemistry*, Vol. 1, 4th Edn., Macmillan India Ltd., 2011.
2. B. R. Puri, L. R. Sharma, M. S. Pathania, *Elements of Physical chemistry*, Vishal Pub. Co., 2013.

**Module III: Liquid State and Solutions (6 hrs)**

*Liquid State:* Introduction - Vapour pressure, surface tension and viscosity – Explanation of these properties on the basis of intermolecular attraction.
*Solutions:* Kinds of solutions - Solubility of gases in liquids – Henry's law and its applications - Colligative properties - Osmotic pressure - Laws of osmotic pressure - Reverse osmosis and its applications - Determination of molecular mass using colligative properties.

**References**

1. K. L. Kapoor, *A Textbook of Physical chemistry*, Vol. 1, 4th Edn., Macmillan India Ltd., 2011.
2. B. R. Puri, L. R. Sharma, M. S. Pathania, *Elements of Physical chemistry*, Vishal Pub. Co., 2013.

**Module IV: Electrochemistry (10 hrs)**

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 – Conductometric titrations.
Galvanic cells - Cell and electrode potentials - IUPAC sign convention – Reference electrodes – Standard Hydrogen electrode – Calomel electrode - Standard electrode potential - Nernst equation - $H_2$-$O_2$ fuel cell.
Ostwald's dilution law – Buffer solutions – Buffer action [acetic acid/sodium acetate & $NH_4OH/NH_4Cl$], applications of buffers.

**References**

1. P. Atkins, J. Paula Atkins, *Physical Chemistry*, 8th Edn., Oxford University Press, 2006.
2. K. K. Sharma, L. K. Sharma, *A Textbook of Physical Chemistry*, 5th Edn., Vikas Publishing House, New Delhi, 2012.

3. Gordon M. Barrow, *Physical Chemistry*, 5th Edn., Tata McGraw Hill Education, New Delhi, 2006.

4. F. Daniels, R. A. Alberty, *Physical Chemistry*, 5th Edn., John Wiley and Sons, Canada, 1980.

| **Mark Distribution** | |
|---|---|
| Module I | 16 Marks |
| Module II | 23 Marks |
| Module III | 16 Marks |
| Module IV | 24 Marks |

**SEMESTER III**

**Course Code: CHE3C03**

**Complementary Course III: ORGANIC CHEMISTRY**

Total Hours: 48; Credits: 2; Hours/Week: 3; Total Marks 75 (Internal 15 & External 60)

| **CHE3C03** | **ORGANIC CHEMISTRY** | L | T | P | C |
|---|---|---|---|---|---|
| | | 3 | 0 | 0 | 2 |
| Objective(s) | To provide the students a thorough knowledge about basic theory and concepts of organic chemistry. | | | | |
| Course outcome (s) | | | | | |
| CO1 | To understand the basic concepts involved in reaction intermediates. | | | | |
| CO2 | To realise the importance of optical activity and chirality. | | | | |
| CO3 | To appreciate the importance of functional groups and aromatic stability. | | | | |
| CO4 | To understand the basic structure and importance of carbohydrates, nucleic acids, alkaloids and terpenes. | | | | |

**Module I: Organic Chemistry – Some Basic Concepts (10 hrs)**

*Introduction:* Homolysis and heterolysis of bonds – Electrophiles and nucleophiles.

*Reaction Intermediates*: Carbocations, carbanions and free radicals (types, hybridization and stability).

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

*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 aniline. Hyperconjugation: Definition – Characteristics. Example: Propene.

Applications: Comparison of stability of 1-butene & 2-butene. Electromeric effect: Definition – Characteristics - +E effect (addition of $H^+$ to ethene) and –E effect (addition of $CN^-$ to acetaldehyde). Steric effect (causes and simple examples).

**References**

1. Peter Sykes, *A Guide book to Mechanism in Organic Chemistry*, 6th Edn., Pearson Education, New Delhi, 2013.

2. P. S. Kalsi, *Organic Reactions, Stereochemistry and Mechanisms*, 4th Edn., New Age International Publishers, New Delhi, 2006.

3. K. S. Tewari, N. K. Vishnoi, S. N. Mehrotra, *A Textbook of Organic Chemistry*, 2nd Edn., Vikas Publishing House, New Delhi, 2004.

4. M. K. Jain, S. C. Sharma, *Modern Organic Chemistry*, 3rd Edn., Vishal Publishing Company Co., 2010.

5. R. T. Morrison, R. N. Boyd, *Organic Chemistry*, 7th Edn., Pearson Education, New Delhi, 2013.
6. I. L. Finar, *Organic Chemistry*, Vol. I, 5th Edn., Pearson Education, New Delhi, 2013.

**Module II: Stereochemistry (6 hrs)**

*Conformations:* Conformations of ethane, cyclohexane and methylcyclohexane – Explanation of stability.
*Geometrical Isomerism:* Definition – Condition – Geometrical isomerism in but-2-ene and but-2-ene-1,4-dioic acid – Methods of distinguishing geometrical isomers using melting point and dipole moment.
*Optical Isomerism:* Optical activity – Chirality – Enantiomers – Meso compounds – Diastereoisomers – Optical isomerism in lactic acid and tartaric acid.

**References**

1. R. T. Morrison, R. N. Boyd, *Organic Chemistry*, 7th Edn., Pearson Education, New Delhi, 2013.
2. I. L. Finar, *Organic Chemistry*, Vol. I, 5th Edn., Pearson Education, New Delhi, 2013.
3. M. K. Jain, S. C. Sharma, *Modern Organic Chemistry*, 3rd Edn., Vishal Publishing Company Co., 2010.
4. K. S. Tewari, N. K. Vishnoi, S. N. Mehrotra, *A Textbook of Organic Chemistry*, 2nd Edn., Vikas Publishing House, New Delhi, 2004.

**Module III: Aromatic Hydrocarbons (5 hrs)**

Nomenclature and isomerism in substituted benzene. Structure and stability of benzene: Kekule, resonance and molecular orbital description.
Mechanism of aromatic electrophilic substitution: Halogenation, nitration, sulphonation and Friedel-Craft's reactions – orientation effect of substituents.
Aromaticity and Huckel's rule: Application to benzenoid (benzene, naphthalene and anthracene) and nonbenzenoid (pyrrole, pyridine and indol) aromatic compounds.

**References**

1. R. T. Morrison, R. N. Boyd, *Organic Chemistry*, 7th Edn., Pearson Education, New Delhi, 2013.
2. I. L. Finar, *Organic Chemistry*, Vol. I, 5th Edn., Pearson Education, New Delhi, 2013.
3. M. K. Jain, S. C. Sharma, *Modern Organic Chemistry*, 3rd Edn., Vishal Publishing Company Co., 2010.
4. K. S. Tewari, N. K. Vishnoi, S. N. Mehrotra, *A Textbook of Organic Chemistry*, 2nd Edn., Vikas Publishing House, New Delhi, 2004.

**Module IV: Chemistry of Functional Groups – I (8 hrs)**

*Halogen Compounds:* Preparation of alkyl halides from alkanes and alkenes – Wurtz reaction and Fittig's reaction – Mechanism of $S_N1$ and $S_N2$ reactions of alkyl halides – Effect of substrate and stereochemistry.
*Alcohols:* Preparation from Grignard reagent – Preparation of ethanol from molasses – Wash, rectified spirit, absolute alcohol, denatured spirit, proof spirit and power alcohol (mention only) – Comparison of acidity of ethanol, isopropyl alcohol and *tert*-butyl alcohol – Haloform reaction and iodoform test – Luca's test – Chemistry of methanol poisoning – Harmful effects of ethanol in the human body.
*Phenols:* Preparation from chlorobenzene – Comparison of acidity of phenol, *p*-nitrophenol and *p*-methoxyphenol – Preparation and uses of phenolphthalein.

**Module V: Chemistry of Functional Groups – II (8 hrs)**

*Aldehydes & Ketones:* Preparation from alcohols – Nucleophilic addition reactions (HCN and bisulphite) – Comparison of nucleophilic addition rate of aliphatic aldehydes and ketones.
*Carboxylic Acids:* Preparation from Grignard reagent – Decarboxylation – Kolbe electrolysis.
*Amines:* Preparation from nitro compounds – Hofmann's bromamide reaction – Hofmann's carbylamines reaction. Basicity: Comparison of basicity of ammonia, methyl amine and aniline.
*Diazonium Salts*: Preparation and synthetic applications of benzene diazonium chloride – Preparation and uses of methyl orange.

**References**

1. R. T. Morrison, R. N. Boyd, *Organic Chemistry*, 7th Edn., Pearson Education, New Delhi, 2013.
2. I. L. Finar, *Organic Chemistry*, Vol. I, 5th Edn., Pearson Education, New Delhi, 2013.
3. M. K. Jain, S. C. Sharma, *Modern Organic Chemistry*, 3rd Edn., Vishal Publishing Company Co., 2010.
4. K. S. Tewari, N. K. Vishnoi, S. N. Mehrotra, *A Textbook of Organic Chemistry*, 2nd Edn., Vikas Publishing House, New Delhi, 2004.

**Module VI: Biomolecules (8 hrs)**

*Carbohydrates: C*lassification with examples - cyclic structures of glucose and fructose - Applications of carbohydrates.

*Proteins:* Amino acids – Classification – Zwitter ion formation – Peptide linkage – Polypeptides and proteins – Primary, secondary and tertiary structure of proteins – Globular and fibrous proteins – Denaturation of proteins.

Enzymes: Characteristics and examples.

*Nucleic acids:* Structure of pentose sugar, nitrogenous base, nucleoside and nucleotide – Double-helical structure of DNA – Difference between DNA and RNA – DNA fingerprinting and its applications.

**References**

1. R. T. Morrison, R. N. Boyd, *Organic Chemistry*, 7th Edn., Pearson Education, New Delhi, 2013.

2. I. L. Finar, *Organic Chemistry*, Vol. I, 5th Edn., Pearson Education, New Delhi, 2013.

3. M. K. Jain, S. C. Sharma, *Modern Organic Chemistry*, 3rd Edn., Vishal Publishing Company Co., 2010.

4. K. S. Tewari, N. K. Vishnoi, S. N. Mehrotra, *A Textbook of Organic Chemistry*, 2nd Edn., Vikas Publishing House, New Delhi, 2004.

**Moldule VII: Alkaloids and Terpenes (3 hrs)**

*Alkaloids:* Classification – Source, structure and physiological functions of nicotine, coniine and piperine.

*Terpenes:* 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 menthol – Natural rubber – Vulcanization and its advantages.

*Note: Structural elucidation not expected in any case.*

**References**

1. R. T. Morrison, R. N. Boyd, *Organic Chemistry*, 7th Edn., Pearson Education, New Delhi, 2013.

2. I. L. Finar, *Organic Chemistry*, Vol. I, 5th Edn., Pearson Education, New Delhi, 2013.

3. M. K. Jain, S. C. Sharma, *Modern Organic Chemistry*, 3rd Edn., Vishal Publishing Company Co., 2010.

4. K. S. Tewari, N. K. Vishnoi, S. N. Mehrotra, *A Textbook of Organic Chemistry*, 2nd Edn., Vikas Publishing House, New Delhi, 2004.

| **Mark Distribution** | |
|---|---|
| Module I | 15 Marks |
| Module II | 10 Marks |
| Module III | 10 Marks |
| Module IV | 14 Marks |
| Module V | 13 Marks |
| Module VI | 12 Marks |
| Module VII | 5 Marks |

**SEMESTER IV**

**Course Code: CHE4C04**

**Complementary Course IV: PHYSICAL AND APPLIED CHEMISTRY**

Total Hours: 48; Credits: 2; Hours/Week: 3; Total Marks 75 (Internal 15 & External 60)

| **CHE4C04** | **PHYSICAL AND APPLIED CHEMISTRY** | L | T | P | C |
|---|---|---|---|---|---|
| | | 3 | 0 | 0 | 2 |
| Objective (s) | To provide the students a thorough knowledge about colloidal chemistry, nanochemistry and the importance of chemistry in daily life. It also provides a basic idea related to separation and spectral techniques. It also imparts the idea of green processes with special emphasis on environment. | | | | |
| Course outcome (s) | | | | | |
| CO1 | To understand the basic concepts behind colloidal state and nanochemistry. | | | | |
| CO2 | To understand the importance of green chemistry and pollution prevention. | | | | |
| CO3 | To appreciate the importance of different separation methods and spectral techniques. | | | | |
| CO4 | To understand the extent of chemistry in daily life. | | | | |

**Module I: Colloidal Chemistry (6 hrs)**

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 – Coagulation - Hardy Schulze rule – Protective colloids - Gold number. Emulsions. Applications of colloids: Delta formation, medicines, emulsification, cleaning action of detergents and soaps.

**References**

1. B. R. Puri, L. R. Sharma, M. S. Pathania, *Principles of Physical Chemistry*, 46th Edn., Vishal Publishing Company, New Delhi, 2013.
2. F. Daniels, R. A. Alberty, *Physical Chemistry*, 5th Edn., John Wiley and Sons, Canada, 1980.

**Module II: New Vistas in Chemistry (6 hrs)**

*Nanochemistry*: Introduction – classification of nanomaterials (0D, 1D, 2D) - size dependence of material properties (optical, electrical and catalytic) - surface to volume ratio and its significance - application of nanomaterials in electronics, optics, catalysis and medicine (detailed discussion not expected).

*Green Chemistry*: Definition and need of green chemistry - principles (detailed discussion not expected) - atom economy - green solvents - green synthesis of Ibuprofen.

**References**

1. M. A. Shah, Tokeer Ahmad, *Principles of Nanoscience and Nanotechnology*, Narosa Publishing House, New Delhi, 2010.
2. T. Pradeep, *A Textbook of Nanoscience and Nanotechnology*, McGrawhill, New Delhi, 2012.
3. V. K. Ahluwaliya, *Green Chemistry*, Narosa Publishing House, New Delhi, 2011.

**Module III: Chromatography (6 hrs)**

*Chromatography*- Introduction - Adsorption and partition chromatography - Principle and applications of column, thin layer, paper and gas chromatography - Rf value – Relative merits of different techniques.

**References**

1. R. A. Day Junior, A. L. Underwood, *Quantitative Analysis*, 5th Edn., Prentice Hall of India Pvt. Ltd., New Delhi, 1988.
2. J. Mendham, R. C. Denney, J. D. Barnes, M. Thomas, *Vogel's Text Book of Quantitative Chemical Analysis*, 6th Edn., Pearson Education, 2003.
3. R. Gopalan, P.Subramanian, K Rengarajan, *Elements of Analytical Chemistry*, S. Chand and Co., New Delhi, 2004.
4. R. P. Budhiraja, *Separation chemistry*, New Age International (P) Ltd., 2007.

**Module IV: Spectroscopy (10 hrs)**

Origin of spectra - Interaction of electromagnetic radiation with matter. Different types of energy levels in molecules: Rotational, vibrational and electronic levels. Statement of Born-Oppenheimer approximation - Fundamental laws of spectroscopy and selection rules (derivations not required).

*IR Spectroscopy:* Introduction - Group frequency concept - Characteristic stretching frequencies of O-H, N-H, C-H, C=C, C=N and C=O functional groups - Fingerprint region in IR spectra.

*UV-Visible Spectroscopy:* Introduction - Beer-Lambert's law - Electronic transitions in molecules ($\sigma\rightarrow\sigma^*$, $n\rightarrow\sigma^*$, $\pi\rightarrow\pi^*$ and $n\rightarrow\pi^*$) - Chromophore and auxochrome - Red shift and blue shift.

*NMR Spectroscopy:* Introduction - Chemical shift and spin-spin coupling - Application in elucidating the structure of ethanol, dimethyl ether, propanal and acetone (detailed study not required).

**References**

1. P. S. Kalsi, *Applications of Spectroscopic Techniques in Organic Chemistry*, 6th Edn., New Age International (P) Ltd., New Delhi, 2004.

2. C. N. Banwell, E. M. Mc Cash, *Fundamentals* of *Molecular Spectroscopy*, 4th Edn., McGraw–Hill publishing Company Limited, New Delhi, 2002.

**Module V: Polymers (4 hrs)**

Classification of polymers - Addition and condensation polymers – Thermoplastics and thermosetting plastics - Structure and applications of synthetic rubbers (Buna-S, Buna-N and neoprene), synthetic fibres (Nylon 66, Nylon 6 and dacron), thermoplastics (polyethene, polystyrene, PVC and teflon) and thermosetting plastics (bakelite and melmac). Uses of kevlar, nomex and lexan – Biodegradable polymers (PGA, PLA and PHBV) and their applications.

**References**

1. V. R. Gowarikar, *Polymer Chemistry*, New Age International Pvt. Ltd., New Delhi, 2010.
2. Fred. W. Billmeyer, *Textbook of Polymer Science*, 3rd Edn., Wiley India, Delhi, 2008.

**Module VI: Environmental Pollution (6 hrs)**

Definition – Types of pollution.

Air pollution: Pollution by oxides of nitrogen, carbon and sulphur. Effects of air pollution: Depletion of ozone, green house effect and acid rain.

Water pollution: Pollution due to sewage, industrial effluents, soaps, detergents, pesticides, fertilizers and heavy metals – Eutrophication - Biological magnification and bioaccumulation - Effects of water pollution. Water quality parameters – DO, BOD and COD (elementary idea only).

Soil pollution – Pollution due to plastics.

Thermal pollution and radioactive pollution: Sources, effects and control measures.

**References**

1. A. K. De, *Environmental Chemistry*, 6th Edn., New Age International Pvt. Ltd., New Delhi, 2006.
2. A. K. Ahluwalia, *Environmental Chemistry*, Ane Books India, New Delhi, 2008.

**Module VII: Chemistry in Daily Life (10 hrs)**

*Petrochemicals:* Name, carbon range and uses of fractions of petroleum distillation – Octane number - Cetane number – Flash point. LPG and CNG: Composition and uses.

*Pharmaceuticals:* Drug - Chemical name, generic name and trade names with examples. Antipyretics, analgesics, antibiotics, antacids, antiseptics (definition and examples, structure not expected).

*Dyes:* Definition – Requirements of a dye - Theories of colour and chemical constitution – Structure and applications of martius yellow, indigo and alizarin.

*Food:* Food additives: Food preservatives, artificial sweeteners and antioxidants (definition and examples, structures not required) Commonly used permitted and non-permitted food colours (structures not required).

*Cement*: Manufacture, composition and setting.

*Glass*: Types of glasses and uses.

**References**

1. Gurdeep R. Chatwal, *Synthetic Drugs*, Himalaya Publishing House, Bombay, 1995.

2. Jayashree Ghosh, *A Textbook of Pharmaceutical Chemistry*, 3rd Edn., S. Chand and Company Ltd., New Delhi, 1999.

3. B. Sivasankar, *Food processing and preservation*, Prentice – Hall of India Pvt. Ltd., New Delhi, 2002.

4. Srinivasan Damodaran, Kirk L. Parkin, Owen R. Fennema, *Food Chemistry*, 4th Edn., CRC Press, New York, 2007.

| **Mark Distribution** | |
|---|---|
| Module I | 10 Marks |
| Module II | 10 Marks |
| Module III | 10 Marks |
| Module IV | 15 Marks |
| Module V | 7 Marks |
| Module VI | 10 Marks |
| Module VII | 17 Marks |

**SEMESTER IV**

**Course Code: CHE4C05(P)**

**Complementary Course V: CHEMISTRY PRACTICAL**

Total Hours: 128; Credits: 4; Hours/Week: 2 (I, II, III & IV Semesters); Total Marks 100 (Internal 20 & External 80)

| **CHE4C05(P)** | **CHEMISTRY PRACTICAL** | L | T | P | C |
|---|---|---|---|---|---|
| | | 0 | 0 | 2 | 4 |
| Objective (s) | To develop proficiency in quantitative and qualitative analysis and expertise in organic preparation and determination of physical constants. | | | | |
| Course outcome (s) | | | | | |
| CO1 | To understand the basic concepts of inter group separation. | | | | |
| CO2 | To enable the students to develop analytical and preparation skills. | | | | |

**General Instructions**

1. Semi micro analysis may be adopted for inorganic qualitative analysis.
2. For weighing, either electronic balance or chemical balance may be used.
3. For titrations, double burette titration method must be used.
4. Standard solution must be prepared by the student.
5. Use safety coat, gloves, shoes and goggles in the laboratory.
6. A minimum of 7 inorganic mixtures and 9 volumetric estimations must be done to appear for the examination.
7. Practical examination will be conducted at the end of semester IV.

**Module I: Laboratory Safety, First Aid and Treatment of Fires**

Importance of lab safety – Burns – Eye accidents – Cuts – Gas poisoning – Electric shocks –Treatment of fires – Precautions and preventive measures.

**Module II: Volumetric Analysis**

1. Weighing using chemical balance and electronic balance.
2. Preparation of standard solutions.
3. Neutralization Titrations (i) Strong acid – strong base. (ii) Strong acid – weak base. (iii) Weak acid – strong base.
4. Redox Titrations

Permanganometry:

(i) Estimation of oxalic acid.

(ii) Estimation of $Fe^{2+}$/$FeSO_4.7H_2O$/Mohr's salt.

Dichrometry:

(i) Estimation of $Fe^{2+}$/$FeSO_4.7H_2O$/Mohr's salt using internal indicator.

(ii) Estimation of $Fe^{2+}$/$FeSO_4.7H_2O$/Mohr's salt using external indicator.

Iodimetry and Iodometry:

(i) Estimation of iodine. (ii) Estimation of copper. (iii) Estimation of chromium.

5. Complexometric Titrations (i) Estimation of zinc. (ii) Estimation of magnesium. (iii) Determination of hardness of water.

**Module III: Gravimetric Analysis**

1. Determination of water of hydration in crystalline barium chloride.
2. Estimation of $Ba^{2+}$ as $BaSO_4$.

**Module IV: Inorganic Qualitative Analysis**

(a) Reactions of Cations: Study of the reactions of the following cations with a view of their identification and confirmation. $Pb^{2+}$, $Bi^{3+}$, $Cu^{2+}$, $Cd^{2+}$, $Fe^{2+}$, $Fe^{3+}$, $Al^{3+}$, $Ni^{2+}$, $Co^{2+}$, $Mn^{2+}$, $Zn^{2+}$, $Ba^{2+}$, $Sr^{2+}$, $Ca^{2+}$, $Mg^{2+}$ and $NH_4^+$. (b) Systematic qualitative analysis of a solution containing any two cations from the above list.

**Module V: Determination of Physical Constants**

1. Determination of boiling point.
2. Determination of melting point.

**Module VI: Organic Preparations**

1. *p*-Bromoacetanilide from acetanilide.
2. *p*-Nitroacetanilide from acetanilide.
3. Benzoic acid from benzaldehyde.
4. Benzoic acid from benzamide.

**References**

1. J. Mendham, R. C. Denney, J. D. Barnes, M. Thomas, *Vogel's Textbook of Quantitative Chemical Analysis*, 6th Edn., Pearson Education, Noida, 2013.

2. D. A. Skoog, D. M. West, F. J. Holler, S. R. Crouch, *Fundamentals of Analytical Chemistry*, 8th Edn., Brooks/Cole, Thomson Learning, USA, 2004.

3. V. K. Ahluwalia, Sunita Dhingra, Adarsh Gulati, *College Practical Chemistry*, Universities Press (India) Pvt. Ltd., Hyderabad, 2008 (Reprint).

4. G. Svehla, *Vogel's Qualitative Inorganic Analysis*, 7th Edn., Prentice Hall, New Delhi, 1996.

5. V. V. Ramanujam, *Inorganic Semi Micro Qualitative Analysis*, 3rd Edn., The National Publishing Company, Chennai, 1974.

6. W. G. Palmer, *Experimental Inorganic Chemistry*, Cambridge University Press, 1970.

# EVALUATION SCHEME

# FOR

# COMPLEMENTARY COURSES

## COMPLEMENTARY COURSE THEORY: EVALUATION SCHEME

The evaluation scheme for each course contains two parts: *viz.*, internal evaluation and external evaluation.

### 1. INTERNAL EVALUATION

20% of the total marks in each course are for internal evaluation. The colleges shall send only the marks obtained for internal examination to the university. The internal assessment shall be based on a predetermined transparent system involving written tests, class room participation based on attendance, assignment and seminar/viva in respect of theory courses. For practical course it is based on lab involvement and record.

**Table 1: Components of Evaluation**

| *Sl. No.* | *Components* | *Marks* |
|---|---|---|
| 1 | Class room participation based on attendance (20%) | 3 |
| 2 | Test papers I (40%) | 6 |
| 3 | Assignment (20%) | 3 |
| 4 | Seminar/viva (20%) | 3 |
| *Total Marks* | | 15 |

**Table 2: Percentage of attendance based on class room participation and eligible marks**

| *% of attendance* | *Marks* |
|---|---|
| 85% and above | 3 |
| 75 - <85% | 2 |
| 50 - <75% | 1 |

**Table 3: Pattern of Test Papers**

| *Duration* | *Pattern* | *Total number of questions* | *Number of questions to be answered* | *Marks for each question* | *Ceiling of Marks* |
|---|---|---|---|---|---|
| 1 Hour | Short answer | 6 | Up to 6 | 2 | 10 |
| | Paragraph | 4 | Up to 4 | 5 | 15 |
| | Essay | 2 | 1 | 10 | 10 |
| *Total Marks** | | | | | 35 |

*85% and above = 6, 65 to below 85% = 5, 55 to below 65% = 4, 45 to below 55% = 3, 35 to below 45% = 2, below 35% = 1

## 2. EXTERNAL EVALUATION

External evaluation carries 80% marks. University examinations for two hours duration will be conducted at the end of each semester.

**Table 1: Pattern of Question Papers**

| *Duration* | *Pattern* | *Total number of questions* | *Number of questions to be answered* | *Marks for each question* | *Ceiling of Marks* |
|---|---|---|---|---|---|
| 2 Hours | Short answer | 12 | Up to 12 | 2 | 20 |
| | Paragraph | 7 | Up to 7 | 5 | 30 |
| | Essay | 2 | 1 | 10 | 10 |
| *Total Marks* | | | | | 60 |

## COMPLEMENTARY COURSE PRACTICAL: EVALUATION SCHEME

The evaluation scheme contains two parts: *viz.*, internal evaluation and external evaluation.

## 1. INTERNAL EVALUATION

20% of the total marks are for internal evaluation. The colleges shall send only the marks obtained for internal examination to the university.

**Table 1: Components of Evaluation**

| *Sl. No.* | *Components* | *Marks* |
|---|---|---|
| 1 | Record | 12 |
| 2 | Lab involvement (viva – 4 and punctuality – 4) | 8 |
| *Total Marks* | | 20 |

**Table 2: Number of Experiments and Marks for Practical Records**

| *Number of Experiments (Marks in brackets)* | |
|---|---|
| *Volumetric Analysis* | *Mixture Analysis* |
| 11-12 (6) | 9-10 (6) |
| 10 (5) | 8 (5) |
| 9 (4) | 7 (4) |

## 2. EXTERNAL EVALUATION

External evaluation carries 80% marks. Practical examination will be conducted at the end of IV$^{th}$ semester.

**Table 1: Pattern of Question Paper**

| *Duration* | *Pattern* | *Marks* | *Total* |
|---|---|---|---|
| 3 Hours | Question on qualitative and quantitative analysis | 8 | 80 |
| | Procedure on volumetric analysis | 6 | |
| | Volumetric analysis | 28 | |
| | Mixture analysis | 28 | |
| | Record | 10 | |

*Guidelines*

1. *Valuation of Volumetric Procedure*: Eight points – 6 marks. 1. Correct intermediate; 2. Preparation of standard solution; 3. Standardisation of intermediate; 4. Indicator and end point of standardization; 5. Making up of given solution; 6. Titration of made up solution; 7. Indicator; 8. End point/any other relevant points.

2. *Marks for Result:* The reported values (RV) of the students are compared with theoretical value (TV) and skilled value (SV) and calculate error percentage. Up to 1.5% error: 24 marks; between 1.51 – 2%: 20 marks; between 2.1– 2.5%: 16 marks; between 2.51– 3%: 12 marks; greater than 3%: 8 marks.

3. *Marks for Calculation:* Eight points – 4 marks. 1. Equivalent mass of the primary standard substance; 2. Calculation of normality of primary standard; 3. Table for standardization of intermediate with standard substance and indicator at the top; 4. Calculation of normality of the intermediate; 5. Table for estimation including standard substance and indicator; 6. Calculation of normality of the given solution; 7. Equivalent mass of the compound/ion in the given solution; 8. Calculation of weight in the whole of the given solution.

4. *Marks for Mixture Analysis:* Group identification: 1 mark each. Cation identification tests: 3 mark each. Chemistry of identification tests: 3 mark each. Cation confirmation tests: 3 marks each. Chemistry of confirmation tests: 3 mark each. Systematic procedure: 2 marks.

**Table 2: Evaluation of Records**

| *Number of Experiments (Marks in brackets)* | |
|---|---|
| Volumetric Analysis (Max. Marks:5) | Mixture Analysis (Max. Marks: 5) |
| 11-12 (5) | 9-10 (5) |
| 10 (4) | 8 (4) |
| 9 (3) | 7 (3) |

# SYLLABUS

# FOR

# OPEN COURSES

# OPEN COURSE STRUCTURE

## (FOR STUDENTS OTHER THAN B.Sc. CHEMISTRY) Total Credits: 3 (Internal 20%; External 80%)

| ***Semester*** | *Code No* | *Course Title* | *Hrs/ Week* | *Total Hrs* | *Marks* |
|---|---|---|---|---|---|
| **V** | CHE5D01 | Open Course 1: Environmental Chemistry | 3 | 48 | 75 |
| | CHE5D02 | Open Course 2: Chemistry in Daily Life | | | |
| | CHE5D03 | Open Course 3: Food Science and Medicinal Chemistry | | | |

# SEMESTER V

## Course Code: CHE5D01

## Open Course 1: ENVIRONMENTAL CHEMISTRY

Total Hours: 48; Credits: 3; Hours/Week: 3; Total Marks 75 (Internal 15 & External 60)

**Course outcomes**

At the end of the course, students will be able to:

CO 1: Recall the technical/scientific terms involved in pollution.

CO 2: Understand the causes and effects of air pollution.

CO 3: Understand the sources, types and effects of water pollution.

CO 4: Describe water quality parameters.

CO 5: Know soil, noise, thermal and radioactive pollutions and their effects.

CO 6: Study various pollution control measures.

CO 7: Understand the basics of green chemistry.

### Module I: Introduction to Environment and Environmental pollution (4 hrs)

Environmental chemistry - introduction, Environmental segments – Lithosphere: components of soils, Hydrosphere: water resources, Biosphere, Atmosphere - regions of atmosphere – Troposphere, stratosphere, mesosphere, thermosphere.

Environmental pollution – Concepts and definition – Pollutant, contaminant, receptor and sink – Classification of pollutants – Global, regional, local, persistent and non-persistent pollutants.

**References**

1. A. K. De, *Environmental Chemistry*, 7th Edn., New Age International, 2012.
2. A. K. Ahluwalia, *Environmental Chemistry*, The Energy and Resources Institute, 2017.
3. Balram Pani, *Textbook of Environmental Chemistry*, I. K. International Pvt Ltd, 2010.

### Module II: Air Pollution (8 hrs)

Tropospheric pollution – Gaseous air pollutants – Hydrocarbons, oxides of sulphur, nitrogen and carbon – Global warming, green house effect, acid rain – Particulates – Smog: London smog and photochemical smog – effects and control of photochemical smog – stratospheric pollution - depletion of ozone layer, chlorofluorocarbons - Automobile pollution. Control of air pollution – Alternate refrigerants – Bhopal Tragedy (a brief study). Air pollution in Indian cities (Delhi, Agra and Kanpur).

**References**

1. S. K. Banergy, *Environmental Chemistry*, 2nd Edn., Prentice-Hall of India Pvt. Ltd., New Delhi, 2005.
2. V. N. Bashkin, *Environmental Chemistry: Asian Lessons*, Springer Science & Business Media, 2003.
3. S. E. Manahan, *Environmental Chemistry*, 8th Edn., CRC Press, Florida, 2004.
4. A. K. Ahluwalia, *Environmental Chemistry*, The Energy and Resources Institute, 2017.
5. Balram Pani, *Textbook of Environmental Chemistry*, I. K. International Pvt. Ltd., 2010.

**Module III: Water Pollution (10 hrs)**

Impurities in water – cause of pollution – natural and anthropogenic – Marine water pollution – Underground water pollution.

Source of water pollution – Industrial waste, Municipal waste, Agricultural waste, Radioactive waste, Petroleum, Pharmaceutical, heavy metal, pesticides, soaps and detergents.

Types of water pollutants: Biological agents, physical agents and chemical agents – Eutrophication - biomagnification and bioaccumulation.

Water quality parameters: DO, BOD, COD, alkalianity, hardness, chloride, fluoride and nitrate. Toxic metals in water and their effects: Cadmium, lead and mercury – Minamata disaster (a brief study), itai-itai disease, oil pollution in water. International standards for drinking water.

**References**

1. S. K. Banergy, *Environmental Chemistry*, 2nd Edn., Prentice-Hall of India Pvt. Ltd., New Delhi, 2005.
2. J. M. H. Selendy, *Water and Sanitation-Related Diseases and the Changing Environment*, John Wiley & Sons, 2011.
3. P. K. Goel, *Water Pollution: Causes, Effects and Control*, New Age International, 2006.
4. V. N. Bashkin, *Environmental Chemistry: Asian Lessons*, Springer Science & Business Media, 2003.
5. S. E. Manahan, *Environmental Chemistry*, 8th Edn., CRC Press, Florida, 2004.
6. A. K. Ahluwalia, *Environmental Chemistry*, The Energy and Resources Institute, 2017.
7. Balram Pani, *Textbook of Environmental Chemistry*, I. K. International Pvt. Ltd., 2010.

**Module IV: Soil, Noise, Thermal, light and Radioactive Pollutions (8 hrs)**

Soil pollution: Sources by industrial and urban wastes. Pollution due to plastics, pesticides, biomedical waste and *e-waste* (source, effects and control measures) – Control of soil

pollution - Solid waste Management – Open dumping, landfilling, incineration, re-use, reclamation, recycle, composting.

Non-degradable, degradable and biodegradable wastes. Hazardous waste.

Noise Pollution – physiological response to noise, Noise categories - effect of noise – biological effects.

Thermal pollution – definition, sources, harmful effects and prevention. Light pollution.

Radioactive pollution (source, effects and control measures) – Hiroshima, Nagasaki and Chernobyl accidents (brief study). Endosulfan disaster in Kerala (brief study).

**References**

1. S. E. Manahan, *Environmental Chemistry*, 8th Edn., CRC Press, Florida, 2004.
2. A. K. Ahluwalia, *Environmental Chemistry*, The Energy and Resources Institute, 2017.
3. A. K. De, *Environmental Chemistry*, 6th Edn., New Age International.
4. Balram Pani, *Textbook of Environmental Chemistry*, I. K. International Pvt. Ltd., 2010.
5. Anindita Basak, *Environmental Studies*, Pearson Education India, 2009.
6. Pallavi Saxena, Vaishali Naik, *Air Pollution: Sources, Impacts and Controls*, CAB International, 2018.

**Module V: Pollution Control Measures (12 hrs)**

Air pollution control measures – Gravitational settling chamber, fabric filter, wet scrubber, catalytic converters, stacks and chimneys, cyclone collectors, Cottrell electrostatic precipitator, extraction ventilator, zoning and green belt.

**References**

1. N. P Cheremisinoff , *Handbook of Air Pollution Prevention and Control*, 2002.
2. M. Senapati, *Advanced Engineering Chemistry*, 2006.
3. K. C. Schifftner, *Air Pollution Control Equipment Selection Guide*, CRC Press, 2013.
4. K. B. Schnelle, C. A. Brown, *Air Pollution Control Technology Handbook*, CRC Press, 2016.

**Module VI: Green Chemistry (6 hrs)**

Introduction- Definition of green Chemistry, need of green chemistry, basic principles of green chemistry. Applications of green chemistry in daily life.

**References**

1. V.K. Ahluwalia, M. Kidwai, *New Trends in Green Chemistry*, Springer Science & Business Media, 2012.
2. M. Lancaster, *Green Chemistry*: *An Introductory Text*, Royal Society of Chemistry, 2010.
3. S. C. Ameta, R. Ameta, *Green Chemistry*: *Fundamentals and Applications*, CRC Press,

2013.

**Scheme of Examinations**:

The external question paper carries 60 marks and internal examination is of 15 marks. Duration of each external examination is 2 Hrs. The pattern of External Examination is as given below:

| | |
|---|---|
| **Section A** | |
| Short answer type carries 2 marks each – 12 questions | Ceiling – 20 |
| **Section B** | |
| Paragraph/ Problem type carries 5 marks each – 7 questions | Ceiling – 30 |
| **Section C** | |
| Essay type carries 10 marks (1 out of 2) | 1x10=10 |

The students can answer all the questions in sections A & B but there shall be ceiling.

| **Mark Distribution** | |
|---|---|
| Module I | 9 Marks |
| Module II | 14 Marks |
| Module III | 18 Marks |
| Module IV | 14 Marks |
| Module V | 16 Marks |
| Module VI | 8 Marks |

**SEMESTER V**

**Course Code: CHE5D02**

**Open Course 2: CHEMISTRY IN DAILY LIFE**

Total Hours: 48; Credits: 3; Hours/Week: 3; Total Marks 75 (Internal 15 & External 60)

**Course outcomes**

At the end of the course, students will be able to:

CO 1: Understand the basics of polymer chemistry.

CO 2: Explain the functions of biomolecules, vitamins, enzymes, hormones and nucleic acid.

CO 3: Describe food additives and food habits.

CO 4: Explain the uses of pesticides and fertilizers and their impacts on the environment.

CO 5: Understand advantages and disadvantages of cleansing agents and cosmetics.

CO 6: Recognize the common classes of drugs in pharmaceutical industry and their application.

CO 7: Understand the basic concepts and processes in petroleum industry.

**Module I: Polymers (8 hrs)**

Classification of polymers: Origin, structure, synthesis, molecular forces. Commercially important polymers: Application of polyethylene, polystyrene, polyhaloolefines, Nylon 6, Nylon 66, Melamine, Terylene, Bakelite, natural and synthetic rubber, vulcanization, Advantages of vulcanized rubber, natural silk and artificial silk, inorganic polymer: (Examples Only) - Plastic identification codes – Applications of biodegradable polymers (PGA, PLA and PHBV) – Importance of plastic recycling.

**References**

1. B. K. Sharma, *Industrial Chemistry*, 11th Edn., Goel publishing House, Meerut, 2000.

2. K. S. Tewari, N. K. Vishnoi, S. N. Mehrotra, *A Textbook of Organic Chemistry*, 2nd Edn., Vikas Publishing House (Pvt.) Ltd., New Delhi, 2004.

3. V. R. Gowarikar, *Polymer Chemistry*, New Age International Pvt. Ltd., New Delhi, 2010.

4. B. K. Sharma, *Polymer Chemistry*, Goel Publishing House, Meerut, 1989.

5. M. G. Arora, M. Singh, M. S. Yadav, *Polymer Chemistry*, 2nd Revised Edn., Anmol Publications Private Ltd., New Delhi, 1989.

6. Catia Bastioli, *Handbook of Biodegradable Polymers*, Smithers Rapra Publishing, 2005.

**Module II: Chemistry in Biological Systems (8 hrs)**

Vitamins: Name, source, function and deficiency diseases. Enzymes - Classifications, characteristics, role, examples. Hormones - Sex hormones - Androgens, oestrogens, progesterone, example, function. Cortical hormones - a few examples with function. Nucleic acid - RNA, DNA: Introduction - role in life process (No structure or chemical

reactions needed).

**References**

1. M. V. Kulkarni, *Biochemistry*, Pragati Books Pvt. Ltd., 2008.
2. S. C. Rastogi, *Biochemistry*, 2nd Edn., Tata McGraw Hill Publishing Co., New Delhi, 2007.
3. U. Satyanarayana, U. Chakrapani, *Biochemistry*, Elsevier Health Sciences, 2014.
4. K. S. Tewari, N. K. Vishnoi, S. N. Mehrotra, *A Textbook of Organic Chemistry*, 2nd Edn., Vikas Publishing House (Pvt.) Ltd., New Delhi, 2004.
5. D. Sriram, *Medicinal Chemistry*, Pearson Education India, 2010.
6. N. V. Bhagavan, *Medical Biochemistry*, Academic Press, 2002.

**Module III: Food Chemistry (8 hrs)**

Common adulterants in different foods: Milk and milk products, vegetable oils, cereals, tea, coffee powder, chilly powder and beverages.
Food Additives: Antioxidants and food preservatives – Commonly used permitted and non-permitted food colours – Artificial sweeteners – Taste enhancers – Artificial ripening of fruits and its side effects.
Modern Food Habits: Definition and health effects of fast foods, instant foods, dehydrated foods and junk foods. Harmful effects of modern food habits.
Importance of milk, coconut water and Neera.

**References**

1. Lillian Hoagland Meyer, *Food Chemistry*, 1st Edn., CBS Publishers & Distributors, New Delhi, 2004.
2. B. A. Fox, A. G. Cameron, E. Arnold, *Food Science*, Nutrition and Health, 6th Edn., Edward Arnold, London, 1995.
3. A. Siddiqui, N. Anusha, *Deleterious Effects of Food Habits in Present Era*, J. Aller. Ther. 3:114, 2012.
4. H. S. Ramaswamy, M. Marcotte, *Food Processing: Principles and Applications*, CRC Press, 2005.
5. A. F. Smith, *Encyclopedia of Junk Food and Fast Food*, Greenwood Publishing Group, 2006.
6. T. A. M. Sagati, The Chemistry of Food Additives and Preservatives, John Wiley & Sons, 2012.
7. S. N. Mahindru, *Food Additives*, APH Publishing, 2009.
8. Biju Mathew, *Anchor India*, Info Kerala Communications Pvt. Ltd., 2015.

**Module IV: Agriculture (4 hrs)**

Fertilizers: Essential nutrients for plants – NPK value – Natural and synthetic fertilizers – Nitrogenous, phosphatic and potash fertilizers (examples) – Impact of excessive use of

fertilizers on environment – Biofertilizers.

Pesticides: Classification – Insecticides, herbicides, rodenticides and fungicides (definition and examples only) – Non-degradable pesticides – Pesticide pollution and its impact on environment – Endosulfan disaster in Kerala (brief study). Pheromones.

**References**

1. H. S. Rathore, L. M. L. Nollet, *Pesticides: Evaluation of Environmental Pollution*, CRC Press, USA, 2012.

2. Murray Park, *The Fertilizer Industry*, Elsevier, 2001.

3. B. K. Sharma, *Industrial Chemistry*, Krishna Prakashan Media, 1991.

**Module V: Cleansing Agents and Cosmetics (6 hrs)**

Cleansing Agents: Soaps – Hard and soft soaps – Alkali content – TFM – Detergents (classification) – Cleaning action – Advantages and disadvantages of soaps and detergents – Shaving creams. Shampoos: Ingredients and functions – Different kinds of shampoos (Anti-dandruff, anti-lice, herbal and baby shampoos). Tooth paste: Composition and health effects.

Cosmetics: Hair dye: Chemicals used and its harmful effects. Face and skin powders: Types, ingredients and functions. Cleansing creams: Cold creams, vanishing creams and bleach creams. Perfumes, antiperspirants, sun screen preparations, nail polishes, lipsticks, rouges, eyebrow pencils and eye liners (ingredients and functions) – Harmful effects of cosmetics.

**References**

1. B. K. Sharma, *Industrial Chemistry*, Krishna Prakashan Media, 1991.

2. M. S. R. Winter, *A Consumer's Dictionary of Cosmetic Ingredients*, 7th Edn., Three Rivers Press, New York, 2009.

**Module VI: Pharmaceuticals and Dyes (8 hrs)**

Drug: Chemical name, generic name and trade names with examples. Terminology: Prodrug, pharmacy, pharmacology, pharmacophore, pharmacognosy, pharmacodynamics and pharmacokinetics (elementary idea only). Antipyretics, analgesics, antacids, antihistamines, antibiotics, antiseptics, disinfectants, anaesthetics, tranquilizers, narcotics, antidepressants and psychedelic drugs (definition and examples).

Dyes: classification based on constitution, application, examples, uses.

Dyes: Requirements of a dye – Classification based on mode of application to the fabric – Applications of dyes (general study). Ancient and modern colours – Mention of indigo and alizarin.

**References**

1. B. K. Sharma, *Industrial Chemistry*, Krishna Prakashan Media, 1991.

2. Gurdeep R. Chatwal, *Synthetic Drugs*, Himalaya Publishing House, Bombay, 1995.
3. Jayashree Ghosh, *A Textbook of Pharmaceutical Chemistry*, 3rd Edn., S. Chand and Company Ltd., New Delhi, 1999.

**Module VII: Fuels (6 hrs)**

Definition and classification of fuels – Characteristics of a good fuel – Combustion – Calorific value – Wood.

Coal: Classification based on carbon content – Fractional distillation products of coal and uses of various fractions.

Petroleum: Origin – Fractional distillation – Different fractions, their composition and uses. Petrol: Knocking – Octane number – Aviation fuel. Diesel: Cetane number. Flash point. Natural gas, biogas and LPG: Composition and uses.

Pollution due to burning of fossil fuels.

Solar energy and solar cells (applications only).

**References**

1. B. K. B. Rao, *Modern Petroleum Refining Processes*, 4th Edn., Oxford & IBH Publishing Co. Pvt. Ltd., New Delhi, 2002.
2. B. K. Sharma, *Industrial Chemistry*, Krishna Prakashan Media, 1991.

**Scheme of Examinations**:

The external question paper carries 60 marks and internal examination is of 15 marks. Duration of each external examination is 2 Hrs. The pattern of External Examination is as given below:

| | |
|---|---|
| **Section A** | |
| Short answer type carries 2 marks each – 12 questions | Ceiling – 20 |
| **Section B** | |
| Paragraph/ Problem type carries 5 marks each – 7 questions | Ceiling – 30 |
| **Section C** | |
| Essay type carries 10 marks (1 out of 2) | 1x10=10 |

The students can answer all the questions in sections A & B but there shall be ceiling.

| **Mark Distribution** | |
|---|---|
| Module I | 14 Marks |
| Module II | 12 Marks |
| Module III | 12 Marks |
| Module IV | 8 Marks |
| Module V | 11 Marks |
| Module VI | 12 Marks |
| Module VII | 10 Marks |

## SEMESTER V

### Course Code: CHE5D03

### Open Course 3: FOOD SCIENCE AND MEDICINAL CHEMISTRY

Total Hours: 48; Credits: 3; Hours/Week: 3; Total Marks 75 (Internal 15 & External 60)

**Course outcomes**

At the end of the course, students will be able to:

CO 1: Understand food adulteration and preservation methods.

CO 2: Understand food additives.

CO 3: Compare modern food with natural food.

CO 4: Describe the harmful effects of alcohol and modern food habits.

CO 5: Exhibit a broad and coherent body of knowledge on the biomolecules, vitamins, enzymes, hormones and nucleic acids.

CO 6: Recognize the uses of Indian medicinal plants and plant extracts.

CO 7: Recall the chemical, generic and trade names of drugs and their uses.

CO 8: Describe the treatment methods used in medical field.

CO 9: Illustrate first aids and the safety steps to be taken for common illnesses.

**Module I: Food Adulteration and Preservation (6 hrs)**

Common adulterants in different foods and their identification*:* Milk and milk products, vegetable oils and fats, spices and condiments, cereals, pulses, tea, coffee powder, chilly powder, turmeric powder and beverages - Contamination with toxic chemicals, pesticides and insecticides.

Methods of preservation*:* Need for preservation - Classification - Freezing, smoking, use of sugar, pickling, artificial food additives, canning and bottling, high pressure, burial in the ground, controlled use of micro organism and bio-preservation.

Packaging of foods*:* Classification - Materials used for packaging – Harmful effects.

**References**

1. B. Siva Sankar, *Food Processing and Preservation*, Prentice–Hall of India Pvt. Ltd., New Delhi, 2002.

2. Shyam Narayan Jha, *Rapid Detection of Food Adulterants and Contaminants: Theory and Practice*, Academic Press, 2015.

3. *Encyclopedia of Food Chemistry*, Elsevier, 2018.

4. B. Srilakshmi, *Food Science*, 5th Edn., New Age Publishers, New Delhi, 2010.

**Module II: Chemistry of Food (10 hrs)**

Food additives*:* Antioxidants and food preservatives – Commonly used permitted and non-permitted food colours - Artificial sweeteners - Taste enhancers – Monosodium glutamate – Vinegar - Artificial ripening of fruits and its health effects.

Modern food habits*:* Introduction – Definition and health effects of fast foods, instant foods, dehydrated foods, junk foods and condiments - Composition and health effects of chocolates, soft drinks and soda water.

Natural Food*:* Importance of milk, coconut water and Neera - Importance of regional and seasonal fruits - Traditional Kerala foods and their advantages.

**References**

1. B. Siva Sankar, *Food Processing and Preservation*, Prentice–Hall of India Pvt. Ltd., New Delhi, 2002.
2. Lillian Hoagland Meyer, *Food Chemistry*, 1st Edn., CBS Publishers & Distributors, New Delhi, 2004.
3. B. A. Fox, A. G. Cameron, E. Arnold, *Food Science, Nutrition and Health*, 6th Edn., Edward Arnold, London, 1995.

**Module III: Beverages (4 hrs)**

Definition and examples - Classification of beverages - fruit beverages - milk based beverages - malted beverages - alcoholic and non alcoholic beverages - examples. Appetizers - definition - classification - examples.

Addiction to alcohol - Cirrhosis of liver and social problems. Harmful effects of modern food habits.

**References**

1. B. Siva Sankar, *Food Processing and Preservation*, Prentice–Hall of India Pvt. Ltd., New Delhi, 2002.
2. Srilakshmi, *Food Science*, 5th Edn., New Age Publishers, New Delhi, 2010.
3. Lillian Hoagland Meyer, *Food Chemistry*, 1st Edn., CBS Publishers & Distributors, New Delhi, 2004.
4. B. A. Fox, A. G. Cameron, E. Arnold, *Food Science, Nutrition and Health*, 6th Edn., Edward Arnold, London, 1995.

**Module IV: Biochemistry (5 hrs)**

Vitamins (name, source, function and deficiency diseases). Enzymes (classification, characteristics, function and examples) - Hormones (classification, organ of secretion and functions) - Nucleic acids (introduction and role in life processes) – DNA finger printing (a brief study).

**References**

1. S. C. Rastogi, *Biochemistry*, 2nd Edn., Tata McGraw Hill Publishing Co., New Delhi, 2007.

2. M. V. Kulkarni, *Biochemistry*, Pragati Books Pvt. Ltd., 2008.

3. U. Satyanarayana, U. Chakrapani, *Biochemistry*, Elsevier Health Sciences, 2014.

4. K. S. Tewari, N. K. Vishnoi, S. N. Mehrotra, *A Textbook of Organic Chemistry*, 2nd Edn., Vikas Publishing House (Pvt.) Ltd., New Delhi, 2004.

**Module V: Medicinal Chemistry – I (5 hrs)**

Health and Biochemical Analysis*:* Definition of health - WHO standard - Biochemical analysis of urine and serum. Blood: Composition, grouping and Rh factor - Blood transfusion.

Indian Medicinal Plants*:* Kizharnelli, Thumbai, Hibiscus, Adathodai, Nochi, Thulasi, Brahmi, Aloe Vera and Neem plant (major chemical constituents and medicinal uses).

Essential Oils*:* Extraction by steam distillation – Source and medicinal uses of eucalyptus oil, sandalwood oil and lemongrass oil.

**References**

1. Guyton and Hall, *Textbook of Medical Physiology*, 12th Edn., Saunders, US, 2010.

2. B. L. Oser, *Hawk's Physiological Chemistry*, Tata McGraw-Hill Publishing Co. Ltd., New Delhi, 1979.

3. S. C. Rastogi, *Biochemistry*, 2nd Edn., Tata McGraw Hill Publishing Co., New Delhi, 2007.

4. Rasheeduz Zafar, *Medicinal Plants of India*, 1st Edn., CBS Publishers & Distributors Pvt. Ltd., New Delhi, 2009.

5. *https://en.wikipedia.org.*

**Module VI: Medicinal Chemistry – II (12 hrs)**

Medicines*:* Drug - Chemical name, generic name and trade names with examples – Terminology: Prodrug, pharmacy, pharmacology, pharmacophore, pharmacognosy, pharmacodynamics and pharmacokinetics (elementary idea only). Routes of drug administration: Topical, enteral and parenteral. Definition and examples of antacids, antipyretics, analgesics, antibiotics, antiseptics, disinfectants, antihistamines, tranquilizers, narcotics, antidepressants and hallucinogenic drugs – Drug toxicity – Thalidomide tragedy (a brief study) - Effective use of drugs – Prescription and non-prescription drugs – Over dosage – Drug abuse.

Some Diseases and Treatment*:* Causes, symptoms and drugs used for the treatment of influenza, measles, tuberculosis, cholera, dysentery, bronchial asthma, kidney stone, diabetes and myocardial infection – Drugs used in the treatment for systemic hypertension and hypercholesterolemia. Cancer: Definition - Lung cancer (causes, symptoms and treatment) – Avenues for the treatment of terminal cancer.

Medical applications of nanomaterials. Radio diagnosis: Benefits and risks. Biodegradable polymers used in surgical sutures and capsule covers.

**References**

1. Gurdeep R. Chatwal, *Synthetic Drugs*, Himalaya Publishing House, Bombay, 1995.
2. Jayashree Ghosh, *A Textbook of Pharmaceutical Chemistry*, 3rd Edn., S. Chand and Company Ltd., New Delhi, 1999.
3. A. H. Beckett, J. B Stenlake, *Practical Pharmaceutical Chemistry*, 4th Edn., CBS Publishers and Distributors, New Delhi, 2000.

**Module VII: Clinical chemistry (6 hrs)**

First aid to prevent bleeding and maintain breathing, Causes and symptoms of food poisoning, botulism - mushroom and plant poisoning - first aid. Causes, symptoms and treatment of anemia, diabetes, tuberculosis, asthma, jaundice.
First Aid and Safety*:* Electric shocks, hemorrhage, cuts, wounds, burns and snake bite.

**References**

1. Jayashree Ghosh, *A Textbook of Pharmaceutical Chemistry*, 3rd Edn., S. Chand and Company Ltd., New Delhi, 1999.
2. A. H. Beckett, J. B Stenlake, *Practical Pharmaceutical Chemistry*, 4th Edn., CBS Publishers and Distributors, New Delhi, 2000.
3. *https://en.wikipedia.org.*

**Scheme of Examinations**:

The external question paper carries 60 marks and internal examination is of 15 marks. Duration of each external examination is 2 Hrs. The pattern of External Examination is as given below:

| | |
|---|---|
| **Section A** | |
| Short answer type carries 2 marks each - 12 questions | Ceiling - 20 |
| **Section B** | |
| Paragraph/ Problem type carries 5 marks each - 7 questions | Ceiling - 30 |
| **Section C** | |
| Essay type carries 10 marks (1 out of 2) | 1x10=10 |

The students can answer all the questions in sections A & B but there shall be ceiling.

| Mark Distribution | |
|---|---|
| Module I | 13 Marks |
| Module II | 16 Marks |
| Module III | 6 Marks |
| Module IV | 8 Marks |
| Module V | 8 Marks |
| Module VI | 18 Marks |
| Module VII | 10 Marks |

# SCHEME OF EVALUATION

# FOR

# OPEN COURSES

## OPEN COURSE: EVALUATION SCHEME

The evaluation scheme contains two parts: *viz.,* internal evaluation and external evaluation.

### 1. INTERNAL EVALUATION

20% of the total marks are for internal evaluation. The colleges shall send only the marks obtained for internal examination to the university.

**Table 1: Components of Evaluation**

| *Sl. No.* | *Component* | *Marks* |
|---|---|---|
| 1 | Class room participation based on attendance (20%) | 3 |
| 2 | Test papers I (40%) | 6 |
| 3 | Assignment (20%) | 3 |
| 4 | Seminar (20%) | 3 |
| *Total Marks* | | 15 |

**Table 2: Percentage of attendance based on class room participation and Eligible Marks**

| *% of attendance* | *Marks* |
|---|---|
| 85% and above | 3 |
| 75 - <85% | 2 |
| 50 - <75% | 1 |

**Table 3: Pattern of Test Papers**

| *Duration* | *Pattern* | *Total number of questions* | *Number of questions to be answered* | *Marks for each question* | *Ceiling of Marks* |
|---|---|---|---|---|---|
| 1 Hour | Short answer | 6 | Up to 6 | 2 | 10 |
| | Paragraph | 4 | Up to 4 | 5 | 15 |
| | Essay | 2 | 1 | 10 | 10 |
| *Total Marks** | | | | | 35 |

*85% and above = 6, 65 to below 85% = 5, 55 to below 65% = 4, 45 to below 55% = 3, 35 to below

45% = 2, below 35% = 1

### 2. EXTERNAL EVALUATION

External evaluation carries 80% marks. University examinations will be conducted at the end of each semester. Duration of each external examination is 2 hours.

**Table 1: Pattern of Question Paper**

| *Duration* | *Pattern* | *Total number of questions* | *Number of questions to be answered* | *Marks for each question* | *Ceiling of Marks* |
|---|---|---|---|---|---|
| 2 Hours | Short answer | 12 | Up to 12 | 2 | 20 |
| | Paragraph | 7 | Up to 7 | 5 | 30 |
| | Essay | 2 | 1 | 10 | 10 |
| *Total Marks* | | | | | 60 |

**FIRST SEMESTER B.Sc DEGREE EXAMINATION**

**CBCSSUG - CHEMISTRY**

**CHE1B01 - Core Course I**

**THEORETICAL AND INORGANIC CHEMISTRY - I**

**Time: Two Hours** **Maximum: 60 Marks**

**Section A (Short answers)**

**(Answer questions up to 20 marks. Each question carries 2 marks)**

1. Differentiate between scientific theory and law.
2. Write note on S phrase and R phrase?
3. What do the terms absolute error and relative error mean with regard to an analytical determination?
4. Calculate the mole fractions of the components in a solution made up of 1 mole of ethanol and 9 moles of water?
5. Explain a redox titration with example.
6. What is meant by ionization enthalpy?
7. Explain the principles behind hydrogen bomb and atom bomb.
8. How will you prepare nitric acid?
9. Write a note on inert pair effect.
10. Distinguish between hard and soft acids and bases.
11. Write note on radioactive tracer.
12. Draw the structure of boric acid. **[Ceiling of marks: 20]**

**Section B (Paragraph)**

**(Answer questions up to 30 marks. Each question carries 5 marks)**

13. Explain the term scientific observation and its role in science.
14. Discuss the Ostwald's theory of acid –base indicators.
15. An item of old wooden furniture shows a C-14 activity which is 45% of the activity found in fresh wood. Calculate the age of the wood.
16. Explain with example the calculation of effective nuclear charge.
17. Describe the structure, properties and applications of diboranes.
18. Explain the principles of Aston's mass spectrograph.
19. Write note on complexometric titration **[Ceiling of marks: 30]**

**Section C (Essay)**

**(Answer any one. Each question carries 10 marks)**

20. a) Correlate N/P ratio and nuclear stability. b) Write a note on nuclear reactor.
21. a) Compare the electro negativity and ionization energy of s and p block elements. b) Explain the structure of oxides of N and P. **[1 X 10 = 10]**

**SECOND SEMESTER B.Sc DEGREE EXAMINATION**

**CBCSSUG - CHEMISTRY**

**CHE2B02 - Core Course II**

**THEORETICAL AND INORGANIC CHEMISTRY - II**

**Time: Two Hours** **Maximum: 60 Marks**

**Section A (Short answers)**

**(Answer questions up to 20 marks. Each question carries 2 marks)**

1. Predict the hybridization and geometry of $SF_4$ and $IF_7$.

2. Briefly explain Einstein interpretation of photoelectric effect.

3. State Bohr quantization of orbits.

4. What is de-Broglie's wavelength of an electron with speed of $4.12 \times 10^6$ m/s? (mass of electron: $9.1 \times 10^{-31}$ Kg).

5. Explain the importance of normalization.

6. Pick the molecule/molecules which exist as stable species: $Ne_2$, $C_2$, $Li_2$ and $He_2^+$. Give suitable explanation.

7. Describe the importance of Born-Oppenheimer approximation.

8. Explain the term Hermitian operator.

9. Sketch the radial probability plot of 1s and 3s orbital.

10. State Heisenberg's uncertainty principle. Does it have measurable consequence in the macroscopic world?

11. What is an Eigen value? Are the Eigen value of Hamiltonian operator always real?

12. Mention four limitation of Bohr theory. **[Ceiling of marks: 20]**

**Section B (Paragraph)**

**(Answer questions up to 30 marks. Each question carries 5 marks)**

13. Explain the postulates of quantum mechanics.

14. Write a note on quantum numbers. What are the four quantum numbers that represent an electron in 2p orbital?

15. Draw the molecular orbital diagram of NO. Predict its bond order?

16. Explain the hybridization of $BH_3$ and $CH_4$ by applying LCAO treatment.

17. A particle is confined in a 3D box that has side a=b=1.5c, a) Write the expression for wave function and energy, b) Predict its degeneracy for first four energy level.

18. Explain the required qualities of well behaved function with an example.

19. Distinguish VBT and MOT. **[Ceiling of marks: 30]**

**Section C (Essay)**

**(Answer any one. Each question carries 10 marks)**

20. Discuss briefly the concept of particle in 1D box. Using Schrodinger equation predicts its energy and wave function.

21. a) Write a note on atomic spectrum of hydrogen, b) A line of the Lyman series of the spectrum of hydrogen has a wavelength of $9.50 \times 10^{-8}$ m. Calcualte the $n_i$ involved in the associated electron transition. **[1 X 10 = 10]**

**THIRD SEMESTER B.Sc DEGREE EXAMINATION**

**CBCSSUG - CHEMISTRY**

**CHE3B03 - Core Course III**

**PHYSICAL CHEMISTRY – I**

**Time: Two Hours** **Maximum: 60 Marks**

**Section A (Short answers)**

**(Answer questions up to 20 marks. Each question carries 2 marks)**

1. Calculate the temperature at which $O_2$ molecule will have the same RMS velocity as $CO_2$ molecule.

2. Calculate the value of work done when 2g of $H_2$ expands from a volume of 1 litre to a volume of 10 litres at $27^oC$.

3. Write Clapeyron - Clausius equation (integrated form) for liquid-vapour equilibrium and explain the terms.

4. Write Gibbs-Duhem equation and explain the terms.

5. Explain the physical significance of entropy.

6. Define third law of thermodynamics.

7. Calculate the entropy of vapourisation of a liquid which boils at $120^oC$. Given enthalpy of vapourisation is 3600 $Jmol^{-1}$.

8. What is optical exaltation?

9. Give the equation for molar refraction of a liquid and explain the terms.

10. Why chemical equilibrium is termed dynamic?

11. State Le Chatelier's principle.

12. What is homogeneous equilibrium? Give example. **[Ceiling of marks: 20]**

**Section B (Paragraph)**

**(Answer questions up to 30 marks. Each question carries 5 marks)**

13. Derive the relationship between heat capacity at constant volume and constant pressure for an ideal gas.

14. Derive the expressions for critical constants in terms of vander-Waals constants.

15. Derive the relation between temperature and pressure for an adiabatic process.

16. Calculate the change in freezing point for ice when the pressure is increased by 1 atm. Molar volume of water and ice are 18.0 and 19.6 $cm^3$ and the enthalpy of fusion for ice is 6008 $Jmol^{-1}$. (IJ = 9.87 x $10^{-3}$ $dm^3$.atm.)

17. Discuss the variation of free energy with temperature and pressure.

18. Derive an expression for the relation between entropy and probability?

19. What is Parachor? How is it used for structure elucidation? **[Ceiling of marks: 30]**

## Section C (Essay)

**(Answer any one. Each question carries 10 marks)**

20. Derive the relationship between $K_p$ and $K_c$.

21. What is Joule-Thomson effect? Describe Linde's method and Claude's method for the liquifaction of gases. **[1 X 10 = 10]**

**FOURTH SEMESTER B.Sc DEGREE EXAMINATION**

**CBCSSUG - CHEMISTRY**

**CHE4B04 - Core Course IV**

**ORGANIC CHEMISTRY – I**

**Time: Two Hours** **Maximum: 60**

**Marks**

**Section A (Short answers)**

**(Answer questions up to 20 marks. Each question carries 2 marks)**

1. Distinguish between chain and position isomerism with an example.

2. Draw the Newman projections of the two extreme conformations of butane.

3. Explain the isomerism exhibited by fumaric and maleic acids.

4. Explain the terms electrophile and nucleophile with examples for each.

5. Compare the basicities of aniline, p-nitroaniline and *p*-anisidine.

6. What is the product formed when isopropyl bromide is treated with metallic sodium in ether solvent? Write equation and IUPAC name of the product.

7. State and illustrate Saytzeff's rule of elimination.

8. Why are 1-alkynes acidic?

9. Write two tests to distinguish between alkanes and alkenes.

10. What is Lindlar's catalyst? What is its use in organic synthesis?

11. Write equation to show the Birch reduction of benzene.

12. Write the mechanism of nitration of benzene. **[Ceiling of marks: 20]**

**Section B (Paragraph)**

**(Answer questions up to 30 marks. Each question carries 5 marks)**

13. What is Huckel's rule of aromaticity. Using it discuss the aromaticity of azulene and annulenes.

14. a) Write any three methods of resolution racemic mixtures. b) Distinguish between absolute and partial asymmetric synthesis

15. What is hyperconjugation? Write the order of stability of propene, 1-butene and 2-butene. Explain why?

16. Write a short note on hybridisation, structure, formation and stability of carbenes.

17. a) What is Corey – House synthesis? b) Write the mechanism of free radical chlorination of methane.

18. What is ozonolysis? One mole of alkene, $C_6H_{12}$ on ozonolysis yields 1mole each of propanal and propanone. Find the structure of the parent alkene and write equation for the ozonolysis sequence.

19. Explain the postulates of Baeyer's strain theory. **[Ceiling of marks: 30]**

**Section C (Essay)**

**(Answer any one. Each question carries 10 marks)**

20. a) Differenciate between Friedel-Craft's alkylation and acylation reactions. Write the mechanism of each reaction. b) Explain the elimination-addition mechanism (benzyne) of aromatic nucleophilic substitution.

21. a)Explain the Markownikov and Anti-Markownikov addition to alkenes with mechanism. b) Write the SN1and SN2 mechanisms of aliphatic nucleophilic substitution reactions with stereochemical aspects. **[1 X 10 = 10]**

**FOURTH SEMESTER B.Sc DEGREE EXAMINATION**
**CBCSSUG - CHEMISTRY**
**CHE4B05(P) - Core Course V**
**INORGANIC CHEMISTRY PRACTICAL - I**

**Time: 3 Hours** **Maximum marks: 80**

## Section A
**Answer the following questions in 10 minutes**

1. Calculate the mass of Mohr's salt required to prepare 500 mL of its 0.5 N solution?
2. Calculate the normality of $K_2Cr_2O_7$ solution when 0.49 g of it is dissolved in water in a 100 mL standard flask?
3. When 100 mL 1N $ZnSO_4$ solution is diluted to 500 mL the normality of the resulting solution will be ----------
4. Name the indicator used for the titration of $K_2Cr_2O_7$ against $FeSO_4$.
5. Write the balanced chemical equation for the titration of $I_2$ solution against $Na_2S_2O_3$.
6. The titration of $Fe^{2+}$ solution against $KMnO_4$ is a ---------- titration.
7. What is the role of $SnCl_2$ in the estimation of $Fe^{3+}$ during dichrometry?
8. Write the structure of Phenolphthalein. (1x8 = 8 Marks)

## Section B
**Answer the following questions in 15 minutes**

9. Give a brief outline of the method for the volumetric estimation of $Mg^{2+}$ in the whole of the given solution of $MgSO_4$, being provided with AR $ZnSO_4$ crystals. (8 Marks)
10. Write a brief outline of the method for the preparation of ferric alum. (4 Marks)

## Part C
11. Estimate the weight of $Fe^{3+}$ in the whole of the given solution of ferric alum, being provided with AR Mohr's salt. (39 Marks)

## Part D
12. Prepare the inorganic complex …….. Exhibit the crude and recrystallised sample. (5 marks)

## Part E
Viva-Voce (8 marks)
Record (8 marks)

**FIFTH SEMESTER BSc. DEGREE EXAMINATION**
**CBCSSUG - CHEMISTRY**
**CHE5B06 -Core Course VI**
**INORGANIC CHEMISTRY – III**

**Time: 2 Hrs** **Max Marks: 60**

**Section A (Short answers)**

**(Answer questions up to 20 marks. Each question carries 2 marks)**

1. The solubility of magnesium hydroxide at 298 K is 1.71 x $10^{-4}$mol $dm^{-3}$. Calculate the solubility product.
2. Explain the terms co precipitation and post precipitation with examples.
3. Explain zone refining with example.
4. Give composition of gunmetal.
5. What are pseudo halogen compounds? Give examples.
6. Iodine is electropositive. Justify.
7. What are silicones? Give its applications.
8. Explain autoionisation of liquid $SO_2$ and liquid HF with equations.
9. Explain the relation between acid rain and pollution.
10. What are BOD and COD? How it can be measured?
11. Triple R is an important term in managing waste. Justify.
12. What are the 4 major types of medical waste? **[Ceiling of marks: 20]**

**Section B (Paragraph)**

**(Answer questions up to 30 marks. Each question carries 5 marks)**

13. What are Interfering acid radicals? How they can be eliminated?
14.(a) Discuss the use of Ellingham diagram in extraction of elements.(b) Using the Ellingham diagram of oxides, determine whether Aluminum can be used to reduce MgO.
15. Explain structure and hybridization of $ClF_3$, $ICl_3$.
16. Discuss the separation of noble gas by charcoal adsorption method.
17. Give an account of preparation, properties and structure of $S_4N_4$.
18. How we can prevent thermal and radioactive pollution?
19. Discuss the challenges in managing solid waste. **[Ceiling of marks: 30]**

**Section C (Essay)**

**(Answer any one. Each question carries 10 marks)**

20. Explain the applications of common ion effect and solubility product in separation and identification of cations.
21. (a) Explain the sources of water pollution. (b) What are the control measures for water pollution? **[1 X 10 = 10]**

**FIFTH SEMESTER BSc. DEGREE EXAMINATION**

**CBCSSUG - CHEMISTRY**

**CHE5B07 -Core Course VII**

**ORGANIC CHEMISTRY – II**

**Time: 2 Hrs** **Max Marks: 60**

**Section A (Short answers)**

**(Answer questions up to 20 marks. Each question carries 2 marks)**

1. How are alcohols prepared by the hydroboration oxidation?
2. What is Lucas test?
3. How are ethers prepared from alkyl halides?
4. Explain the Zeisel's method of estimation of methoxy groups.
5. What is Etard's reaction?
6. Write two tests to distinguish between aldehydes and ketones.
7. Acetic acid or formic acid ,which is more acidic? Why?
8. What is HVZ reaction? Write an example.
9. What is tosylation reaction?
10. What is nitro – aci tautomerism? Explain.
11. What is Hoffmann bromamide reaction?
12. How will you explain the basicity of guanidine? **[Ceiling of marks: 20]**

**Section B (Paragraph)**

**(Answer questions up to 30 marks. Each question carries 5 marks)**

13. What is pinacol- pinacolone rearrangement? Explain with mechanism.
14. What are crown ethers? What are their applications in organic synthesis and catalysis?
15. Explain the synthetic utility of Wittig reaction and Beckmann rearrangement.
16. How is citric acid prepared using Reformatsky reaction? What are the uses of it?
17. Explain the separation of primary , secondary and tertiary amines by the Hinsberg's method.
18 How is ethyl acetoacetate prepared by Claisen condensation? Write the mechanism.
19. a) How is methyl orange prepared? How will you explain its colour change with pH?
b) How is urea estimated by the urease method? **[Ceiling of marks: 30]**

**Section C (Essay)**

**(Answer any one. Each question carries 10 marks)**

20. a) Explain the important synthetic applications of Grignard's reagent. b) Explain the Aldol and Benzoin condensations.
21. Explain the following reactions with mechanism. a)Riemer – Tiemann reaction. b) Haloform reaction c) Kolbe electrolysis d) Hofmann elimination. **[1 X 10 = 10]**

**FIFTH SEMESTER B.Sc DEGREE EXAMINATION**

**CBCSSUG - CHEMISTRY**

**CHE5B08 - Core Course VIII**

**PHYSICAL CHEMISTRY – II**

**Time: Two Hours** **Maximum: 60 Marks**

**Section A (Short answers)**

**(Answer questions up to 20 marks. Each question carries 2 marks)**

1. Order of a reaction need not be whole number always. Account.
2. Give one example each for (i) a parallel reaction; (ii) a consecutive reaction.
3. What is chemiluminescence? Give one example.
4. Explain Bredig's method for the preparation of gold sol.
5. What is meant by Dorn Effect?
6. Name the different symmetry elements implied by $C_6$ axis.
7. Discuss the principle of gel permeation chromatography.
8. What type of molecules gives rotational Raman spectra?
9. What is Frank – Condon principle?
10. Write any two advantages of Raman spectra over IR spectra.
11. Discuss the ESR spectra of methyl radical.
12. What is proper axis of rotation? **[Ceiling of marks: 20]**

**Section B (Paragraph)**

**(Answer questions up to 30 marks. Each question carries 5 marks)**

13. Draw the group multiplication table of $C_{2V}$ point group.
14. Discuss briefly the activated complex theory of reaction rates.
15. Certain reactions have very high quantum yield whereas others have very low quantum yield. Explain.
16. Draw phase diagram of sulphur system. Explain it.
17. Draw and explain the phase diagram of Zn-Mg system.
18. Explain how rotational spectroscopy can be used to find the bond length.
19. Explain the term chemical shift. **[Ceiling of marks: 30]**

**Section C (Essay)**

**(Answer any one. Each question carries 10 marks)**

20. (a) Give methods for purification of colloids (b) Derive Langmuir isotherm.
21. (a) Derive an expression for the rate constant of a bimolecular gaseous reaction using collision theory (b) $E_a$ for a first order reaction is 250 $KJmol^{-1}$. The half life of the reaction is $6.5 \times 10^6$ second at $450^oC$. What will be the half life at $550^oC$? **[1 X 10 = 10]**

**SIXTH SEMESTER BSc. DEGREE EXAMINATION**

**CBCSSUG - CHEMISTRY**

**CHE6B09 - Core Course IX**

**INORGANIC CHEMISTRY – IV**

**Time: 2 Hrs** **Max Marks: 60**

**Section A (Short answers)**

**(Answer questions up to 20 marks. Each question carries 2 marks)**

1. Calculate the CFSE in $[Mn(H_2O)_6]^{2+}$.
2. Explain Bragg's Law.
3. Why do transition metals show catalytic properties?
4. While $MnSO_4 \cdot 4H_2O$ is pale pink in colour, $KMnO_4$ exhibits dark violet colour. Why?
5. The absorbance of an iron thiocyanate solution containing 0.00500 mg Fe/mL was reported as 0.4900 at 540 nm. Calculate the specific absorptivity of iron thyocyanate assuming that a 1.00 cm cuvette was used.
6. What is Spectrochemical series?
7. Distinguish high spin and low spin among $[Co(en)_3]^{3+}$ and $[CoF_6]^{3-}$. Give reason [en-ethylenediammine].
8. While $[Co(H_2O)_6]^{2+}$ is pink in colour, $[CoCl_4]^{2}$ is blue in colour. Why?
9. Name the catalyst used for (i) polymerization of alkene and (ii) hydrogenation of alkene.
10. What is Zeise's salt?
11. Explain the significance of zinc in biological systems.
12. Why is lead considered as a toxic metal? **[Ceiling of marks: 20]**

**Section B (Paragraph)**

**(Answer questions up to 30 marks. Each question carries 5 marks)**

13. Discuss the structure and oxygen binding mechanism of Haemoglobin.
14. Differentiate between Scanning Electron Microscopy and Transmission Electron Microscopy.
15. Explain the process involved in separation of lanthanides.
16. Discuss any five factors influencing stability of complexes.
17. (i) Explain the hybridization and structure of (a) $[Ni(CN)_4]^{2-}$ and (b) $[NiCl_4]^{2-}$ based on VBT. (ii) Which of the two is diamagnetic in nature?
18. What is 18- Electron rule? Justify how $Fe(CO)_5$ and $Fe_2(CO)_9$ obey 18- Electron rule.
19. Explain the principle and working of Atomic Force Microscope.**[Ceiling of marks: 30]**

**Section C (Essay)**

**(Answer any one. Each question carries 10 marks)**

20. Write an account on the MOT of octahedral complexes containing only sigma bonds?
21. (i) Discuss the structure and significance of *Cis*-platin. (ii) Explain the preparation and properties of Ferrocene. **[1 X 10 = 10]**

**SIXTH SEMESTER BSc. DEGREE EXAMINATION**

**CBCSSUG - CHEMISTRY**

**CHE6B10 - Core Course X**

**ORGANIC CHEMISTRY - III**

**Time: 2 Hrs** **Max Marks: 60**

**Section A (Short answers)**

**(Answer questions up to 20 marks. Each question carries 2 marks)**

1. Write note on chromophore and auxochrome.
2. Distinguish ethanol and acetone using NMR spectroscopy.
3. Write short note on mutarotation.
4. Write short note on reducing and nonreducig sugar.
5. Explain the chemistry of tollens test and molisch test.
6. Explain strecker synthesis of aminoacids.
7. Write short note on denaturation of proteins.
8. Draw the structure of nitrogenous base present in the DNA.
9. Write note on saponification value and iodine value.
10. Draw the structure of vitamine C and cholesterol.
11. Explain the physiological action of nicotine and quinine.
12. Write short note on vulcanization. **[Ceiling of marks: 20]**

**Section B (Paragraph)**

**(Answer questions up to 30 marks. Each question carries 5 marks)**

13. How will you distinguish ethyl acetate and propanoic acid by IR and $^{1}H$ NMR spectroscopy?
14. Write note on column and paper chromatography.
15. Write short note on killani –Fischer synthesis.
16. Write note on sangers method for structure elucidation of peptides.
17. Write note on structure and uses of citral,geraniol and menthol.
18. Explain cope and claisen rearrangement with mechanism.
19. Write note on replication of DNA. **[Ceiling of marks: 30]**

**Section C (Essay)**

**(Answer any one. Each question carries 10 marks)**

20. (a) Explain the structure of DNA. (b) Explain DNA finger printing and its application?
21. (a) Sketch the MO diagram of 1,3-butadiene and show the HOMO and LUMO in the ground state (b) Using the Frontier orbital diagram show the mode of cyclisation of 1,3-butadiene under thermal and photochemical conditions. **[1 X 10 = 10]**

**SIXTH SEMESTER B.Sc DEGREE EXAMINATION**

**CBCSSUG - CHEMISTRY**

**CHE6B11 - Core Course XI**

**PHYSICAL CHEMISTRY – III**

**Time: Two Hours** **Maximum: 60 Marks**

**Section A (Short answers)**

**(Answer questions up to 20 marks. Each question carries 2 marks)**

1. What is the molality of a solution prepared by dissolving 5.0g of toluene in 225 g of benzene?

2. How does band theory distinguish semiconductors from insulators and conductors?

3. 0.0654 g of a metal was deposited by the passage of a current of 0.4 amperes for 30 minutes through its salt solution. Calculate the equivalent mass of the metal.

4. Explain the term electrophoretic effect based on Debye –Huckel theory of strong electrolytes.

5. Explain leveling effect of a solvent with a suitable example.

6. State Henry's law and explain one of its applicaions.

7. Explain the principle behind the purification of sea water by reverse osmosis method.

8. 2% solution of an organic solute A is found to be isotonic with a 3% solution of of sucrose. Calculate the molar mass of A.

9. Distinguish between an electrode concentration cell and electrolyte concentration cell.

10. Explain the principle behind the conductometric titration of a weak acid against a strong base.

11. Discuss the effect of dilution on molar conductivity of an electrolytic solution

12. What is an ideal solution? **[Ceiling of marks: 20]**

**Section B (Paragraph)**

**(Answer questions up to 30 marks. Each question carries 5 marks)**

13. State and explain Kohlrausch's law. Based on it determine the molar conductivity at infinite dilution of acetic acid.

14. What is meant by salt hydrolysis? Explain why an aqueous solution of sodium carbonate is basic while that of ammonium nitrate is acidic.

15. The emf of the cell $Ag\,|\,AgI$ in 0.045 M $KI\,\|\,0.045$ M $AgNO_3\,|\,Ag$ is 0.788 at $25^0$C. Calculate (i) the solubility product of AgI and the (ii) solubility of AgI in water at $25^0$C.

16. Explain the electrochemical theory of corrosion with a suitable example

17. (a) Explain the term buffer index with regard to buffer solutions. (b) Derive the Henderson equation for the pH of an acidic buffer.

18. (a) Explain common ion effect with an example (b) Calculate the degree of hydrolysis of deci molar solution of ammonium acetate at 28°C.Dissociation constants of acetic acid and ammonium hydroxide are $1.75\times10^{-5}$ and $1.85\times10^{-5}$ respectively and $K_w = 1.008\times10^{-14}$ at 28°C.

19. (a) Discuss $H_2$-$O_2$ fuel cell (b) How can you determine pH of a solution using standard hydrogen electrode (SHE)? **[Ceiling of marks: 30]**

**Section C (Essay)**

**(Answer any one. Each question carries 10 marks)**

20. (a) Calomel electrode is used as a reference electrode. Describe its construction and working. (b) Differentiate between hexagonal close packing and cubic close packing of uniform spheres.

21. (a) Discuss the structures of two AB type compounds (b) Discuss the salient features of different types of liquid crystals. **[1 X 10 = 10]**

**SIXTH SEMESTER BSc.DEGREE EXAMINATION**

**CBCSSUG – CHEMISTRY**

**CHE6B12 - Core Course XII**

**ADVANCED AND APPLIED CHEMISTRY**

**Time: 2 Hrs** **Max Marks: 60**

**Section A (Short answers)**

**(Answer questions up to 20 marks. Each question carries 2 marks)**

1. Explain the term global minimum in computational chemistry.
2. Describe the change melting point when the particle size of a material approaches nanoscale rang.
3. What are the advantages of microwave assisted organic synthesis?
4. Explain any two principles of green chemistry.
5. Draw the structure of endosulphan and DDT.
6. Explain the uses of nanomaterials.
7. Describe the term prodrugs with example.
8. What are BHA and BHT? Mention their important applications.
9. Name two software used in computational chemistry.
10. What is talc? What is its composition?
11. Name one nitrogenous fertilizer and one potash fertilizer.
12. Explain the importance of combinatorial synthesis. **[Ceiling of marks: 20]**

**Section B (Paragraph)**

**(Answer questions up to 30 marks. Each question carries 5 marks)**

13. Distinguish between the bottom up and top down methods of nanoscale synthesis.
14. Explain different host-guest interactions in supramolecules.
15. Explain with example the difference between percentage yield and atom economy.
16. Distinguish between molecular mechanics method and electronic structure method in computational chemistry.
17. Explain the term PHBV and PGA. Discuss its significance and applications.
18. Write a short note on the role of water in setting of cement.
19. Explain the theories behind color of dyeing compounds. **[Ceiling of marks: 30]**

**Section C (Essay)**

**(Answer any one. Each question carries 10 marks)**

20. a) Describe a method for the purification of collide. b) Explain the advantages of Zeigler Natta polymerization.

21) Write a short note on

a) zeta potential, b) artificial ripening, c) Travancore Cochin Chemicals, d) Flash point of a liquid fuel. **[1 X 10 = 10]**

**SIXTH SEMESTER B. Sc. DEGREE EXAMINATION**

**(CBCSSUG) - CHEMISTRY**

**CHE6B13(E1) - Core Course XIII**

**INDUSTRIAL CHEMISTRY**

**Time: 2 Hrs** **Max Marks: 60**

**Section A (Short answers)**

**(Answer questions up to 20 marks. Each question carries 2 marks)**

1. Describe the term pilot plant?
2. How we can convert wash to rectified spirit?
3. How coal is classified based on carbon content?
4. Differentiate between paraffin base and asphalt base.
5. What are the different routes of drug administration?
6. Explain the term prodrug with example?
7. What is Zeigler Natta catalyst? Mention its important application.
8. Mention the applications of ruthenium based catalysts.
9. What is a nanoparticle catalyst? Give examples.
10. Explain the term denatured spirit and mention it's applications.
11. What are chromatic and achromatic colours?
12. Describe the components of paint. **[Ceiling of marks: 20]**

**Section B (Paragraph)**

**(Answer questions up to 30 marks. Each question carries 5 marks)**

13. What are the important features of environmental management systems?
14. Discuss the various steps involved in the manufacture of leather.
15. What are anti-knocking compounds? Discuss their mechanism of action.
16. Discuss the composition and uses white lead, ultramarine and guignet's green.
17. Discuss the causes, symptoms and treatment of lung cancer.
18. What is meant by phase transfer catalysis? What are its important applications?
19. Discuss briefly the medical applications of nanomaterials. **[Ceiling of marks: 30]**

**Section C (Essay)**

**(Answer any one. Each question carries 10 marks)**

20. Write notes on (a) oil based paints (b) luminescent paints (c) fire retardant paints.
21. (a) What is synthetic petrol? How is it manufactured? (b) Discuss the manufacture of ethylene glycol. **[1 X 10 = 10]**

**SIXTH SEMESTER B. Sc. DEGREE EXAMINATION**

**(CBCSSUG) - CHEMISTRY**

**CHE6B13(E2) - Core Course XIII**

**POLYMER CHEMISTRY**

**Time: 2 Hrs** **Max Marks: 60**

**Section A (Short answers)**

**(Answer questions up to 20 marks. Each question carries 2 marks)**

1. Describe the term tacticity of polymers.
2. Explain ring opening polymerization? Give an example.
3. Distinguish between thermoplastics and thermosetting plastics.
4. What is bulk polymerization?
5. What is meant by average molecular weight of polymers? Give mathematical expression for weight average molecular weight.
6. Define Tg. What are the factors affecting Tg?
7. What is meant by degradation of polymers?
8. What is Kevlar. Give two applications.
9. Give the structure of nylon 6 and nylon 66.
10. Explain the importance of vulcanization.
11. How silicones are prepared?
12. What is meant by resins? Give an example. **[Ceiling of marks: 20]**

**Section B (Paragraph)**

**(Answer questions up to 30 marks. Each question carries 5 marks)**

13. Distinguish between plastics, fibers and elastomers with examples.
14. Write a short note on suspension polymerization.
15. How can you determine the molecular weight of polymers by viscosity method?
16. What is meant by recycling of plastics? What are its advantages?
17. Explain thermal and oxidative degradation of polymers with examples.
18. What is meant by dopping of polymers.
19. Distinguish between addition and condensation polymerization. **[Ceiling of marks: 30]**

**Section C (Essay)**

**(Answer any one. Each question carries 10 marks)**

20. Explain Zeigler Natta polymerization with mechanism.
21. Explain any three polymer processing techniques with neat diagram. **[1 X 10 = 10]**

**SIXTH SEMESTER B. Sc. DEGREE EXAMINATION**

**(CBCSSUG) - CHEMISTRY**

**CHE6B13(E3) - Core Course XIII**

**MEDICINAL AND ENVIRONMENTAL CHEMISTRY**

**Time: 2 Hrs** **Max Marks: 60**

**Section A (Short answers)**

**(Answer questions up to 20 marks. Each question carries 2 marks)**

1. Explain the importance in sterilization of surgical instruments.
2. What precautions are to be taken during blood transfusion?
3. What is difference between LD50 and ED50?
4. What is systemic hypertension? Name a drug used for its treatment.
5. What is hepatitis A? What are its causes and symptoms?
6. What are the toxicological effects of phenol and benzene?
7. What are the analytical methods used for the detection of hydrocarbons?
8. Write a note on activated sludge process
9. Explain the working of Cottrell electrostatic precipitator.
10. What is BOD? How is it determined by Winkler's titration method?
11. What is USAB process?
12. Discuss the sources and harmful effects of Hg. **[Ceiling of marks: 20]**

**Section B (Paragraph)**

**(Answer questions up to 30 marks. Each question carries 5 marks)**

13. How is sugar content in urine determined?
14. Write notes on (a) Rain water harvesting (b) Sea water for agriculture.
15. Discuss the toxicological effects of phenylene diamines and nitroso amines.
16. Discuss the sampling methods used for gases.
17. Discuss how gravitational settling chamber and fabric filter are used in air pollution control.
18. Write notes on settlable solids and suspended solids related to water pollution.
19. Discuss the treatment for poisons due to snake bite. **[Ceiling of marks: 30]**

**Section C (Essay)**

**(Answer any one. Each question carries 10 marks)**

20. Discuss the major chemical constituents and medicinal uses of any five Indian medicinal plants.
21. Discuss the causes and drugs used for the treatment of influenza, cholera, kidney stone and myocardial infarction. **[1 X 10 = 10]**

**SIXTH SEMESTER B. Sc. DEGREE EXAMINATION**

**CBCSSUG - CHEMISTRY**

**CHE6B14(P) - Core Course XIV**

**PHYSICAL CHEMISTRY PRACTICAL**

**Time: 3 Hours** **Maximum marks: 80**

**Section A**

A. Write in the first ten minutes the principle and procedure for the question marked in Section B (4 + 4 Marks)

**Section B**

B. Conduct the experiment for the question marked below and records the data and results neatly and systematically. (56 Marks)

1. Determine the cryoscopic constant ($K_f$) of the given solid solvent 1A---. Solute IB---- of molecular mass------- is given. Conduct a duplicate experiment. Draw cooling curves for the solvent and the two trials. Report two $K_f$ values. Weight of pure solvent given is ----- g.
2. Determine the molecular mass (M) of the given solute 2B-- by Rast method. $K_f$ of the solvent 2A— is--------. Conduct a duplicate experiment. Draw cooling curves for the solvent and the two trials. Report two M values. Weight of pure solvent given is ------- g.
3. Determine the transition temperature constant ($K_t$) of crystalline 3A----. Solute 3B-- of molecular mass------ is given. Draw cooling curves for the solvent and the two trials. Report two $K_t$ values. Weight of pure solvent is given is ------- g.
4. Determine the molecular mass (M) of the given solute 4B-- by measuring the depression in transition temperature of the solvent 4A---. Transition temperature constant ($K_t$) of crystalline 4A --- is------. Draw cooling curves for the solvent and two trials. Report two M values. Weight of pure solvent given is ------- g.
5. Determine the composition of the given binary mixture of 5A----- & 5B----- viscometrically using at least five mixtures of known composition.
6. Determine the miscibility temperatures of at least five mixtures of standard aqueous solutions of sodium chloride and phenol & determine the concentration of the given sodium chloride solution 6A------- graphically.
7. Determine the composition of the given mixture 7A--- of glycerol and water by refractometric method, using five standard mixtures of the two components.
8. By potentiometric titration, standardize the given HCl solution 8A--- with the given standard KOH solution of normality ---------.
9. By conductometric titration, standardize the given HCl solution 9A---- with the given standard KOH solution of normality ---------.

**Section C**

Viva-Voce (8 marks)

Record (8 marks)

**SIXTH SEMESTER B. Sc. DEGREE EXAMINATION**

**CBCSSUG - CHEMISTRY**

**CHE6B15(P) - Core Course XV**

**ORGANIC CHEMISTRY PRACTICAL**

**Time: 3 Hours** **Maximum marks: 80**

## Section A

**Answer the following questions in 10 minutes**

1. The formula of Prussian blue is ----------
2. When cinnamic acid is treated with bromine water the compound formed is -------
3. When naphthalene in benzene is treated with picric acid in benzene, the compound formed has the structural formula ----------.
4. When acetophenone is treated with Borsche's reagent, the compound formed is ----.
5. Conversion of aniline into tribromoaniline is a/an ---------- reaction.
6. Diazotisation of sulphanilic acid followed by coupling with N,N-dimethyl aniline yield ----
7. The structural formula of the compound formed by the acetylation of salicylic acid is ----
8. The electrophile during nitration is ---------- (1x8 = 8 Marks)

## Section B

**Answer the following question in 10 minutes**

9. Write the principle and procedure for the conversion of benzamide into benzoic acid. (8 Marks)

## Section C

10. Convert the whole of the given acetanilide in to *p*-nitroacetanilide. Exhibit the crude and crystallised samples for inspection. (12 Marks)

11. Analyse qualitatively and systematically the given organic compound by micro method with a view to identify the following. (a) Detect the elements present in it. (b) Find out whether the compound is aliphatic or aromatic. (c) Find out whether the compound is saturated or unsaturated. (d) Detect the elements present in it. (e) Identify and confirm the functional groups. (f) Suggest a suitable derivative. Give its method of preparation. Prepare the derivative suggested by the examiner and exhibit. (g) Write the systematic procedure of analysis including chemistry of identification tests, confirmation tests and derivative preparation. (36 Marks)

## Section D

Viva-Voce (8 marks)

Record (8 marks)

**SIXTH SEMESTER B. Sc. DEGREE EXAMINATION**

**CBCSSUG - CHEMISTRY**

**CHE6B16(P) - Core Course XVI**

**INORGANIC CHEMISTRY PRACTCAL - II**

**Time: 3 Hours** **Maximum marks: 80**

## Section A

**Answer the following question in 15 minutes**

1. Write a brief outline of the method used for the colorimetric estimation of chromium in the whole of the given solution of $K_2Cr_2O_7$. (4 Marks)

2. Write a brief outline of the method used for the gravimetric estimation of nickel in the whole of the given solution of nickel chloride. (8 Marks)

## Section B

3. Estimate gravimetrically the mass of barium present in the whole of the given solution of barium chloride. (37 Marks)

## Section C

Viva-Voce based on colorimetry and gravimetry (8 marks)

Record (8 marks)

## Section D

Report of industrial visit (8 marks)

Viva-Voce based on industrial visit (7 marks)

**SIXTH SEMESTER B. Sc. DEGREE EXAMINATION**

**CBCSSUG - CHEMISTRY**

**CHE6B17(P) - Core Course XVII**

**INORGANIC CHEMISTRY PRACTICAL - III**

**Time: 3 Hours** **Maximum marks: 80**

## Section A

**Answer the following questions in 10 minutes**

1. The reddish brown precipitate in the confirmatory test for $Cu^{2+}$ ion is due to the formation of -----

2. The yellow precipitate formed in the identification test for phosphate, on adding conc. $HNO_3$ and ammonium molybdate, has the formula ---------

3. The compound responsible for the green edged flame in the ethyl borate test is ------

4. The chemical compound formed in the ash test for zinc is ---------- (4x1 = 4 Marks)

## Section B

5. Analyse qualitatively the given mixture by semimicro method to identify and confirm the two cations and two anions present in it. Record the data systematically including chemistry of identification tests and confirmation tests

(60 Marks)

## Section C

Viva-Voce (8 marks)

Record (8 marks)

**FIRST SEMESTER BSc. DEGREE EXAMINATION**

**CBCSSUG - CHEMISTRY**

**CHE1C01-Complementary course: I**

**GENERAL CHEMISTRY**

**Time: 2 Hrs** **Max Marks: 60**

**Section A (Short answers)**

**(Answer questions up to 20 marks. Each question carries 2 marks)**

1. Methyl orange is not a suitable indicator in the titration of a weak acid against a strong base. Why?
2. Calculate the number of molecules in 2.8 L of $CO_2$ gas at STP.
3. Write any two advantages of microanalysis.
4. Write Schrodinger wave equation and explain the terms.
5. $H_2O$ is a liquid while $H_2S$ is a gas. Why?
6. How is N/P ratio related to the stability of nucleus?
7. Write any two uses of radioisotopes in medical diagnosis.
8. State Soddy's group displacement law
9. Distinguish isobars and isotones with suitable examples.
10. Explain how mass defect and binding energy are related.
11. Briefly explain the term photosynthesis.
12. Name two iron containing enzymes and their functions. **[Ceiling of marks: 20]**

**Section B (Paragraph)**

**(Answer questions up to 30 marks. Each question carries 5 marks)**

13. Explain the principle and advantages of double burette method of titration.
14. Discuss the principle of complexometric titration taking suitable example.
15. Using VSEPR theory explain the geometries of $SF_4$ and $NH_3$ .
16. Define lattice energy. Explain the Born-Haber cycle for NaCl.
17. Give an account of biochemical function of Zinc in living beings.
18. Explain the structure and mechanism of action of Na-K pump.
19. What is radiocarbon dating technique? Explain. **[Ceiling of marks: 30]**

**Section C (Essay)**

**(Answer any one. Each question carries 10 marks)**

20. Describe how solubility product principle and common ion effect are applied in qualitative inorganic analysis.
21. (a) What are quantum numbers? How are they significant? (b) Sketch the MO diagram of $O_2$ molecule and compare the stability of $O_2$ with $O_2^{2+}$ and $O_2^{2-}$ **[1 X 10= 10]**

**SECOND SEMESTER B. Sc. DEGREE EXAMINATION**

**CBCSSUG - CHEMISTRY**

**CHE2C02 - Complementary course: II**

**Physical Chemistry**

**Time: 2 Hrs** **Max Marks: 60**

**Section A (Short answers)**

**(Answer questions up to 20 marks. Each question carries 2 marks)**

1. How is internal energy change in a process is related to heat and work.
2. Above what temperature does the reaction: $2NO_{(g)} + O_2$ (g) $\rightarrow 2NO_2(g)$ become spontaneous, if $\Delta H = -101.5$ kJ and and $\Delta S = -145JK^{-1}$.
3. State third law of thermodynamics.
4. Mention the entropy criteria for spontaneity and equilibrium.
5. What is meant by anisotropic property? Give one example.
6. If the intercepts of a plane are a/2, b/3 and c/2. What are its Miller indices?
7. Write the significance of van der Waals constants.
8. What are the factors affecting vapour pressure of a liquid.
9. What is meant by reverse osmosis? Give one of its application.
10. What is electrochemical series? Give any two of its utility.
11. What are fuel cells? Schematically depict $H_2$-$O_2$ fuel cell.
12. Define Henry's law. Mention one of its applications. **[Ceiling of marks: 20]**

**Section B (Paragraph)**

**(Answer questions up to 30 marks. Each question carries 5 marks)**

13. Show that decrease in Gibbs free energy in a process is equal to the useful work done by the system.
14. Give the Maxwell's equation for the distribution of molecular velocities. Explain the influence of temperature on distribution.
15. Discuss the symmetry elements in crystals.
16. Define surface tension of a liquid and explain why water wets glass while mercury does not.
17. Derive van't Hoff osmotic osmotic pressure equation.
18. Explain the principle of coductometric titrations. Discuss the titration curve of a strong acid against weak base.
19. What are buffer solutions? Discuss their applications. Explain the buffer action of $NH_4Cl/NH_4OH$ buffer. **[Ceiling of marks: 30]**

**Section C (Essay)**

**(Answer any one. Each question carries 10 marks)**

20. (a) Write a note on different types of defects in crystals. (b) Derive Bragg equation.
21. Define Kohlrausch's law. Discuss the different applications of it. **[1 X 10 = 10]**

**THIRD SEMESTER BSc. DEGREE EXAMINATION**
**CBCSSUG - CHEMISTRY**
**CHE3C03-Complementary course: III**
**ORGANIC CHEMISTRY**

**Time: 2 Hrs** **Maximum Marks:60**

**Section A (Short answers)**
**(Answer questions up to 20 marks. Each question carries 2 marks)**

1. Illustrate the hybridisation of carbon in carbocations
2. Differentiate Electrophiles and nucleopholes.
3. Draw the most stable conformation of ethane.
4. What are meso compounds.
5. Which is the electrophile in sulphonation reaction? How is it generated?
6. Show that naphthalene is aromatic based on Huckel's rule.
7. Explain iodoform test.
8. Draw the structure of phenolphthalein
9. What is zwitter ion?
10. What is rectified spirit?
11. Explain isoprene rule.
12. What is meant by vulcanisation? **[Ceiling of marks: 20]**

**Section B (Paragraph)**
**(Answer questions up to 30 marks. Each question carries 5 marks)**

13. Explain electromeric effect with suitable examples.
14. Compare the stability of boat and chair conformations of cyclohexane.
15. Explain the molecular orbital description of the structure of benzene.
16. Discuss Luca's test for distinguishing different types of alcohols.
17. Compare the rate of nucleophilic addition reaction of aliphatic aldehyde and aliphatic ketones.
18. Discuss the basicity of ammonia, methylamine, and aniline.
19. Explain the structure and the physiological effects nicotine. **[Ceiling of marks: 30]**

**Section C (Essay)**
**(Answer any one. Each question carries 10 marks)**

20. (a) Explain the mechanism of Friedel-Craft's alkylation reaction. (b) Discuss the synthetic applications of Diazonium salts.
21. Explain the double helical structure of DNA. **[1 X 10 = 10]**

**FOURTH SEMESTER BSc. DEGREE EXAMINATION**
**CBCSSUG - CHEMISTRY**
**CHE4C04 - Complementary course: IV**
**PHYSICAL AND APPLIED CHEMISTRY**

**Time: 2 Hrs** **Maximum Marks:60**

**Section A (Short answers)**
**(Answer questions up to 20 marks. Each question carries 2 marks)**

1. Why lyophilic sols are more stable than lyophobic sols.
2. Explain the applications of nanomaterials.
3. Give any two limitations of GLC technique.
4. What is Bathochromic shift?
5. Draw a labelled schematic diagram of NMR spectrum of acetone.
6. Differentiate between thermoplastics and thermosetting plastics.
7. How is Nylon 66 prepared?
8. Why COD greater than BOD?
9. Explain the consequences of eutrophication.
10. Give any two examples of natural food preservatives and artificial sweeteners.
11. Write notr on green solvents.
12. Compare LPG and CNG. **[Ceiling of marks: 20]**

**Section B (Paragraph)**
**(Answer questions up to 30 marks. Each question carries 5 marks)**

13. Explain the different purification techniques of colloids.
14. Give the applications of nanomaterial in medicine and catalysis.
15. Sketch and explain different vibrational modes of $CO_2$.
16. Briefly explain the classification of polymers on the basis of intermolecular forces.
17. What is greenhouse effect? Explain its consequence and control measures.
18. Explain the principles behind TLC.
19. Explain briefly different theories of dye. **[Ceiling of marks: 30]**

**Section C (Essay)**
**(Answer any one. Each question carries 10 marks)**

20. What are biodegradable polymers? Explain the applications of different biodegradable polymers.
21. Write a note about manufacture of cement and glass. **[1 X 10 = 10]**

**FOURTH SEMESTER BSc. DEGREE EXAMINATION**
**CBCSSUG - CHEMISTRY**
**CHE4C05(P) - Complimentary Course V**
**CHEMISTRY PRACTICAL**

**Time: 3 Hours** **Maximum marks: 80**

## Section A
**Answer the following questions in 6 minutes.**

1. Calculate the mass of Mohr's salt required to prepare 100 ml of its 0.05 N solution?
2. Calculate the normality of oxalic acid solution when 0.63 g of it is dissolved in water in a 100 ml standard flask?
3. Name the indicator used for the titration of $Na_2CO_3$ against HCl.
4. Write the balanced chemical equation for any permanganometric titration.
5. The yellow precipitate formed on adding potassium chromate solution to $Ba^{2+}$ salt solution is chemically ---------
6. What is/are the group reagent/s for $5^{th}$ group in inorganic qualitative analysis?
7. The chemical compound formed in the ash test for Aluminium is
8. The pink colour in permanganic acid test is ……. (1x8 = 8 Marks)

## Section B
**Answer the following question in 10 minutes**

7. Give a brief outline of the method for the volumetric estimation of oxalic acid in the whole of the given solution, being provided with AR Mohr's salt crystals. (6 Marks)

## Section C

8. Estimate volumetrically the mass of $FeSO_4.7H_2O$ present in the whole of the given solution, being provided with pure Mohr's salt and approximately 0.1N $K_2Cr_2O_7$ solution. (28 Marks)
9. Analyse qualitatively and systematically the given solution with a view to identify and confirm the two cations present in it. Submit a detailed report including chemistry of the identification and confirmation tests & systematic procedure. (28 Marks)

## Section D

Record (10 marks)

**FIFTH SEMESTER B. Sc. DEGREE EXAMINATION**
**CBCSSUG - CHEMISTRY**
**CHE5D01 - Open Course 1**
**ENVIRONMENTAL CHEMISTRY**

**Time: 2 Hours** **Maximum marks: 60**

**Section A (Short answers)**

**(Answer questions up to 20 marks. Each question carries 2 marks)**

1. Explain why troposphere is a turbulent region.
2. Discuss about the different regions of atmosphere.
3. What are the main sources of particulates?
4. What is meant by photochemical smog?
5. Write a note on alternate refrigerants.
6. What is eutrophication?
7. How can the marine water be polluted?
8. Define thermal pollution.
9. How can we classify the wastes on the basis of their biodegradability?
10. Write a short note on biomedical waste.
11. Define green chemistry.
12. Discuss the working of wet scrubber. **[Ceiling of marks: 20]**

**Section B (Paragraph)**

**(Answer questions up to 30 marks. Each question carries 5 marks)**

13. Write the causes and symptoms of any two air-borne diseases.
14. Describe any three water quality parameters.
15. What are the main sources of water pollution
16. Write a note on solid waste management.
17. What is Green house effect? Discuss its causes and consequences.
18. Discuss the depletion of ozone layer.
19. Discuss the basic principles of green chemistry. **[Ceiling of marks: 30]**

**Section C (Essay)**

**(Answer any one. Each question carries 10 marks)**

20. Discuss the air pollution control by Cottrell electrostatic precipitator and extraction ventilator.

21. (a) Name any two toxic metals in water and explain their harmful effects. (b) What is radioactive pollution? How is it controlled? **[1 X 10 = 10]**

**FIFTH SEMESTER B. Sc. DEGREE EXAMINATION**
**CBCSSUG - CHEMISTRY**
**CHE5D02 - Open Course 2**
**CHEMISTRY IN DAILY LIFE**

**Time: 2 Hours** **Maximum marks: 60**

**Section A (Short answers)**

**(Answer questions up to 20 marks. Each question carries 2 marks)**

1. Explain vulcanization and it's advantages.
2. Describe the applications of bakelite?
3. Descibe the main functions of vitamin C.
4. Explain the main characteristics of enzymes.
5. What are the common adulterants in tea?
6. Which are the essential nutrients for plants?
7. Define biofertilizers.
8. Discuss the TFM value in soap.
9. Explain the terms pharmacology and pharmacognosy.
10. What is meant by antipyretics? Give one example.
11. How coal is classified based on carbon content?
12. Define the term octane number. **[Ceiling of marks: 20]**

**Section B (Paragraph)**

**(Answer questions up to 30 marks. Each question carries 5 marks)**

13. Explain the classifiation of polymers on the basis of molecular forces.
14. Describe any three water quality parameters.
15. Write a note on the importance of DNA.
16. Give a short note on classification of dyes based on constitution and their applications.
17. Briefly explain the pesticide pollution and its impact on environment.
18. Describe the cleaning action of soaps and detergents.
19. Discuss the health effects of fast food. **[Ceiling of marks: 30]**

**Section C (Essay)**

**(Answer any one. Each question carries 10 marks)**

20. (a) What are shampoos? How are they classified? Discuss their ingredients and functions. (b) What is radioactive pollution? How is it controlled?
21. (a) Write a note on pollution due to burning of fossil fuels. (b) Discuss the applications of solar energy and solar cells. **[1 X 10 = 10]**

**FIFTH SEMESTER B. Sc. DEGREE EXAMINATION**
**CBCSSUG - CHEMISTRY**
**CHE5D03 - Open Course 3**
**FOOD SCIENCE AND MEDICINAL CHEMISTRY**

**Time: 2 Hours** **Maximum marks: 60**

**Section A (Short answers)**

**(Answer questions up to 20 marks. Each question carries 2 marks)**

1. What is the need for the preservation of food?
2. Which are the main materials used for packaging?
3. What are artificial sweeteners? Give an example.
4. Discuss about the artificial ripening of fruits and its health effects.
5. How can beverages be classified?
6. Define appetizers.
7. What is meant by DNA finger printing?
8. Give a note on blood transfusion.
9. Explain the terms pharmacology and pharmacognosy.
10. What are prescription and non-prescription drugs?
11. Define antacids with an example.
12. Describe the causes and symptoms of food poisoning. **[Ceiling of marks: 20]**

**Section B (Paragraph)**

**(Answer questions up to 30 marks. Each question carries 5 marks)**

13. How can food be contaminated by toxic chemicals?
14. Discribe the harmful effect of modern food habits.
15. Write a note on the importance of DNA.
16. Give the characteristics of enzymes. Discuss their classification.
17. Explain the source and medicinal uses of eucalyptus oil.
18. Explain the causes, symptoms and drugs used for the treatment of influenza, cholera, bronchial asthma and diabetes.
19. What are the first aids given to prevent bleeding? **[Ceiling of marks: 30]**

**Section C (Essay)**

**(Answer any one. Each question carries 10 marks)**

20. Name any three Indian medicinal plants. List their major chemical constituents and medicinal uses.
21. Discuss (a) Medical applications of nanomaterials. (b) Applications of radioactive isotopes. **[1 X 10 = 10]**

File Ref.No.34494/GA - IV - J2/2013/CU

**UNIVERSITY OF CALICUT**

**Abstract**

General and Academic - Faculty of Science - Syllabus of MSc Chemistry Programme for affiliated colleges under CBCSS PG Regulations 2019 with effect from 2019 Admission onwards - Implemented- Orders Issued

**G & A - IV - J**

U.O.No. 8957/2019/Admn Dated, Calicut University.P.O, 06.07.2019

*Read:*-1. U.O.No. 4487/2019/Admn dated 26.03.2019

2. Item No. 2 in the minutes of the meeting of the Board of Studies in Chemistry (PG) held on 12.06.2019

3. Item No. I.13 in the minutes of the meeting of Faculty of Science held on 27.06.2019

ORDER

The Regulations for Choice Based Credit and Semester System for Post Graduate (PG) Curriculum-2019 (CBCSS PG Regulations 2019) for all PG Programmes under CBCSS for Affiliated Colleges and SDE/PrivateRegistration w.e.f. 2019 admission has been implemented vide paper read first above.

The meeting of Board of Studies in Chemistry (PG) held on 12/06/2019 has approved the Syllabus of MSc Chemsitry Programme in tune with the new CBCSS PG Regulations with effect from 2019 Admission onwards, vide paper read second above.

The Faculty of Science at its meeting held on 27/06/2019 has approved the minutes of the meeting of the Board of Studies in Chemsitry (PG) held on 12/06/2019, vide paper read third above.

Under these circumstances, considering the urgency, the Vice Chancellor has accorded sanction to implement the Scheme and Syllabus of MSc Chemistry Programme in accordance with new CBCSS PG Regulations 2019, for affiliated colleges in the University with effect from 2019 Admission onwards, subject to ratification by the Academic Council.

The Scheme and Syllabus of M Sc Chemistry Programme for affiliated colleges in accordance with CBCSS PG Regulations 2019, is therefore implemented in the University with effect from 2019 Admission onwards.

Orders are issued accordingly. (Syllabus appended)

Biju George K

Assistant Registrar

To

The Principals of all Affiliated Colleges

Copy to: PS to VC/PA to PVC/ PA to Registrar/PA to CE/JCE I/JCE V/DoA/EX and EG Sections/GA I F/CHMK Library/Information Centres/SF/DF/FC

Forwarded / By Order

Section Officer

**UNIVERSITY OF CALICUT**

**M.Sc. CHEMISTRY (CBCSS PATTERN)**

# Regulations and Syllabus with effect from 2019 admission

The Board of Studies in Chemistry (PG) at its meeting held on 15-05-2019 considered the revision of M.Sc. Chemistry syllabus under Credit Semester System (CBCSS) and resolved to implement the revised syllabus from 2019 admission onwards. The revised programme pattern; syllabus, distribution of credits and scheme of evaluation, etc. approved by the Board of studies in Chemistry (PG) at its meeting held on **12-06-2019** are given below:

***The pattern of the Programme***

a) The name of the programme shall be **M.Sc. Chemistry under CBCSS pattern**.

b) The programme shall be offered in four semesters within a period of two academic years.

c) Eligibility for admission will be as per the rules laid down by the University from time to time.

d) Details of the programme offered are given in Table 1. The programme shall be conducted in accordance with the programme pattern, the scheme of examination and syllabus prescribed. Of the 25 hours per week, 13 hours shall be allotted for theory and 12 hours for practicals. 1 theory hour per week during even semesters shall be allotted for the seminar.

***Theory Courses***

In the first three semesters there will be **four** theory courses and in the fourth semester **three** theory courses. All the theory courses in the first and second semesters are core courses. In the third semester, there will be three core theory courses and one elective theory course. Colleges can choose any one of the elective courses given in **table 1**. In the fourth semester, there will be one core theory course and two elective theory courses. Colleges can select any two of the elective courses from those given in table 1. However, a student may be permitted to choose any other elective course of his choice in the third and fourth semesters, without having any lecture classes. Of all the elective courses, one elective course in the third semester and two elective courses for the fourth semester chosen by the college only will be considered for calculating the workload of teachers. All the theory courses in the first, third and fourth semesters (both core and elective) are of 4 credits while the theory courses (both core and elective) in the third semester are of 3credits.

***Practical Courses***

In each semester, there will be three core practical courses. However, the practical

examinations will be conducted only at the end of the second and fourth semesters. At the end of the second semester, three practical examinations with the codes CHE1L01 & CHE2L04, CHE1L02 & CHE2L05, and CHE1L03 & CHE2L06 will be conducted. Practical examinations for the codes CHE3L07 & CHE4L10, CHE3L08 & CHE4L11, and CHE3L09 & CHE4L12 will be conducted at the end of the fourth semester. **Each practical examination will be of six-hour duration with 3 credits. Three hours per week in the fourth semester are allotted for conducting individual project work by the students under the guidance of a faculty and it can be treated as practical hours while calculating the workload of teachers.**

***Project and Viva-Voce***

Each student has to perform an independent research project work during the programme under the guidance of a faculty member of the college/ scientists or faculties of recognized research institutions. Projects done in the quality control or quality analysis division of the industries will not be considered. At the same time, projects done in the R & D division of the reputed industry can be considered. Each student has to submit three copies of the project dissertation for valuation at the end of the fourth semester. After the valuation one copy may be returned to the student, one may be given to the project supervisor and the third one should be kept in the department/college library. **Evaluation of the project work (4 credits) will be done on a separate day at the end of the fourth semester, after the theory examinations. Viva-voce on the project will also be done on the same day.**

A comprehensive viva voce examination (2credits), based on all the theory and practical courses, will be conducted at the end of the fourth semester, on a separate day.

***Grading and Evaluation***

**(1) Accumulated minimum credit required for successful completion of the programme shall be 80.**

**(2)** A project work of 4 credits is compulsory and it should be done during the programme. 3 hours per week are allotted the IV semester, for carrying out the project work. **Project evaluation should be conducted by three external examiners, one each from inorganic chemistry, organic chemistry and physical chemistry area, at the end of the fourth semester, on a separate day.**

**(3) Also, a comprehensive Viva Voce Examination (carrying 2 credits) may be conducted by three external examiners, one each from inorganic chemistry, organic chemistry and physical chemistry area, at the end of the fourth semester on a separate day.**

(4) Evaluation and Grading should be done by the direct grading system. All grading during the evaluation of courses and the semester is done on a 6-point scale (A+, A, B, C, D, E). Grading in the 6-point scale is as given below.

| Grade | Grade point |
|---|---|
| **A+** | **5** |
| **A** | **4** |
| **B** | **3** |
| **C** | **2** |
| **D** | **1** |
| **E** | **0** |

***The calculation of GPA, SGPA & CGPA Shall be based on the direct grading system using a 10-point scale as detailed below.***

| Letter Grade | Grade Range | Range of Percentage (%) | Merit / Indicator |
|---|---|---|---|
| O | 4.25 – 5.00 | 85.00 – 100.00 | Outstanding |
| A+ | 3.75 – 4.24 | 75.00 – 84.99 | Excellent |
| A | 3.25 – 3.74 | 65.00 – 74.99 | Very Good |
| B+ | 2.75 – 3.24 | 55.00 – 64.99 | Good |
| B | 2.50 – 2.74 | 50.00 – 54.99 | Above Average |
| C | 2.25 – 2.49 | 45.00 – 49.99 | Average |
| P | 2.00 -2.24 | 40.00 – 44.99 | Pass |
| F | < 2.00 | Below 40 | Fail |
| I | 0 | - | Incomplete |
| Ab | 0 | - | Absent |

Pass in a course: P grade and above (GPA 2.00 and above). Pass in all courses in a semester is compulsory to calculate the SGPA.GPA, SGPA, and CGPA will be between 0 to 5 and in two decimal points. An overall letter grade (Cumulative Grade) for the whole programme shall be awarded to the student based on the value of CGPA using a 10-point scale given below.

| CGPA | Overall Letter Grade |
|---|---|
| 4.25 – 5.00 | O |
| 3.75 – 4.24 | A+ |
| 3.25 – 3.74 | A |
| 2.75 – 3.24 | B+ |
| 2.50 – 2.74 | B |
| 2.25 – 2.49 | C |
| 2.00 -2.24 | P |
| < 2.00 | F |
| 0 | I |
| 0 | Ab |

**(5) Weightage of Internal and External valuation:**

The evaluation scheme for each course shall contain two parts

(a) Internal evaluation

(b) External evaluation.

Its weightages are as follows:

| *Evaluation* | *Weightage* |
|---|---|
| Internal | 1 (or 20%) |
| External | 4 (or 80%) |

Both internal and external evaluation will be carried out using Direct Grading System, in 6 point scale.

**(6) Internal evaluation(must be transparent and fair):**

**Theory: 5 weightages**

(a) Internal Examinations- weightage = 2 (2 internal exams, both should be considered)

(b) Assignments and Exercises- weightage = 1

i. Seminars/Viva Voce- weightage = 1
ii. Attendance –weightage = 1

**Practical: 10 weightages**

a) Attendance – weightage = 2
b) Lab. skill/quality of their results- weightage = 2
c) Model practical test-weightage = 2 (Best one, out of two model exams is considered)
d) Record-weightage = 2
e) Viva Voce- weightage = 2

**Project: 10 weightages**

a) Literature survey and data collection-weightage = 2
b) Interpretation of data & Preparation of Project report – weightage = 2
c) Research attitude - weightage = 2
d) Viva Voce- weightage = 4

Project internal evaluation of each student should be done by the supervising faculty assigned by the department.

**Viva Voce**: No internal evaluation for viva voce examinations (at the end of the 4th semester).

Attendance: Above 90 %: A+, 85 – 89.99 %: A, 80 – 84.99 %: B,

75 -79.99 %: C, 70– 74.99%: D, < 70%: E

**(7) External evaluation:**

a) **Theory**: In all semesters the theory courses have 30 weightage each. The pattern of Question Papers for theory courses is as follows

| *Division* | *Type* | *No.of Questions* | *Weightage* | *Total Weightage* |
|---|---|---|---|---|
| ***Section A*** | ***Short Answer*** | ***8 out of 12*** | ***1*** | ***8*** |
| ***Section B*** | ***Short Essay*** | ***4 out of 7*** | ***3*** | ***12*** |
| ***Section C*** | ***Essay*** | ***2 out of 4*** | ***5*** | ***10*** |
| **Total weightage in question paper** | | | | **30** |

b) **Practicals**: At the end of II and IV semesters, there will be three practical examinations. Each examination has 30 weightage and 3 credits

c) **Comprehensive Viva Voce**: At the end of IV semester on a separate day (2credits). Vivavoce will be based on both the theory and practical courses of the programme.

| Component | Weightage |
|---|---|
| Physical & Theoretical Chemistry – theory courses | 5 |
| Physical Chemistry – practical courses | 5 |
| Inorganic Chemistry – theory courses | 5 |
| Inorganic Chemistry – practical courses | 5 |
| Organic Chemistry – theory courses | 5 |
| Organic Chemistry – practical courses | 5 |
| **Total weightage** | **30** |

c) **Project Evaluation**: End of IV semester on a separate day. Evaluation is based on:

a) Significance and relevance of the project-weightage = 5

b) Project report – weightage = 8

c) Presentation- weightage = 5

c) Viva Voce- weightage = 12

Total weightage 30 and credit for the project is 4.

**(8) Directions for question papersetters:**

Section A: Set each questions to be answered in 5 minutes duration.

Section B: 20 minutes answerable questions each. May be asked as a single question or parts.

Section C: 30 minutes answerable questions each. May be asked as a single question or parts.

While setting the question paper, all units in each theory courses must be given due consideration and should give equal distribution as possible.
(Further details regarding the grading and evaluation are as per the University PG regulations 2019)

**Dr. Abraham Joseph**
**Chairman, Board of Studies (Chemistry PG),**
**University of Calicut**

**Audit courses:**

***Ability Enhancement Course (AEC):***

This course aims to have hands-on experience for the students in their respective field of study, both in the core and elective subject area. Also, it is a platform for the student community to have basic concepts of research and publication.

AEC is a 4 credit course and should be conducted during the first semester of the programme. The credit of the AEcourse will not be considered while calculating the SGPA/CGPA. But the student has to obtain minimum pass requirements in this course, which is compulsory for an overall pass in the programme

One particular AEC may be selected for all the students in a batch in the department or each student in a batch may choose one AEC, among the pool of courses suggested below. The exact title of the course may be decided by the department, but the area of study should be from the pool of courses suggested below. Either a single faculty from the department may be in charge of this course for a batch or each student may be assigned to a particular faculty in the department, in charge of this AEC, which will be decided by the department council/ HoD.

a) Industrial/Research institution visit/visits
b) Publication of a research article/articles in the national/international journal
c) Presentation of research paper/papers in national level seminar/conference, which should be published in the seminar/conference proceedings
d) Review article/articles on research topics which are presented in a national level seminar/conference and published in the proceedings
e) Internships at any reputed research institutions/R&D centre/Industry

After conducting the AEC, the evaluation/examination should be done either common for all students in a batch or individually depending upon the AEC conducted. The evaluation/ examination must be conducted jointly by the teacher in charge of the AEC and the head of the department. The result of the AEC, duly signed and sealed by both teacher in charge and head of the department, should be uploaded to the University during the stipulated time period in the third semester of the programme. Evaluation/examination must be conducted by 30 weightage pattern, as in the theory courses and the GPA and overall grade of the AEC should be uploaded to the University. Evaluation/examination on AEC must contain the following components: MCQ type written examination, Report on AEC, Presentation of AEC, Viva voce on AEC. Distribution of 30 weightage may be done by the teacher in charge in concurrence with the Head of the department.

***Professional Competency Course (PCC):***

This course particularly aims to improve the skill level of students, especially for using specific as well as nonspecific software useful in their respective field of study, both related to the core and elective subject area. Also, it is a platform for the student community to undertake socially committed projects and thereby developing a method of leaning process by through the involvement with society.

PCC is a 4 credit course and should be conducted during the second semester of the programme. The credit of the PC course will not be considered while calculating the SGPA/CGPA.

But the student has to obtain minimum pass requirements in this course, which is compulsory for an overall pass in the programme

One particular PCC may be selected for all the students in a batch in the department or each student in a batch may choose one PCC, among the pool of courses suggested below. The exact title of the course may be decided by the department, but the area of study should be from the pool of courses suggested below. Either a single faculty from the department may be in charge of this course for a batch or each student may be assigned to a particular faculty in the department, in charge of this PCC, which will be decided by the department council/ HoD.

a) Development of skills on using softwares like Gaussian, Gamessetc which is useful in molecular modeling, drug designing, etc.
b) Development of skills on using softwares like Chemdraw, Chemwindow, ISIS draw, etc which is useful in drawing purposes, structural predictions, etc.
c) Training on computational chemistry
d) Case study and analysis on any relevant issues in the nearby society(for example water analysis, soil analysis, acid/alkali content analysis, sugar content analysis, etc)
e) Any community linking programme relevant to the area of study(For example Training for society on soap/perfume making, waste disposal, plastic recycling, etc)

After conducting the PCC, the evaluation/examination should be done either common for all students in a batch or individually depending upon the PCC conducted. The evaluation/ examination must be conducted jointly by the teacher in charge of the PCC and the head of the department. The result of the PCC, duly signed and sealed by both teacher in charge and head of the department, should be uploaded to the University during the stipulated time period in the third semester of the programme. Evaluation/examination must be conducted by 30 weightage pattern, as in the theory courses and the GPA and overall grade of the PCC should be uploaded to the University. Evaluation/examination on PCC must contain the following components: MCQ type written examination, Report on PCC, Presentation on PCC, Viva voce on PCC. Distribution of 30 weightage may be done by the teacher in charge in concurrence with the Head of the department.

**TABLE 1**

**Courses offered for M.Sc. Chemistry Programme under CBCSS Patten in Affiliated Colleges (2019 onwards)**

| Semester | Course Code | Course Title | Instruction/ Week | Credits |
|---|---|---|---|---|
| I | CHE1C01 | Quantum Mechanics and Computational Chemistry | 4 | 4 |
| | CHE1C02 | Elementary inorganic chemistry | 3 | 4 |
| | CHE1C03 | Structure and reactivity of organic Compounds | 3 | 4 |
| | CHE1C04 | Thermodynamics, kinetics, and catalysis | 3 | 4 |
| | CHE1L01 | Inorganic chemistry practical I | 4 | - |
| | CHE1L02 | Organic chemistry Practical I | 4 | - |
| | CHE1L03 | Physical chemistry practical I | 4 | - |
| | | **Total credits:** | **Core** | **16** |
| II | CHE2C05 | Group theory and Chemical Bonding | 3 | 3 |
| | CHE2C06 | Coordination chemistry | 3 | 3 |
| | CHE2C07 | Reaction mechanism in Organic Chemistry | 3 | 3 |
| | CHE2C08 | Electrochemistry, solid state chemistry, and Statistical Thermodynamics | 3 | 3 |
| | CHE2L04 | Inorganic chemistry practical II | 4 | 3 |
| | CHE2L05 | Organic chemistry practical II | 4 | 3 |
| | CHE2L06 | Physical chemistry practical II | 4 | 3 |
| | | **Total credits:** | **Core** | **21** |
| | CHE3C09 | Molecular spectroscopy | 4 | 4 |
| | CHE3C10 | Organometallic &Bioinorganic chemistry | 3 | 4 |
| | CHE3C11 | Reagents and Transformations in Organic Chemistry | 3 | 4 |

| | | | | |
|---|---|---|---|---|
| **III** | CHE3L07 | Inorganic chemistry practical III | 4 | |
| | CHE3L08 | Organic chemistry practical III | 4 | |
| | CHE3L09 | Physical chemistry practical III | 4 | |
| | CHE3E01 | Synthetic organic chemistry(Elective) | 3 | 4 |
| | CHE3E02 | Computational chemistry(Elective) | 3 | 4 |
| | CHE3E03 | Green and Nanochemistry(Elective) | 3 | 4 |
| | | **Total Credits:** | **Core**<br>**Elective** | **12**<br>**4** |
| **IV** | CHE4C12 | Instrumental Methods of Analysis | 4 | 4 |
| | CHE4L10 | Inorganic Chemistry Practical IV | 3 | 3 |
| | CHE4L11 | Organic Chemistry Practical IV | 3 | 3 |
| | CHE4L12 | Physical Chemistry Practical IV | 3 | 3 |
| | CHE4E04 | Petrochemicals and Cosmetics(Elective) | 4 | 4 |
| | CHE4E05 | Industrial Catalysis(Elective) | 4 | 4 |
| | CHE4E06 | Natural products & Polymer Chemistry (Elective) | 4 | 4 |
| | CHE4E07 | Material Science(Elective) | 4 | 4 |
| | CHE4E08 | Organometallic Chemistry | 4 | 4 |
| | CHE4P01 | Research Project | 3 | 4 |
| | CHE4V01 | Viva Voce | | 2 |
| | | **Total Credits:** | **Core**<br>**Elective**<br>**Project**<br>**Viva** | **13**<br>**8**<br>**4**<br>**2** |
| | **TOTAL CREDITS OF THE PROGRAMME :**<br>**CORE**<br>**ELECTIVE** | | | **62**<br>**12** |

| | | |
|---|---|---|
| | **PROJECT** | **4** |
| | **VIVA-VOCE** | **2** |
| | ***TOTAL CREDITS*** | **80** |

**UNIVERSITY OF CALICUT**

**M.Sc. CHEMISTRY (CSS PATTERN) - SEMESTER I**

## CHE1C01 - QUANTUM MECHANICS AND COMPUTATIONAL CHEMISTRY (4 Credits, 72 h)

### Unit 1: Introduction to Quantum Mechanics (9h)

Black body radiation and Planck's quantum postulate. Einstein's photoelectric equation, Schrodinger's wave mechanics, Detailed discussion of postulates of quantum mechanics – State function or wave function postulate, Born interpretation of the wave function, well behaved functions, orthonormality of wave functions; Operator postulate, operator algebra, linear and nonlinear operators, Non-commuting operators and the Heisenberg's Uncertainty principle, Laplacian operator, Hermitian operators and their properties, eigen functions and eigen values of an operator; Eigen value postulate, eigen value equation, Expectation value postulate; Postulate of time-dependent Schrödinger equation of motion, conservative systems and time-independent Schrödinger equation. Stationary states.

### Unit 2: Quantum Mechanics of Translational & Vibrational Motions (9h)

Free particle in one-dimension; Particle in a one-dimensional box with infinite potential walls, important features of the problem; Particle in a one-dimensional box with one finite potential wall, Particle in a rectangular well, (no derivation), Significance of the problem, Introduction to tunneling; Particle in a three dimensional box, Separation of variables, degeneracy, Symmetry breaking.
One-dimensional harmonic oscillator (complete treatment):- Method of power series, Hermite equation and Hermite polynomials, recursion relation, wave functions, and energies, important features of the problem, harmonic oscillator model and molecular vibrations.

### Unit: 3 Quantum Mechanics of Rotational Motion (9h)

Co-ordinate systems: - Cartesian, and spherical polar coordinates and their relationships. Planar rigid rotor (or particle on a ring), the Phi-equation, solution ofhe Phi-equation, One particle Rigid rotator (non-planar rigid rotator or particle on a sphere) (complete treatment): The wave equation in spherical polar coordinates, separation of variables, the Phi-equation and the Theta-equation and their solutions, Legendre and associated Legendre equations, Legendre and associated Legendre polynomials, Rodrigue's formula, spherical harmonics (imaginary and real forms), polar diagrams of spherical harmonics. Quantization of angular momentum, quantum mechanical operators corresponding to angular momenta ((Lx, Ly, Lz), commutation relations between these operators, Ladder operator method for angular momentum, space quantization.

**Unit 4: Quantum Mechanics of Hydrogen-like Atoms (9h)**

Potential energy of hydrogen-like systems, the wave equation in spherical polar coordinates, separation of variables, the R, Theta and Phi equations and their solutions, Laguerre and associated Laguerre polynomials, wave functions and energies of hydrogen-like atoms, orbitals, radial functions and radial distribution functions and their plots, angular functions (spherical harmonics) and their plots. The postulate of spin by Uhlenbeck and Goudsmith, Dirac's relativistic equation for hydrogen atom and discovery of spin (qualitative treatment), spin orbitals, construction of spin orbitals from orbitals and spin functions.

**Unit 5: Approximation Methods in Quantum Mechanics (9h)**

Many body problem and the need of approximation methods; Independent particle model; Variation method – variation theorem with proof, illustration of variation theorem using a trial function [e.g., x (a-x)] for particle in a 1D-box, variation treatment for the ground state of helium atom; Perturbation method – time-independent perturbation method (non-degenerate case only), illustration by application to particle in a ID-box with slanted bottom, perturbation treatment of the ground state of the helium atom.

**Unit 6: Quantum Mechanics of Many-electron Atoms (9h)**

Hartree's Self-Consistent Field method for atoms, Fock modification using spin orbitals & Hartree -Fock Self- Consistent Field (HF-SCF) method for atoms, the Fock operator; Pauli's antisymmetry principle - Slater determinants; Roothan's concept of basis functions: Slater type orbitals (STO) and Gaussian type orbitals (GTO).

**Unit 7: Introduction to Computational Chemistry - I (9h)**

Electronic structure of molecules – Basics of HF-SCF method of molecules (derivation not required). Classification of Computational Chemistry methods – Molecular mechanics methods (the concept of the force field) and Electronic structure methods, ab initio and semi-empirical methods (Basic idea only), Concept of electron correlation and post HF methods. (Elementary idea)

**Unit 8: Introduction to Computational Chemistry – II (9h)**

Basis set approximation in ab initio methods -classification of basis sets – minimal, double zeta, triple zeta, split-valence, polarization & diffuse basis sets, Pople-style basis sets, and their nomenclature.Simple calculations using Gaussian programme– The structure of a Gaussian input file, Types of keywords, Specification of molecular geometry using a) Cartesian coordinates and b) Internal coordinates. The Z-matrix, Z- matrices of some simple molecules like $H_2$, $H_2O$, formaldehyde ammonia and methanol.

**Reference (for units 1 to 6)**


1. F.L. Pilar, *Elementary Quantum Chemistry*, McGraw-Hill, 1968.
2. I.N. Levine, *Quantum Chemistry*, 6th Edition, Pearson EducationInc.,
3. P.W.AtkinsandR.S.Friedman,*Molecular Quantum Mechanics*, 4thEdition, Oxford University Press,2005.
4. M.W. Hanna, *Quantum Mechanics in Chemistry*, 2nd Edition, W.A. Benjamin Inc., 1969.
5. Donald, A. McQuarrie, *Quantum Chemistry*, University Science Books, 1983 (first Indian edition,Viva books,2003).
6. Thomas Engel, Quantum Chemistry & Spectroscopy, Pearson Education, 2006.
7. J.P. Lowe, *Quantum Chemistry*, 2nd Edition, Academic Press Inc., 1993.
8. HoriaMetiu, *Physical Chemistry – Quantum Mechanics*, Taylor & Francis, 2006.
9. A.K. Chandra, *Introduction to Quantum Chemistry*, 4th Edition, Tata McGraw-Hill, 1994.
10. L. Pauling and E.B. Wilson, *Introduction to Quantum Mechanics*, McGraw-Hill, 1935 (A good source book for many derivations).
11. R.L. Flurry, Jr., *Quantum Chemistry*, Prentice Hall, 1983.
12. R.K. Prasad, *Quantum Chemistry*, 3rd Edition, New Age International, 2006.
13. M.S. Pathania, *Quantum Chemistry, and Spectroscopy (Problems & Solutions)*, Vishal Publications, 1984.
14. C.N. Datta, *Lectures on Chemical Bonding and Quantum Chemistry*, Prism Books Pvt. Ltd. 1998.
15. Jack Simons, *An Introduction to Theoretical Chemistry*, Cambridge University Press, 2003.


**Reference (for units 7 & 8)**


1. C. J. Cramer, *Essentials of computational Chemistry: Theories and models*, John Wiley & Sons 2002.
2. Frank Jensen, *Introduction to Computational Chemistry*, John Wiley & Sons LTD1999.
3. J. Foresman &Aelieen Frisch, *Exploring Chemistry with Electronic Structure Methods*, Gaussian Inc., 2000.
4. David Young, *Computational Chemistry- A Practical Guide for Applying Techniques to Real- World Problems"*, Wiley -Interscience, 2001.
5. Errol G. Lewars, *Computational Chemistry: Introduction to the theory and applications of molecular quantum mechanics,* 2 ndedn., Springer2011

**UNIVERSITY OF CALICUT**

**M.Sc. CHEMISTRY (CSS PATTERN) - SEMESTER I**

## CHE1C02 - - ELEMENTARY INORGANIC CHEMISTRY (4 Credits, 54h)

### Unit 1: Concepts of Acids and Bases (9h)

Major acid-base concepts, Arrhenius, Bronsted-Lowry, Solvent system, Lux-Flood, Lewis and Usanovich concepts. Classification of acids and bases as hard and soft. HSAB principle. The theoretical basis of hardness and softness. The Drago-Wayland equation, E and C parameters- Symbiosis. Applications of HSAB concept.
Chemistry of nonaqueous solvents- $NH_3$, $SO_2$, $H_2SO_4$, $BrF_3$, HF, $N_2O_4$, and $HSO_3F$. Nonaqueous solvents and acid-base strength. Super acids–surface acidity.

### Unit 2: Chemistry of Main Group Elements-I (9h)

Chemical periodicity-First and Second raw anomalies-The diagonal relationship-Periodic anomalies of the nonmetals and post-transition metals.
Allotropes of C, S, P. As, Sb, Bi, O, and Se. Electron-deficient compounds-Boron hydrides-preparation, reactions, structure, and bonding. Styx numbers-closo, nido, arachno polyhedral structures. Boron cluster compounds-Wade's rule. Polyhedral borane anion-carboranes, metallaboranes and metallacarboranes. Borazines and borides.

.

### Unit 3: Chemistry of Main Group Elements-II (9h)

Silicates and alumino silicates-Structure, molecular sieves-Zeolite. Silicones-Synthesis, structure and uses. Carbides and silicides. Synthesis, structure, bonding, and uses of Phosphorous-Nitrogen, Phosphorous-Sulphur, and Sulphur-Nitrogen compounds.

### Unit 4: Chemistry of Transition and Inner Transition Elements (9h)

Heteropoly and isopoly anions of W, Mo, V.Standard reduction potentials and their diagrammatic representations Ellingham diagram. Latimer and Frost diagrams. Pourbaix diagram.Differences between 4f and 5f orbitals. Magnetic and spectroscopic properties. Uranyl compounds. Trans-actinide elements. Super heavy elements : production and chemistry

### Unit 5: Nuclear and Radiation Chemistry (9h)

Structure of nucleus: shell, liquid drop, Fermi gas, collective and optical models. Nuclear reaction: Bethe`s notation of nuclear process- Types-reaction cross section-

photonuclear and thermonuclear reactions. Nuclear fission: Theory of fission-neutron capture cross section and critical size. Nuclear fusion. Neutron activation analysis. Radiation chemistry: Interaction of radiation with matter. Detection and measurement of radiation- GM and scintillation counters – radiolysis of water-radiation hazards- radiation dosimetry.

**Unit 6: Chemistry of Nanomaterials (9h)**

History of nanomaterials - Classification. Size - dependence of properties. Synthesis of nanostructures: bottom-up-approach, top-down approach, self-assembly, lithography, molecular synthesis, template-assisted synthesis.Methods of characterization: Electron microscopies-SEM, TEM. Scanning probe microscopies- STM, AFM. X-ray photoelectron spectroscopy (XPS), Dynamic light scattering (DLS), and X-ray diffraction (XRD) .Applications: Nanoelectronics, nanosensors, nanocatalysts, nanofiltration, diagnostic and therapeutic applications, and targeted drug delivery.Introduction to graphenes and fullerenes.

**Reference (for units 1 to 5)**


1. N.N. Greenwood and A.Earnshaw, *Chemistry of Elements, 2/e, Elsevier* Butterworth- Heinemann, 2005.
2. J.E.Huheey, E.A.Keiter, R.L.Keiter. O.K.Medhi. *Inorganic Chemistry, principles of structure and reactivity*, Pearson Education, 2006.
3. G.L.Miessler, D.A.Tarr, *Inorganic Chemistry*, Pearson, 2010.
4. D.F.Shriver, P.W.Atkins, *Inorganic Chemistry*, Oxford University Press, 2002
5. William W Porterfield, *Inorganic Chemistry-Aunified approach*, AcademicPress, 2005.
6. Keith F Purcell, John C Kotz, *Inorganic Chemistry*, Cengage Learning, 2010.
7. James E House, *Inorganic Chemistry*, Academic Press, 2008.
8. H.J.Arnikar, *Essentials of Nuclear chemistry*, New Age International, 2005.
9. Friedlander and J.W.Kennedy, *Introduction to Radiochemistry*, John Wiley and Sons, 1981.
10. S. Glastone, *Source Book on Atomic Energy*, *3rd* edn., Affiliated East-West Press Pvt.Ltd., 1967.


**Reference (for unit 6):**


1. C.P.Poole(Jr.) and F.J. Owens, *Introduction to Nanotechnology*,Wiley India,2007.
2. G.A.Ozin and A.C.Arsenault, *Nanochemistry*, RSCPublishing, 2008.
3. T.Pradeep, *The essentials of Nanotechnology*, Tata McGraw-Hill, New Delhi, 2007.
4. K.J.Klabunde(Ed.), *Nanoscale Materials in Chemistry*, John Wiley&Sons,2001.

**UNIVERSITY OF CALICUT**

**M.Sc. CHEMISTRY (CSS PATTERN) - SEMESTER I**

## CHE1C03 - STRUCTURE, AND REACTIVITY OF ORGANIC COMPOUNDS

**(4 Credits, 54h)**

### Unit 1: Structure and Bonding in Organic Molecules (9h)

Nature of Bonding in Organic Molecules: Localized and delocalized chemical bonding, bonding weaker than the covalent bond, cross- conjugation, resonance, rules of resonance, resonance hybrid and resonance energy, tautomerism, hyperconjugation, π-π interactions, pπ-dπ bonding (ylides).

Hydrogen bonding: Inter and intra-molecular hydrogen bonding. Range of the energy of hydrogen bonding. Effect of hydrogen bond on conformation, physical and chemical properties of organic compounds- volatility, acidity, basicity, and stability. Stabilization of hydrates of glyoxal and chloral, and ninhydrin. High acid strength of maleic acid compared to fumaric acid. Electron donor-acceptor complexes, crown ether complexes, cryptates, inclusion compounds, and cyclodextrins.

Hückel MO method. MO's of simple molecules, ethylene, allyl radical and 1, 3-butadiene. Hückel rule and modern theory of aromaticity, criteria for aromaticity and antiaromaticity, MO description of aromaticity and antiaromaticity. Homoaromaticity. Aromaticity of annulenes and hetero annulenes, fused ring systems, fulvenes, fulvalenes, azulenes, pentalenes, and heptalenes. Preparation of aromatic and antiaromatic compounds by different methods, the stability of benzylic cations and radicals. Effect of delocalized electrons on pKa.

### Unit 2: Structure and Reactivity (9h)

Transition state theory, Potential energy vs reaction co-ordinate curve, substituent effects (inductive, mesomeric, inductomeric, electromeric and field effects) on reactivity. A qualitative study of substitution effects in $S_N1$- $S_N2$ reactions. Neighbouring group participation, the participation of carboxylate ion, halogen, hydroxyl group, acetoxy group, phenyl group and pi -bond. Classical and nonclassical carbocations

Basic concepts in the study of organic reaction mechanisms: Application of experimental criteria to mechanistic studies, kinetic versus thermodynamic control- Hammond postulate, Bell- Evans- Polanyi principle, Marcus equation, Curtin-Hammet principles, Acidity constant, Hammet acidity function.

Isotope effect (labeling experiments), stereochemical correlations. Semiquantitative study of substituent effects on the acidity of carboxylic acids. Quantitative correlation of substituent effects on reactivity. Linear free energy relationships. Hammet and Taft equation for polar effects and Taft's steric substituent constant for steric effect. Solvent effects.

**Unit 3: Conformational Analysis – I (9h)**

Factors affecting the conformational stability of molecules – dipole interaction, bond opposition strain, bond angle strain. Confirmation of acyclic compounds – Ethane, n-butane, alkene dihalides, glycols, chlorohydrins, tartaric acid, erythro and threoisomer.

Interconversion of axial and equatorial bonds in chair conformation of cylohexane– distance between the various H atoms and C atoms in chair and boat conformations. Monosubstituted cyclohexane–methyl and t-butyl cyclohexanes–flexible and rigid systems. Confirmation of substituted cyclohexanone, 2-bromocyclohexanone, dibromocyclohexanone, (cis & trans), 2-bromo-4, 4-dimethyl cyclohexanone. Anchoring group and conformationaly biased molecules. Conformations of 1, 4 -cis and-trans disubstituted cyclohexanes in which one of the substituents is 1-butyl and their importance in assessing the reactivity of an axial or equatorial substituent.

**Unit 4: Conformational Analysis – II (9 h)**

Effect of conformation on the course and rate of reactions in (a) debromination of dl and meso 2, 3-dibromobutane or stilbene dibromide using KI. (b) semipinacolic deamination of erythro and threo 1,2-diphenyl-1-(p-chlorophenyl)-2-aminoethanol. (c) dehydrohalogenation of stilbene dihalide (dl and meso) and erythro and threo-bromo-1,2-diphenyl propane.

Effect of conformation on the course and rate of reactions in cyclohexane systems illustrated by (a) $S_N2$ and $S_N1$ reactions for (i) an axial substituent, and (ii) an equatorial substituent inflexible and rigid systems. (b) E1, E2 eliminations illustrated by the following compounds. (i) 4-t-Butylcyclohexyl tosylate (cis and trans) (ii) 2-Phenylcyclohexanol (cis and trans) (iii) Menthyl and neomenthyl chlorides and benzene hexachlorides. (c) Pyrolytic elimination of esters (cis elimination) (d) Esterification of axial as well as equatorial hydroxyl and hydrolysis of their esters in rigid and flexible systems. (Compare the rate of esterification of methanol, isomenthol, neomenthol, and neoisomenthol). (f) Esterification of axial as well as equatorial carboxyl groups and hydrolysis of their esters. (g) Hydrolysis of axial and equatorial tosylates. (h) Oxidation of axial and equatorial hydroxyl group to ketones by chromic acid.

Bredt's rule. Stereochemistry of fused, bridged and caged ring systems- decalins, norbornane, barrelene, and adamantanes.

**Unit 5: Stereochemistry (9h)**

Conformation and configuration, Fischer, Newman, and Sawhorse projection formulae and their interconversion. Concept of chirality, recognition of symmetry elements and chiral structures, conditions for optical activity, optical purity. Specific rotation and its variation in sign and magnitude under different conditions, relative and absolute configurations, Fisher projection formula, sequence rule – *R and S*

notation in cyclic and acyclic compounds, Cahn- Ingold- Prelog (CIP) rule. Mixtures of stereoisomers; enantiomeric excess and diastereomeric excess and their determination. Methods of resolution diastereomers. Resolution of racemates after conversion into diastereomers; use of S- brucine, kinetic resolution of enantiomers, chiral chromatography.

Optical isomerism of compounds containing one or more asymmetric carbon atoms, enantiotopic, homotopic, diastereotopic hydrogen atoms, prochiral centre. Pro-R, Pro-S,Re, and Si.

Optical isomerism in biphenyls, allenes, and nitrogen and sulphur compounds, conditions for optical activity, R and S notations. Optical activity in cis-trans conformational isomers of 1, 2-, 1, 3- and 1,4-dimethylcyclohexanes.Restricted rotation in biphenyls – Molecular overcrowding. Chirality due to the folding of helicalstructures.

Geometrical isomerism – E and Z notation of compounds with one and more double bonds in acyclic systems. Configuration of cyclic compounds- monocyclic, fused and bridged ring systems, interconversion of geometrical isomers. Methods of determination of the configuration of geometrical isomers in acyclic acid cyclic systems, the stereochemistry of aldoximes and ketoximes

**Unit 6: Asymmetric Synthesis (9 h)**

Asymmetric synthesis, need for asymmetric synthesis, stereoselectivity and stereospecificity. Chiral pool: chiral pool synthesis of beetle pheromone component (*S*)- (–)-ipsenol from(S)-(–)-leucine.

Classification of Asymmetric reactions into (1) Substrate controlled (2) Chiral auxiliary controlled (3) Chiral reagent controlled and (4) Chiral catalyst controlled.

Substrate controlled asymmetric synthesis: Nucleophillic addition to chiral carbonyl compounds. 1, 2-asymmetric induction, Cram's rule and Felkin-Anhmodel. Chiral auxiliary controlled asymmetric synthesis: α-Alkylation of chiral enolates, azaenolates, imines and hydrazones, chiral sulfoxides. 1, 4-Asymmetric induction and Prelog's rule. Use of chiral auxiliary in Diels-Alder and Copereactions.Chiral reagent controlled asymmetric synthesis: Asymmetric reduction using BINAL– H. Asymmetric hydroboration using $IPC_2BH$ and $IPCBH_2$. Reduction with CBH reagent. Stereochemistry of Sharpless asymmetric epoxidation anddihydroxylation. Asymmetric aldol reaction: Diastereoselective aldol reaction and its explanation by Zimmermann-*Traxler* model. Auxillary controlled aldol reaction. Double diastereoselection-matched and mismatched aldol

**References:**


1. R. R. Carey and R. J. Sundburg, *Advanced Organic Chemistry, Part A*, Springer, 5/e, 2007.
2. M. B. Smith, J. March, *March's Advanced Organic Chemistry*, John Wiley & Sons, 6/e, 2007.
3. T. H. Lowry and K. S. Richardson, *Mechanism and Theory in Organic Chemistry*, 3/e Addison- Wesley, 1998.
4. J. Clayden, N. Greeves, S. Warren, and P. Wothers, *Organic Chemistry*, 2/e, Oxford UniversityPress,2012.
5. E. V. Anslyn and D. A. Dougherty, *Modern Physical Organic Chemistry*, University Science Books, 2005.
6. M. S. Singh, *Advanced Organic Chemistry: Reactions and Mechanisms*, Pearson, 2013.
7. P. Sykes, *A Guide book to Mechanism in Organic Chemistry*, 6/e, Pearson, 2006.
8. C. K. Ingold, Structure and Mechanism in Organic chemistry, 2/e, CBS Publishers, 1994.
9. E. L. Eliel, S. H. Wilen, and L. N. Mander, *Stereochemistry of Carbon Compounds*, John Wiley, 1997.
10. G. L. D. Krupadanam, *Fundamentals of Asymmetric Synthesis*, Universities Press, 2013.
11. Okuyama and Maskill, Organic Chemistry: A Mechanistic Approach, Oxford University Press,2013
12. S. Warren and P. Wyatt, *Organic Synthesis: The Disconnection Approach*, 2/e, John Wiley & Sons, 2008.

**UNIVERSITY OF CALICUT**

**M.Sc. CHEMISTRY (CSS PATTERN) - SEMESTER I**

## CHE1C04 – THERMODYNAMICS, KINETICS AND CATALYSIS

**(4 Credits, 54h)**

### Unit 1: Thermodynamics (9h)

Review of First and Second law of thermodynamics, Third law of thermodynamics, Need for third law, Nernst heat theorem, Apparent exceptions to third law, Applications of Third law, Determination of Absolute entropies, Residual entropy.
Thermodynamics of Solutions: Partial molar quantities, Chemical potential, Variation of chemical potential with temperature and pressure, Partial molar volume and its determination, Gibbs-Duhem equation, Thermodynamics of ideal and real gases and gaseous mixtures, Fugacities of gases and their determinations, Activity, Activity coefficient, standard state of substance (for solute and solvents), Duhem-Margules equation and its applications. Thermodynamics of ideal solutions, Deduction of the laws of Raoult's ebullioscopy, cryoscopy, and osmotic pressure. Non-ideal solutions, Deviations from Raoult's law, Excess functions- excess free energy, excess entropy, excess enthalpy, excess volume.

### Unit 2: Thermodynamics of Irreversible Processes (9 h)

Simple examples of irreversible processes, general theory of non-equilibrium processes, entropy production, the phenomenological relations, Onsager reciprocal relations, application to the theory of diffusion, thermal diffusion, thermo-osmosis, and thermo- molecular pressure difference, electro-kinetic effects, the Glansdorf-Pregogine equation.

### Unit 3: Chemical Kinetics (9 h)

Kinetics of reactions involving reactive atoms and free radicals - Rice - Herzfeld mechanism and steady state approximation in the kinetics of organic gas phase decompositions (acetaldehyde & ethane); Kinetics of chain reactions – branching chain and explosion limits ($H_2$-$O_2$reaction as an example); Kinetics of fast reactions-relaxation methods, molecular beams, flash photolysis; Solution kinetics: Factors affecting reaction rates in solution, Effect of solvent and ionic strength (primary salt effect) on the rate constant, secondary salt effects.

**Unit 4: Molecular Reaction Dynamics (9 h)**

Reactive encounters: Collision theory, diffusion-controlled reactions, the material balance equation, Activated Complex theory – the Eyring equation, thermodynamic aspects of ACT; Comparison of collision and activated complex theories; The dynamics of molecular collisions – Molecular beams, principle of crossed-molecular beams; Potential energy surfaces - attractive and repulsive surfaces, London equation, Statistical distribution of molecular energies; Theories of unimolecular reactions - Lindemann's theory, Hinshelwood's modification, Rice -Ramsperger and Kassel (RRK) model.

**Unit 5: Surface Chemistry (9 h)**

Structure and chemical nature of surfaces, Adsorption at surfaces - Adsorption isotherms, Langmuir's unimolecular theory of adsorption, BET equation, derivation, Determination of surface area and pore structure of adsorbents - physical adsorption methods, X-ray methods, mercury intrusion method, chemisorption methods. Determination of surface acidity-TPD method. Heat of adsorption and its determination.

**Unit 6: Catalysis (9h)**

Features of homogeneous catalysis–Enzyme catalysis - Michaelis-Menten Mechanism.Features of heterogeneous catalysis -Langmuir-Hinshelwood mechanism and Eley-Rideal mechanism – illustration using the reaction $2CO + O_2$ ---› $2CO_2$. Methods of preparation of heterogeneous catalysts - precipitation and co-precipitation methods, sol gel method, flame hydrolysis. Preparation of Zeolites and silica supports. Auto catalysis - oscillating reactions – mechanisms of oscillating reactions (Lotko -Volterra, brusselator, and oregonator). Introduction to Phase transfer catalysis, biocatalysis, nanocatalysis, and polymer supported catalysis.

**Reference:**


1. *P. Atkins & J. De Paula, Atkins's Physical Chemistry, 10/e, OUP, 2014*.

2 Keith J. Laidler, *Chemical Kinetics 3rd edn*., Pearson Education, 1987(Indian reprint 2008).

*3.* Steinfeld, Francisco, and Hase, *Chemical Kinetics and Dynamics, 2ndedition,* Prentice Hall International. Inc

4. Santhosh K. Upadhyay, *Chemical Kinetics and Reaction Dynamics,* Springer, 2006.

5. Richard I. Masel, *Chemical Kinetics and Catalysis,* Wiley Interscience, 2001.

6. K.J.Laidler, J.H.Meiser and B. C. Sanctuary, *Physical Chemistry,* Houghton Mifflin Company, New York, 2003.

7. A.W. Adamson, *Physical Chemistry of surfaces*, 4th edition, Interscience, New York, 1982.

8. G. K. Vemulapalli, *Physical Chemistry*, Printice Hall of India.

9. M.K. Adam, *The Physics and Chemistry of surfaces* , Dover Publications

10. S. Glasstone, *Thermodynamics for chemists*, East-West1973.

11. Rajaram and Kuriokose, *Thermodynamics,* East-West1986

12. Pigoggine, *An introduction to Thermodynamics of irreversible processes*, Interscience

13. B.G. Kyle, *Chemical and Process Thermodynamics*, 2nd Edn, Prentice Hall of India

14. A. W. Adamson and A. P. Gast, *Physical Chemistry of Surfaces*, 6 Edn, Wiley, 2011.

15. Jens Hajen, *Industrial Catalysis: A Practical Approach.* 2nd Edn, Wiley VCH, 2006.

16. Dipak Kumar Chakrabarty, *Adsorption and Catalysis by Solids,* New Age.2007.

17. C.H. Bartholomew and R.J. Farrauto, *Fundamentals of Industrial Catalysis Process,* 2ndEdn. Wiley & Sons Inc.2006.

18. Woodruff, D. P. and Delchar T. A., *Modern Techniques of Surface Science*, Cambridge Solid State Science Series, 1994.

19. Kurt K. Kolasinski, *Surface Science: Foundations of Catalysis and Nanoscience*, 3rd Edn, Wiley U. K., 2012.

**UNIVERSITY OF CALICUT**

**M.Sc. CHEMISTRY (CSS PATTERN) - SEMESTER II**

## CHE2C05 - GROUP THEORY and CHEMICAL BONDING (3 Credits, 54h)

### Unit 1: Foundations of Group Theory & Molecular Symmetry (9h)

Basic principles of group theory - the defining properties of mathematical groups, finite and infinite groups, Abelian and cyclic groups, group multiplication tables (GMT), similarity transformation, sub groups & classes in a group.

Molecular Symmetry & point groups - symmetry elements and symmetry operations in molecules, relations between symmetry operations, complete set of symmetry operations of a molecule, point groups and their systematic identification, GMT of point groups.

Mathematical preliminaries - matrix algebra, addition and multiplication of matrices, inverse of a matrix, square matrix, character of a square matrix, diagonal matrix, direct product and direct sum of square matrices, block factored matrices, solving linear equations by the method of matrices; Matrix representation of symmetry operations.

### UNIT 2: Representationsof Point Groups& Corresponding Theorems (9h)

Representations of point groups - basis for a representation, representations using vectors, atomic orbitals and Cartesian coordinates positioned on the atoms of molecule ($H_2O$ as example) as bases, reducible representations and irreducible representations (IR) of point groups, construction of IR by reduction (qualitative demonstration only), Great Orthogonality Theorem (GOT) (no derivation) and its consequences, derivation of characters of IR using GOT, construction of character tables of point groups ($C_{2V}$, $C_{3V}$, $C_{2h}$ and $C_{4V}$ and $C_3$ as examples), nomenclature of IR - Mulliken symbols, symmetry species. Reduction formula - derivation of reduction formula using GOT, reduction of reducible representations, (e.g.,$\Gamma_{cart}$ ) using the reduction formula. Relation between group theory and quantum mechanics – wavefunctions (orbitals) as bases for IR of point groups.

### Unit 3: Applications of Group Theory to Molecular Spectroscopy (9h)

Molecular vibrations - symmetry species of normal modes of vibration, construction of $\Gamma_{cart}$, normal coordinates and drawings of normal modes (e.g., $H_2O$ and $NH_3$), selection rules for IR and Raman activities based on symmetry arguments, determination of IR active and Raman active modes of molecules (e.g., $H_2O$, $NH_3$, $CH_4$ , $SF_6$), complementary character of IR and Raman spectra.

Spectral transition probabilities - direct product of irreducible representations and its use in identifying vanishing and non–vanishing integrals, transition moment integral

and spectral transition probabilities.
Electronic Spectra – electronic transitions and selection rules, Laporte selection rule for centro symmetric molecules.

**Unit 4: Applications of Group Theory to Chemical Bonding (9h)**

Hybridization - Treatment of hybridization in $BF_3$ and $CH_4$, Inverse transformation and construction of hybrid orbitals. Molecular orbital theory – HCHO and $H_2O$ as examples, classification of atomic orbitals involved into symmetry species, group orbitals, symmetry adapted linear combinations (SALC), projection operator, construction of SALC using projection operator, use of projection operator in constructing SALCs for the Π MOs in cyclopropenyl ($C_3H_3^+$)cation.

**Unit 5: Chemical bonding in diatomic molecule (9h)**

Schrödinger equation for a molecule, Born – Oppenheimer approximation; Valence Bond (VB) theory – VB theory of $H_2$ molecule, singlet and triplet state functions (spin orbitals) of $H_2$; Molecular Orbital (MO) theory – MO theory of $H_2^+$ ion, MO theory of $H_2$ molecule, MO treatment of homonuclear diatomic molecules – $Li_2$, $Be_2$, $C_2$, $N_2$, $O_2$ & $F_2$ and heteronuclear diatomic molecules – LiH, CO, NO & HF, bond order, correlation diagrams, non-crossing rule; Spectroscopic term symbols for diatomic molecules; Comparison of MO and VB theories.

**Unit 6: Chemical Bonding in polyatomic molecules (9h)**

Hybridization – quantum mechanical treatment of sp, $sp^2$ & $sp^3$ hybridisation. Semi empirical MO treatment of planar conjugated molecules – Hückel Molecular Orbital (HMO) theory of ethylene, butadiene & allylic anion. Charge distribution, and bond orders from the coefficients of HMO, calculation of free valence. HMO theory of aromatic hydrocarbons (benzene); formula for the roots of the Hückel determinantal equation, Frost -Hückel circle mnemonic device for cyclic polyenes.

**Reference (for Units 1 to 4)**


1. F.A. Cotton, *Chemical applications of Group Theory*, 3rdEdition, John Wiley &Sons Inc.,2003.
2. H. H. Jaffe and M. Orchin, *Symmetry in Chemistry,* John Wiley &Sons Inc., 1965.
3. L.H. Hall, *Group Theory and Symmetry in Chemistry*, McGraw Hill, 1969.
4. R. McWeeny, *Symmetry: An Introduction to Group Theory and its Applications*, Pergamon Press, London, 1963.
5. P.H. Walton, *Beginning Group Theory for Chemistry*, Oxford University Press Inc., New York, 1998.
6. Mark Ladd, *Symmetry & Group Theory in Chemistry*, Horwood1998.
7. A. Salahuddin Kunju & G. Krishnan, *Group Theory & its Applications in Chemistry,* PHI Learning Pvt. Ltd.2010.
8. Arthur M Lesk, *Introduction to Symmetry & Group theory for Chemists*, Kluwer AcademicPublishers, 2004.
9. K.Veera Reddy, *Symmetry & Spectroscopy of Molecules 2nd Edn.,* New Age International 2009.
10. A.W. Joshi, *Elements of Group Theory for Physicists*, New Age International Publishers, 1997.


**Reference** (**for units 5 &6)**


1. F.L. Pilar, *Elementary Quantum Chemistry*, McGraw-Hill, 1968.
2. I.N. Levine, *Quantum Chemistry*, 6th Edition, Pearson EducationInc.,
3. P.W. Atkins and R.S. Friedman, *Molecular Quantum Mechanics*, 4th Edition, Oxford University Press, 2005.
4. M.W. Hanna, *Quantum Mechanics in Chemistry,* 2nd Edition, W.A. Benjamin Inc., 1969.
5. Donald, A. McQuarrie, *Quantum Chemistry*, University Science Books, 1983 (first Indian edition, Viva books, 2003).
6. Thomas Engel, *Quantum Chemistry & Spectroscopy*, Pearson Education, 2006.
7. J.P. Lowe, *Quantum Chemistry,* 2nd Edition, Academic Press Inc., 1993.
8. A.K. Chandra, *Introduction to Quantum Chemistry*, 4th Edition, Tata McGraw-Hill, 1994.
9. R.K. Prasad, *Quantum Chemistry*, 3rd Edition, New Age International, 2006.
10. C.N. Datta, *Lectures on Chemical Bonding and Quantum Chemistry*, Prism Books Pvt.Ltd.,1998

**UNIVERSITY OF CALICUT**

**M.Sc. CHEMISTRY (CSS PATTERN) - SEMESTER II**

**CHE2C06 - CO-ORDINATION CHEMISTRY (3Credits, 54h)**

**Unit 1: Stability of Co-ordination Compounds (9h)**

Stereochemistry of coordination compounds. Stepwise and overall formation constants and the relationship between them. Trends in stepwise formation constants. Determination of binary formation constants by pH-metry and spectrophotometry. Stabilization of unusual oxidation states. Ambidentate and macrocyclic ligands. Chelate effect and its thermodynamic origin. Macrocyclic and template effects.

**Unit 2: Theories of Bonding in Coordination Compounds (9h)**

Sidgwick`s electronic interpretation of coordination. The valence bond theory and its limitations. The crystal field and ligand field theories. Splitting of d-orbitals in octahedral, tetrahedral and square planar fields. Factors affecting crystal field splitting. Spectrochemical and nephelauxetic series. Racah parameters. Jahn-Teller effect. Molecular orbital theory-composition of ligand group orbitals. MO diagram of octahedral, tetrahedral and square planar complexes. Π-bonding and molecular orbital theory.

**Unit 3: Electronic Spectra and Magnetic Properties of Complexes (9h)**

Spectroscopic ground state. Terms of $d^n$ configurations. Selection rules for d-d transitions. Effect of ligand fields on RS terms in octahedral and tetrahedral complexes. Orgel diagrams. Calculation of $D_q$, B, and β parameters. Tanabe-Sugano diagrams. Charge transfer spectra.

Types of magnetic properties: Paramagnetism and diamagnetism. Curie and Curie-Weiss laws.The$\mu_J$, $\mu_{L+S}$, and $\mu_S$ expressions. Orbital contribution to magnetic moment and its quenching. Spin-orbit coupling. Temperature independent paramagnetism. Antiferromagnetism- types and exchange pathways. Determination of magnetic moment by Gouy method.

**Unit 4: Characterization of Coordination Complexes (9h)**

Infrared spectra of metal complexes. Group frequency concept. Changes in ligand vibrations on coordination- metal ligand vibrations. Application in coordination complexes. ESR spectra – application to copper complexes. NMR spectroscopy for structural studies of diamagnetic metal complexes from chemical shift and spin- spin coupling. Mossbauer spectroscopy- the Mossbauer Effect, hyperfine interactions (qualitative treatment). Application to iron and tin compounds.

**Unit 5: Reaction Mechanism of Metal Complexes (9h)**

Ligand substitution reactions. Labile and inert complexes. Rate laws. Classification of mechanisms-D, A and I mechanisms. Substitution reactions in octahedral complexes. The Eigen-Wilkins Mechanism. Fuoss-Eigen equation. Aquation and base hydrolysis- mechanism.

Substitution reactions in square planar complexes. The trans effect: Applications and theories of trans effect. The cis effect.

**Unit 6: Redox and Photochemical Reactions of Complexes (9h)**

Classification of redox reaction mechanisms. Outer sphere and inner sphere mechanisms. Marcus equation. Effect of the bridging ligand. Methods for distinguishing outer- and inner-sphere redox reactions.

Photochemical reactions of metal complexes: Prompt and delayed reactions. Excited states of metal complexes- Interligand, ligand field, charge transfer, and delocalized states. Properties of ligand field excited states. Photosubstitution-Prediction of substitution lability by Adamson`s rules. Photoaquation. Photo isomerization and photo racemization. Illustration of reducing and oxidizing character of $[Ru\ (bipy)_3]^{2+}$ in the excited state. Metal complex sensitizers- water photolysis.

**References:**


1. N.N.Greenwood and A.Earnshaw, *Chemistry of Elements, 2/e,* Butterworth-Heinemann, 2005.
2 J.E.Huheey, E.A.Keiter, R.L.Keiter and O.K.Medhi, *Inorganic Chemistry, principles of structure* and *reactivity,* Pearson Education, 2006.
3. G.L.Miessler, D.A.Tarr, *Inorganic Chemistry,* Pearson, 2010.
4. D.F.Shriver, P.W.Atkins, *Inorganic Chemistry,*Oxford University Press,2002
5. William W Porterfield, *Inorganic Chemistry-A unified approach,* Academic Press, 2005.
6 .Keith F Purcell, John C Kotz, *Inorganic Chemistry,* Cengage Learning, 2010.
7. James E House, *Inorganic Chemistry,* Academic Press, 2008.
8. B.Douglas, D.McDaniel, J.Alexander, *Concepts and Models of Inorganic Chemistry,*Wiley Student Edition,2006.
*9.* A.W.Adamson and P.D.Fleischauer, *Concepts of Inorganic Photochemistry,Wiley.*
10. F.A.Cotton and G.Wilkinson, *Advanced Inorganic Chemistry,*Wiley.
*11.* A.Earnshaw, *Introduction to Magnetochemistry, Academic Press, 1968.*
12. R.L.Dutta and A.Shyamal, *Elements of Magnetochemistry,* S.Chand and Co.1982.
*13.* A.E. Martell, *Coordination Chemistry, Vol.I*
14. R.S. Drago, *Physical Methods in Inorganic Chemistry*, Affiliated East- West Press Pvt. Ltd.,19

**UNIVERSITY OF CALICUT**

**M.Sc. CHEMISTRY (CSS PATTERN) - SEMESTER II**

## CHE2C07 - REACTION MECHANISM IN ORGANIC CHEMISTRY (3 Credits, 54h)

### Unit 1: Aliphatic and Aromatic Substitutions (9 h)

Nucleophilic Aliphatic Substitution: Mechanism and Stereochemistry of $S_N2$ and $S_N1$ reactions. Ion-pair mechanism. The effect of substrate structure, reaction medium, nature of leaving group and nucleophile on $S_N2$ and $S_N1$ reactions. $S_Ni$ and neighboring group mechanism. SET mechanism. Allylic and benzylic substitutions. Ambident nucleophiles and substrates regioselectivity.

Electrophilic Aliphatic Substitution: Mechanism and stereochemistry of $S_E1$, $S_E2$ (front), $S_E2$ (back) and $S_Ei$ reactions. The effect of substrate structure, leaving group and reaction medium on $S_E1$ and $S_E2$ reactions.

Electrophilic Aromatic Substitution: Arenium ion mechanism, substituent effect on reactivity in mono and disubstituted benzene rings, *ortho/para* ratio, *Ipso* substitution. Relationship between reactivity and selectivity. Nucleophilic Aromatic substitution: Addition- elimination ($S_NAr$) mechanism, elimination-addition (benzyne) mechanism, *cine* substitution, $S_N1$ and $S_{RN}1$ mechanism. The effect of substrate structure, nucleophile and leaving group on aromatic nucleophilic substitution.

### Unit 2: Addition & Elimination Reactions and Reactive Intermediates (9h)

#### (i) Addition and Elimination Reactions (6h)

Mechanistic and stereochemical aspects of addition to C=C involving electrophiles, nucleophiles and free radicals. Effect of substituents on the rate of addition, orientation of addition, addition to conjugated systems and cyclopropane rings, Michael reaction.

Mechanistic and stereochemical aspects of E1, E1cB and E2 eliminations. The effect of substrate structure, base, leaving group and reaction medium on elimination reactions. Saytzev *vs* Hofmann elimination, α- elimination, pyrolytic *syn* elimination (E*i*) and conjugate eliminations. Competition between substitution and elimination reactions, basicity *vs* nucleophilicity. Extrusion reactions- extrusion of $N_2$, CO and $CO_2$.

#### (ii) Reactive Intermediates (3hrs)

Reactive Intermediates: Generation, geometry, stability, and reactions of carbonium ions and carbanions, free radicals, carbenes, nitrenes and benzynes.

### Unit 3: Chemistry of Carbonyl Compounds (9h)

#### (i) Reactions of Carbon-heteromultiple Bonds (7h)

Reactivity of carbonyl compounds toward addition, mechanistic aspects of hydration,

addition of alcohols, and condensation with nitrogen nucleophiles to aldehydes and ketones. Addition of organometallic reagents- Grignard reagents- organozinc, organocopper and organolithium reagents- to carbonyl compounds. Aldol, Perkin, Claison, Dieckmann, Stobbe, and benzoin condensation. Darzen's, Knoevenagel, Reformatsky, Wittig, Cannizaro, Mannich, and Prins reactions. MPV reduction and Oppenauer oxidation.

Addition to carbon-nitrogen multiple bonds: Ritter reaction and Thorpe condensation. Hydrolysis, alcoholysis, and reduction of nitriles.

**(ii) Esterification and Ester Hydrolysis (2h):** Mechanisms of ester hydrolysis and esterification, Acyl-oxygen and alkyl oxygen cleavage.

**Unit 4: Pericyclic Reactions (9 h)**

Phase and symmetry of molecular orbitals, FMOs of ethylene, 1, 3- butadiene, 1, 3, 5- hexatriene, allyl, and 1, 3-pentadienyl systems. Pericyclic reactions: electrocyclic, cycloaddition, sigmatropic, chelotropic and group transfer reactions. Theoretical models of pericyclic reactions: TS aromaticity method (Dewar- Zimmerman approach), FMO method and Correlation diagram method (Woodward- Hoffmann approach). Woodward- Hoffmann selection rules for electrocyclic, cycloaddition and sigmatropic reactions. Stereochemistry of Diels- Alder reactions and regioselectivity. Cope and Claison rearrangements. Stereochemistry of cope rearrangement and valence tautomerism. 1, 3- dipolar cycloaddition reactions and *ene* reactions.

**Unit 5: Photochemistry of Organic Compounds (9 h)**

Photochemical excitation of molecules, spin multiplicity, Jablonski diagram, photosensitization, and quenching. Photochemistry of carbonyl compounds: Norrish type- I cleavage of acyclic, cyclic and β, γ- unsaturated carbonyl compounds, β- cleavage, γ- hydrogen abstraction: Norrish type- II cleavage, photo reduction, photoenolization. Photocyclo- addition of ketones with unsaturated compounds: Paterno- Büchi reaction, photodimerization of α, β- unsaturated ketones, Photo rearrangemets: Photo –Fries, di- π- methane, lumi ketone, oxa di- π- methane rearrangements. Barton and Hoffmann- Loeffler- Freytag reactions. Photo isomerization and dimerization of alkenes, photo isomerization of benzene and substituted benzenes, photooxygenation.

**Unit 6: Chemistry of Natural Products (9 h)**

Chemical classification of natural products. Classification of alkaloids based on ring structure, isolation and general methods of structure elucidation based on degradative reactions. Structures of atropine and quinine. Terpenoids - Isolation and classification of terpenoids, structure of steroids classification of steroids. Woodward synthesis of cholesterol,conversion of cholesterol to testosterone. Total synthesis of Longifolene, Reserpine, Cephalosporin. Introduction to flavonoids and anthocyanins (Structures only)

**References:**


1. M. B. Smith and J. March, *March's Advanced Organic Chemistry*, 6/e, John Wiley & Sons, 2007.
2. F. A. Carey and R. J. Sundburg, *Advanced Organic Chemistry, Part A & B*, 5/e, Springer, 2007.
3. E. V. Anslyn and D. A. Dougherty, *Modern Physical Organic Chemistry*, University Science Books, 2005.
4. T. H. Lowry and K. S. Richardson, *Mechanism and Theory in Organic Chemistry*, 3/e Addison- Wesley, 1998.
5. R. O. C. Norman and J. M. Coxon, *Principles of Organic Synthesis*, 3/e, CRC Press, 1998.
6. Peter Sykes, *A Guide book to Mechanism in Organic Chemistry*, 6/e, Pearson, 2006.
7. S. Sankararaman, *Pericyclic Reactions-A Textbook: Reactions, Applications and Theory*, Wiley VCH, 2005.
8. I. Fleming, *Molecular Orbitals and Organic Chemical Reactions*, Wiley, 2009.
9. J. Sing and J. Sing, *Photochemistry and Pericyclic Reactions*, 3/e, New Age International, 2012.
10. G. M. Loudon, *Organic Chemistry*, 4/e, Oxford University Press, 2008
11. M. B. Smith, *Organic Chemistry: An Acid Base Approach*, CRC Press, 2010.
12. T. Okuyama and H. Maskill, *Organic Chemistry A Mechanistic Approach*, Oxford University Press, 2014.
13. I. Fleming, *Selected Organic Synthesis*, John Wiley and Sons, 1982.
14. T. Landbery, *Strategies and Tactics in Organic Synthesis*, AcademicPress, London, 1989.
15. E. Corey and I.M. Chang, *Logic of Chemical Synthesis*, John Wiley, New York, 1989.
16. I. L. Finar, *Organic Chemistry Vol 2: Stereochemistry and the Chemistry of Natural Products*, 5/e, Pearson, 2006.
17. N. R.Krishnaswamy, *Chemistry of Natural Products: A Laboratory Hand Book*, 2/e, Universities Press

**UNIVERSITY OF CALICUT**

**M.Sc. CHEMISTRY (CSS PATTERN) - SEMESTER II**

## CHE2C08 - ELECTROCHEMISTRY, SOLID STATE CHEMISTRY AND STATISTICAL THERMODYNAMICS (3 Credits, 54h)

### Unit 1: Ionic Interaction & Equilibrium Electrochemistry (9h)

The nature of electrolytes, Ion activity, Ion-ion and ion-solvent interaction, The electrical potential in the vicinity of an ion, Electrical potential, and thermodynamic functions. The Debye-Hückele quation,Limiting and extended forms of the Debye-Hückel equation, Applications of the Debye-Hückel equation for the determination of thermodynamic equilibrium constants and to calculate the effect of ionic strength on ion reaction rates in solution.

Origin of electrode potentials-half cell potential-standard hydrogen electrode, reference electrodes- electrochemical series, applications- cell potential, Nernst equation for electrode and cell potentials, Nernst equation for potential of hydrogen electrode and oxygen electrode- thermodynamics of electrochemical cells, efficiency of electrochemical cells and comparison with heat engines. Primary cells (Zn, $MnO_2$) and secondary cells (lead acid, Ni-Cd and Ni-MH cells), electrode reactions, potentials and cell voltages, advantages and limitations three types of secondary cells.

Fuel cells; polymer electrolyte fuel cell (PEMFCs), alkaline fuel cells (AFCs), phosphoric acid fuel cells (PAFCs), direct methanol fuel cells, electrode reactions and potentials, cell reactions and cell voltages, advantages and limitations of four types of fuel cells.

### Unit 2: Dynamic Electrochemistry (9h)

Electrical double layer-electrode kinetics of electrode processes, the Butler-Volmer equation-The relationship between current density and overvoltage, the Tafel equation. Polarization: electrolytic polarization, dissolution and deposition potentials, concentration polarization; Overvoltage: hydrogen overvoltage and oxygen overvoltage. decomposition potential and overvoltage, individual electrode over voltages and its determination, metal deposition over voltage and its determination, theories of hydrogen overvoltage, the catalytic theory, the slow discharge theory, the electrochemical theory. Principles of polarography, dropping mercury electrode, the half wave potential.

### UNIT 3: Solid State – I (9h)

Crystal symmetry: Symmetry elements and symmetry operations, mathematical proof for the non-existence of 5-fold axis of symmetry, crystal systems, Bravais lattices and crystal classes, Crystallographic point groups - Schönflies& Hermann–Mauguin notations, Stereographic projections of the 27 axial point groups, translational symmetry elements & symmetry operations - screw axes and glide

planes, introduction to space groups.
Bragg's law and applications, lattice planes and Miller indices, *d*-spacing formulae, crystal densities and unit cell contents.
Imperfections in solids - point, line and plane defects, non-stoichiometry.

**UNIT 4: Solid State – II (9h)**

Electronic structure of solids: free electron theory, band theory & Zone theory, Brillouin zones; Electrical properties: electrical conductivity, Hall effect, dielectric properties, piezo electricity, ferro-electricity and ionic conductivity. Superconductivity- Meissner effect, brief discussion of Cooper theory of superconductivity. Optical properties: photo conductivity, luminescence, colour centers, lasers, refraction & birefringence. Magnetic properties: diamagnetism, paramagnetism, ferromagnetism, antiferromagnetism & ferrimagnetism. Thermal properties - thermal conductivity & specific heat

**Unit 5: Statistical Thermodynamics- I (9h)**

Fundamentals: concept of distribution, thermodynamic probability and most probable distribution, ensembles, statistical mechanics for systems of independent particles and its importance in chemistry. Thermodynamic probability & entropy, idea of microstates and macrostates, statistical weight factor (g), Sterling approximation, and Maxwell- Boltzmann statistics. The molecular partition function and its relation to the thermodynamic properties, derivation of third law of thermodynamics, equilibrium-constant &equi-partition principle in terms of partition functions, relation between molecular & molar partition functions, factorisation of the molecular partition function into translational, rotational, vibrational and electronic parts, the corresponding contributions to the thermodynamic properties; Evaluation of partition functions and thermodynamic properties for ideal mono-atomic and diatomic gases.

**Unit 6: Statistical Thermodynamics- II (9h)**

Heat capacities of solids - classical and quantum theories, Einstein's theory of atomic crystals and Debye's modification.
Quantum Statistics: Bose-Einstein distribution law, Bose-Einstein condensation, application to liquid helium. Fermi - Dirac distribution law, application to electrons in metals; Relationship between Maxwell-Boltzmann, Bose-Einstein, and Fermi-Dirac statistics.

**Reference:**

**For Units 1-4**


1. D. R. Crow, *Principles and Applications of Electrochemistry,* Chapman and Hall London, 1979.
2. J.O.M. Bockrisand A.K.N. Reddy, *Modern Electrochemistry, Vol. I and II*, Kluwer Academic / Plenum Publishers, 2000.
3. Carl. H. Hamann, A. Hamnett, W.Vielstich, *Electrochemistry 2nd edn*. , Wiley- VCH, 2007.
4. Philip H Reiger, *Electrochemistry 2nd edn*. , Chapman & Hall, 1994.
5. Praveen Tyagi, *Electrochemistry,* Discovery Publishing House, 2006.
6. D.A. McInnes, *The Principles of Electrochemistry*, Dover publications, 1961.
7. L.V. Azaroff, *Introduction to Solids*, McGraw Hill, NY, 1 960.
8. A.R. West, *Basic Solid State Chemistry 2nd edn. ,* John Wiley & Sons, 1999.
3. A.R. West, *Solid State Chemistry & its Applications,* John Wiley & Sons, 2003 (Reprint2007).
4. Charles Kittel, *Introduction to Solid State Physics, 7th edn,* John Wiley & Sons, 2004 (Reprint2009).
5. Mark Ladd, *Crystal Structures: Lattices & Solids in Stereo view*, Horwood, 1999.
6. Richard Tilley, *Crystals & Crystal Structures*, John Wiley & Sons, 2006.
7. C. Giacovazzo (ed.) *Fundamentals of Crystallography 2nd edn* ., Oxford Uty. Press, 2002.
8. Werner Massa, *Crystal Structure Determination 2nd edn*. , Springer2004.
9. N.B. Hanna, *Solid state Chemistry,* PrenticeHall


**For Units 5 & 6**


1. G.S. Rush Brooke, *Statistical mechanics,* Oxford UniversityPress.
2. T.L. Hill, *Introduction to statistical thermodynamics,* Addison Wesley.
3. K. Huary, *Statistical mechanics, Thermodynamics and Kinetics,* JohnWiley.
4. O.K.Rice, *Statistical mechanics, Thermodynamics and Kinetics,* Freeman and Co.
5. F.C. Andrews, *Equilibrium statistical mechanics,* John Wiley and sons, 1963.
6. M.C. Guptha, *Statistical Thermodynamics* , Wiley eastern Ltd.,1993

**UNIVERSITY OF CALICUT**

**M.Sc. CHEMISTRY – SEMESTER I &II**

## CHE1L01 & CHE2L04 – INORGANIC CHEMISTRY PRACTICALS– I & II (3 Credits)

### UNIT 1: Inorganic Cation Mixture Analysis

Separation and identification of four metal ions of which two are less familiar elements like W, Se Te, Mo, Ce, Th, Ti, Zr, V, U, and Li. (Eliminating acid radicals not present). Confirmation by spot tests.

### UNIT 2: Volumetric Analysis

Volumetric Determinations using:

(a) EDTA (Al, Ba, Ca, Cu, Fe, Ni, Co, hardness of water)

(b) Cerimetry ($Fe^{2+}$,nitrite)

(c) Potassium Iodate (Iodide,$Sn^{2+}$)

### UNIT 3: Colorimetric Analysis

Colorimetric Determinations of metal ions Fe, Cr, Ni, Mn, and Ti.

### References


1. G.H. Jeffery, J. Basseett, J. Mendham andR.C. Denny, *Vogel's Text book of Quantitative Chemical Analysis*, 5th Edition, ELBS, 1989.
2. D.A. Skoog and D.M. West, *Analytical Chemistry, an Introduction*, 4th Edition, CBS Publishing Japan Ltd., 1986.
3. E.J. Meehan, S. Bruckenstein and I.M. Kolthoff and E.B. Sandell, *Quantitative Chemical Analysis*, 4th Edition, The Macmillan Company,1969.
4. R.A. Day (Jr.) and A.L. Underwood, *Quantitative Analysis*, 6th Edition, Prentice Hall of India, 1993.

**UNIVERSITY OF CALICUT**

**M.Sc. CHEMISTRY – SEMESTER I &II**

**CHE1L02 & CHE2L05 – ORGANIC CHEMISTRY PRACTICALS– I & II (3 Credits)**

**Unit 1: Laboratory Techniques**

Methods of Separation and Purification of Organic Compounds: fractional, steam and low-pressure distillations, fractional crystallization and sublimation.

**Unit 2: Separation and identification of the components of organic binary mixtures. (Microscale analysis is preferred)**

Analysis of about ten binary mixtures, some of which containing compounds with more than one functional group. Separation and identification of a few ternary mixtures.

**Unit 3: Organic preparations-double stage (minimum six) and three stage (minimum two)**

**References:**


1. B.S. Furnis, A.J. Hannaford, P.W.G. Smith and A.R. Tatchell, *Vogel's Textbook of Practical Organic Chemistry*, 5/e, Pearson, 1989.
2. Shriner, FusonandCartin, *Systematic Identification of Organic Compounds*, 1964.
3. Fieser, *Experiments in Organic Chemistry*, 1957.
4. Dey, Sitaraman and Govindachari, *A Laboratory Manual of Organic Chemistry*, 3rdEdition, 1957.
5. P.R. Singh, D.C. Gupta, and K.S. Bajpal, *Experimental Organic Chemistry*, Vol. I and II, 1980.
6. Vishnoi, *Practical Organic Chemistry*.
7. Pavia, Kriz, Lampman, and Engel, *A Microscale Approach to Organic Laboratory Techniques*, 5/e, Cengage, 2013.
8. Mohrig, Hammond and Schatz, *Techniques in Organic Chemistry: Miniscale, Standard Taper Microscale and Williamson Microscale,* 3/e, W. H. Freeman and Co., 2010.

**UNIVERSITY OFCALICUT**

**M.Sc. CHEMISTRY – SEMESTER I & II**

**CHE1L03 & CHE2L06 – PHYSICAL CHEMISTRY PRACTICALS – I &II (3 Credits)**

## SECTION A

### Unit 1: Solubility and Heat of solution (minimum 2 experiments)

1. Determination of molar heat of solution of a substance (e.g., ammonium oxalate, succinic acid) from solubility data - analytical method and graphical method

### Unit 2: Phase Equilibria (minimum 3 experiments)

1. (a) Determination of phase diagram of a simple eutectic system (e.g., Biphenyl, Naphthalene- Diphenyl amine) (b) Determination of the composition of a binary solid mixture.
2. Determination of phase diagram of a binary solid system forming a compound (e.g., Naphthalene –m-dinitrobenzene).

### Unit 3: Viscosity (minimum 2 experiments)

1. Viscosity of mixtures - Verification of Kendall's equation (e.g., benzene-nitrobenzene,water-alcohol).
2. Determination of molecular weight of a polymer (e.g., polystyrene)

### Unit 4: Distribution Law (minimum 3 experiments)

1. Determination of distribution coefficient of $I_2$ between $CCl_4$ and $H_2O$.
2. Determination of equilibrium constant of $KI + I_2 = KI_3$
3. Determination of concentration of KI solution.

## SECTION B

### Unit 5: Refractometry (minimum 3 experiments)

1. Determination of molar refractions of pure liquids (e.g:water, methanol, ethanol, chloroform, carbon tetrachloride,glycerol)
2. Determination of the composition of liquid mixtures (e.g., alcohol-water, glycerol-water)
3. Determination of molar refraction and refractive index of a solid.

**Unit 6: Conductivity (minimum 4 experiments)**

1. Determination of equivalent conductance of a weak electrolyte (e.g., acetic acid), verification of Ostwald's dilution law and calculation of dissociation constant.
2. Determination of solubility product of a sparingly soluble salt (e.g., AgCl,$BaSO_4$)
3. Conductometric titrations

(a) HCl vs NaOH

(b) (HCl + $CH_3COOH$) vs NaOH

4. Determination of the degree of hydrolysis of aniline hydrochloride

**Unit 7: Potentiometry (minimum 3 experiments)**

1. Potentiometric titration: HCl vs NaOH, $CH_3COOH$ vs NaOH
2. Redox titration: KI vs $KMnO_4$, $FeSO_4$ vs $K_2Cr_2O_7$
3. Determination of dissociation constant of acetic acid by potentiometric titration
4. Determination of pH of weak acid using Potentiometry
5. Determination of pH of acids and bases using pHmeter

**Reference:**


1. A. Finlay, *Practical Physical Chemistry*, Longman's Green &Co.
2. J.B. Firth, *Practical Physical Chemistry*, Read Books (Reprint2008).
3. A.M. James, *Practical Physical Chemistry*, Longman, 1974.
4. F.Daniel,J.W.Williams,P.Bender,R.A.Alberty,C.D.CornwellandJ.E.Harriman,

*Experimental Physical Chemistry*, McGraw Hill, 1970.

5. W.G. Palmer, *Experimental Physical Chemistry*, 2nd Edition, Cambridge University Press, 1962.
6. D.P. Shoemaker and C.W. Garland, *Experimental Physical Chemistry*, McGraw-Hill.
7. J. B. Yadav, *Advanced Practical Physical Chemistry, Goel Publications*
8. 
9. , 1989.
10. B. Viswanathan & R.S. Raghavan, *Practical Physical Chemistry*, Viva Books, 2009

**UNIVERSITY OF CALICUT**

**M.Sc. CHEMISTRY (CSS PATTERN) - SEMESTER III**

**CHE3C09 - MOLECULAR SPECTROSCOPY (4 Credits, 72h)**

**Unit 1: Basic Aspects and Microwave Spectroscopy - *Theory only* (9h)**

Electromagnetic radiation & it's different regions, interaction of matter with radiation and its effect on the energy of a molecule, factors affecting the width and intensity of spectral lines. *Microwave spectroscopy* **:** Rotation spectra of diatomic and poly atomic molecules - rigid and non-rigid rotator models, asymmetric, symmetric and spherical tops, isotope effect on rotation spectra, Stark effect, nuclear and electron spin interactions, rotational transitions and selection rules, determination of bond length using microwave spectral data.

**Unit 2: Infrared, Raman and Electronic Spectroscopy - *Theory only* (9h)**

*Vibrational spectroscopy:* Normal modes of vibration of a molecule, vibrational spectra of diatomic molecules, anharmonicity, Morse potential, fundamentals, overtones, hot bands, combination bands, difference bands, vibrational spectra of polyatomic molecules, Vibration- rotation spectra of diatomic and polyatomic molecules, spectral branches -P, Q & R branches.

*Raman spectroscopy***:** Classical and Quantum theory of Raman Effect Pure rotational & pure vibrational Raman spectra, vibrational-rotational Raman spectra, selection rules, mutual exclusion principle. Introduction to Resonance Raman spectroscopy (basics only).

*Electronic Spectroscopy:* Characteristics of electronic transitions – Vibrational coarse structure, intensity of electronic transitions, Franck - Condon principle, types of electronic transitions, Dissociation and pre-dissociation, Ground and excited electronic states of diatomic molecules, Electronic spectra of polyatomic molecules, Electronic spectra of conjugated molecules.

**Unit 3: Magnetic Resonance Spectroscopy – I - *Theory only* (9h)**

*NMR:* Quantum mechanical description of Energy levels-Population of energy-Transition probabilities using ladder operators, Nuclear shielding, Chemical shift, Spin-Spin coupling and splitting of NMR signals, Quantum mechanical Description- AX and AB NMR pattern. Effect of Relative magnitudes of J (Spin-Spin coupling) and Chemical Shift on the spectrum of AB type molecule. Karplus relationship. Nuclear Overhauser Effect- FT NMR- Pulse sequence for T1 and T2 (Relaxation ) measurements. 2D NMR COSY

**Unit 4: Magnetic Resonance Spectroscopy – II - *Theory only* (9h)**

*Electron Spin Resonance*: Quantum mechanical description of electron spin in a magnetic field, Energy levels-Population- Transition probabilities using Ladder operators, g factor-hyperfine interaction, Mc Connell Relation, Equivalent and non-equivalent nucleus, g anisotropy, Zero field splitting -Kramer's theorem.

*Mossbauer Spectroscopy:* The Mossbauer Effect, hyperfine interactions, isomer shift, electric quadruple and magnetic hyperfine interactions.

**UNIT 5: Electronic & Vibrational Spectroscopy in Organic Chemistry (9h)**

*UV-Visible spectroscopy:* Factors affecting the position and intensity of electronic absorption bands – conjugation, solvent polarity and steric parameters. Empirical rules for calculating $\lambda_{max}$ of dienes, enones and benzene derivatives.

*Optical Rotatory Dispersion and Circular Dichroism:* Linearly and circularly polarized lights, circular birefringence, elipticity and circular dichroism, ORD and Cotton effect. Octant rule andaxial haloketone rule for the determination of conformation and configuration of 3-methyl cyclohexanone and *cis*- and *trans*-decalones. CD curves.

*Infrared Spectroscopy:* Functional group and finger print regions, Factors affecting vibrational frequency: Conjugation, coupling, electronic, steric, ring strain and hydrogen bonding. Important absorption frequencies of different class of organic compounds-hydrocarbons, alcohols, thiols, carbonyl compounds, amines, nitriles.

**UNIT 6: NMR Spectroscopy in Organic Chemistry - I (9h)**

$^{1}$*HNMR:* Chemical shift, factors influencing chemical shift, anisotropic effect. Chemical shift values of protons in common organic compounds, chemical, magnetic and stereochemical equivalence. Enantiotopic, diasteriotopic and homotopic protons. Protons on oxygen and nitrogen. Quadrapole broadening. Spin – spin coupling, types of coupling, coupling constant, factors influencing coupling constant, effects of chemical exchange, fluxional molecules, hindered rotation on NMR spectrum, first order and non-first order NMR spectra.

**UNIT 7: NMR Spectroscopy in Organic Chemistry - II (9h)**

Simplification of NMR spectra: double resonance, shift reagents, increased field strength, deuterium labelling. NOE spectra, heteronuclear coupling. Introduction to COSY, HMBC, HMQC spectra.

$^{13}$*C NMR:* General considerations, comparison with PMR, factors influencing carbon chemical shifts, carbon chemical shifts and structure-saturated aliphatics, unsaturated aliphatics, carbonyls, and aromatics. Off-resonance and noise decoupled spectra, Introduction to DEPT, INEPT, INADEQUATE.

**UNIT 8: Mass Spectrometry and Spectroscopy for Structure Elucidation (9h)**

*Mass Spectrometry:* Basic concept of EIMS. Molecular ion and metastable ion peaks, isotopic peaks. Molecular weight and molecular formula. Single and multiple bond cleavage, rearrangements - McLafferty rearrangements. Fragmentation pattern of some common organic compounds – saturated and unsaturated hydrocarbons, ethers, alcohols, aldehydes and ketones, amines and amides. High resolution mass spectrometry, index of hydrogen deficiency, Nitrogen rule and Rule of Thirteen. Ionization techniques. FAB spectra.

Structural determination of organic compounds using spectroscopic techniques (Problem

solving approach)

**References: For Units 1, 2, 3 & 4**


1. G.M. Barrow, *Introduction to Molecular Spectroscopy*, McGraw Hill, 1962.
2. C.N. Banwell& E. M. McCash, *Fundamentals of Molecular Spectroscopy*, Tata McGraw Hill,New Delhi,1994.
3. Thomas Engel, *Quantum Chemistry & Spectroscopy*, Pearson education, 2006.
4. P. Atkins & J. De Paula, *Atkins's Physical Chemistry,* 8th Edition, W.H. Freeman & Co., 2006.
5. D.A. McQuarrie and J.D. Simon, *Physical Chemistry - A Molecular Approach*, University Science Books, 1997.
6. D.N. Sathyanarayana, *Electronic Absorption Spectroscopy and Related Techniques*, UniversityPress, 2000.
7. R.S. Drago, *Physical methods for Chemists,* Second edition, Saunders College Publishing 1977 (For NMR and EPR,Mossbauer)
8. Gunther, NMR Spectroscopy: Basic Principles, Concepts and Applications in Chemistry,2/e,

   – John Wiley
9. Ferraro, Nakamoto and Brown, Introductory Raman Spectroscopy, 2/e, Academic Press, 2005.


**For Units 5, 6, 7 & 8**


1. Lambert, Organic Structural Spectroscopy,2/e,Pearson
2. Silverstein, Spectrometric Identification of Organic Compounds, 6/e,John Wiley
3. Pavia, Spectroscopy, 4/e, Cengage
4. Jag Mohan, Organic Spectroscopy: Principles and Applications,2/e,Narosa
5. Fleming, Spectroscopic Methods in Organic Chemistry, 6/e, McGraw-Hill
6. P S Kalsi, Spectroscopy of organic compounds, New Age International,2007
   William Kemp, Organic Spectroscopy, 3e, Palgrave, 2010

## UNIVERSITY OF CALICUT

## M.Sc. CHEMISTRY (CSS PATTERN) - SEMESTER III

## CHE3C10 - ORGANOMETALLIC AND BIOINORGANIC CHEMISTRY (4 Credits, 54h)

### Unit 1: Introduction to Organometallic Chemistry (9h)

Historical background. Classification and nomenclature. Alkyls and aryls of main group metals. Organometallic compounds of transition metals. The 18-electron rule, electron counting by neutral atom method and oxidation state method. The 16-electron rule.
Metal carbonyls- Synthesis, structure, bonding and reactions. Nitrosyl, dihydrogen and dinitrogen complexes. Transition metal to carbon multiple bond-metal carbenes and carbines.

### Unit 2: Organometallic Compounds of Linear and Cyclic π-Systems (9h)

Transition metal complexes with linear π- systems- Hapticity. Synthesis, structure, bonding and properties of complexes with ethylene, allyl, butadiene and acetylene. Complexes of cyclic π- systems-Synthesis, structure, bonding and properties of complexes with cyclobutadiene, $C_5H_5^-$ $C_6H_6$, $C_7H_7^+$ and $C_8H_8^{2-}$. Fullerene complexes. Fluxional organometallics.

### Unit 3: Organometallic Reactions and Catalysis (9h)

Organometallic reactions- ligand dissociation and substitution- Oxidative addition and reductive elimination. Insertion reactions involving CO and alkenes. Carbonylation by Collman`s reagent. Electrophilic and Nucleophilic attack on coordinated ligand.
Homogeneous and heterogeneous catalysts. Homogeneous catalysis by organometallic compounds: Hydrogenation by Wilkinson`s catalyst, Hydroformylation, Wacker process, Monsanto acetic acid process, Cativa process and olefin metathesis.
Heterogeneous catalysis by organometalic compounds: Ziegler-Natta polymerizations, Fischer- Tropsch process and water gas shift reaction.

### Unit 4: Metal Clusters (9h)

Metal-Metal bond and metal clusters. Bonding in metal-metal single, double, triple and quadruple bonded non-carbonyl clusters. Carbonyl clusters-electron count and structure of clusters. Wade-Mingos-Lauher rules. Structure and isolobal analogies. Carbide clusters. Polyatomic Zintl anions and cations. Chevrel phases.

### Unit 5: Bioinorganic Chemistry-I (9h)

Occurrence of inorganic elements in biological systems- bulk and trace metal ions.

Emergence of bioinorganic chemistry. Coordination sites in biologically important ligands. Ion transport across membranes. Role of alkali metal ions in biological systems. The sodium/potassium pump. Structural role of calcium. Storage and transport of metal ions-ferritin, transferrin and siderophores. Oxygen transport by heme proteins-hemoglobin and myoglobin-structure of the oxygen binding site-nature of heme-dioxygen binding-cooperativity. Hemerythrin and hemocyanin.

**Unit 6: Bioinorganic Chemistry-II (9h)**

Metallo enzymes and electron carrier metallo proteins. Iron enzymes: Cytochrome P-450, catalase and peroxidase. Copper enzymes: Oxidase, superoxide dismutase and tyrosinase. Lewis acid role of Zn (II) and Mn(II) containing enzymes. Carboxypeptidase. Vitamin $B_{12}$ and coenzymes. Chlorophil II- Photosystem I and II. Nitrogen fixation-Nitrogenases. Anticancer drugs.

**References:**


1. N.N. Greenwood and A. Earnshaw, *Chemistry of Elements*, 2/e, Elsevier Butterworth-Heinemann, 2005.
2. J.E. Huheey, E.A. Keiter, R.L. Keiter. O.K. Medhi, *Inorganic Chemistry, principles of structure and reactivity*, Pearson Education, 2006.
3. G.L. Miessler, D.A.Tarr, *Inorganic Chemistry,* Pearson, 2010.
4. D.F. Shriver, P.W. Atkins, *Inorganic Chemistry,* Oxford University Press,2002
5. William W Porterfield, *Inorganic Chemistry-A unified approach*, Academic Press, 2005.
6. Keith F Purcell, John C Kotz, *Inorganic Chemistry*, Cengage Learning, 2010.
7. James E House, *Inorganic Chemistry*, Academic Press, 2008.
8. B. Douglas, D. McDaniel, J. Alexander, *Concepts and Models of Inorganic Chemistry*, Wiley Student Edition, 2006.
9. F.A. Cotton and G. Wilkinson, *Advanced Inorganic Chemistry,* Wiley.
10. R.C. Mehrothra and A. Singh, *Organometallic Chemistry, A Unified Approach, W*iley Eastern.
11. P.Powell, *Principles of Organometallic Chemistry, ELBS.*
12. B.D.Gupta and A.J.Elias, *Basic Organometallic Chemistry, Concepts, Synthesis and Applications,* Universities Press, 2010.
13. Piet W.N. M.van Leeuwen, *Homogeneous Catalysis*, Springer, 2010.S.J. Lippard and J.M.Berg, *Principles of Bioinorganic Chemistry*, University ScienceBooks.
14. I. Bertini, H.B. Grey, S.J. Lippard and J.S.Valentine, *Bioinorganic Chemistry, Viva Books Pvt. Ltd., 1998.*

**UNIVERSITY OF CALICUT**

**M.Sc. CHEMISTRY (CSS PATTERN) - SEMESTER III**

## CHE3C11 - REAGENTS AND TRANSFORMATIONS IN ORGANIC CHEMISTRY (4 Credits, 54h)

### Unit 1: Oxidations (9h)

Oxidation of alcohols to carbonyls using DMSO, oxoammonium ions and transition metal oxidants (chromium, manganese, iron, ruthenium). Epoxydation of alkenes by peroxy acids, Sharpless asymmetric epoxidation, Jacobsen epoxidation, dihydroxylation of alkenes using permanganate ion and osmium tetroxide, Prévost and Woodward dihydroxylations, Sharpless asymmetric dihydroxylation. Allylic oxidation with $CrO_3$, Pyridine reagent. Oxidative cleavage of alkenes to carbonyls using $O_3$. Oxidative decarboxylation, Riley reaction, Baeyer Villiger oxidation, Dess Martin oxidation, Swern oxidation, hydroboration oxidation.

### Unit 2: Reductions (9h)

Catalytic hydrogenation of alkenes and other functional groups (heterogeneous and homogeneous), Noyori asymmetric hydrogenation, hydrogenolysis. Liquid ammonia reduction with alkali metals. Metal hydride reductions. Reduction of carbonyl group with hydrazine, p-tosylhydrazine, diimide and semicarbazide. Clemmensen reduction, Birch reduction. Wolff Kishner reduction, Bouveault Blanc reduction, MPV reduction, hydroboration, Pinacol coupling, McMurry coupling, Shapiro reaction.

### Unit 3: Synthetic Reagents (9 h)

Synthetic applications of Crown ethers, β-cyclodextrins, PTC, ionic liquids, Baker's yeast, NBS, LDA, $LiAlH_4$, $LiBH_4$, DIEA, BuLi, diborane, 9-BBN, t-butoxycarbonylchloride, DCC, Gilman's reagent, lithium dimethyl cuprate, tri-n-butyltinhydride, 1,3-dithiane, trimethyl silyl chloride, $Pb(OAc)_4$, ceric ammonium nitrate, DABCO, DMAP, DBU, DDQ, DEAD and Lindlar catalyst in organic synthesis.

### Unit 4: Chemistry of Polymers (9 h)

Classification of polymers, chain, step, free-radical and ionic polymerizations. Plastics, rubbers and fibers, thermosets and thermoplastics, linear, branched, cross -linked and network polymers, block and graft copolymers.
Natural and synthetic rubbers.

Biopolymers: Primary, secondary and tertiary structure of proteins, Merrifield solid phase peptide synthesis, Protecting groups, sequence determination of peptides and proteins, Structure and synthesis of glutathione, structure of RNA and DNA, structure of cellulose

and starch, conversion of cellulose to rayon.

**Unit 5: Heterocyclic chemistry and supramolecular chemistry (9 h)**

Aromatic and nonaromatic heterocyclics. Structure, synthesis and reactions of a few heterocyclics- aziridine, oxirane, indole, pyridine, quinolone, imidazole. Synthesis of uracil, thymine, adenine and guanine

Supramolecular Chemistry: Basic concepts and terminology. Molecular recognition: Molecular receptors for different types of cations, anions and neutral molecules, design of coreceptors and multiple recognition. Strong, weak and very weak Hydrogen bonds. Use of H bonds in in crystal-engineering and molecular recognition. Supramolecular reactivity and catalysis. Supramolecular photochemistry and examples for supramolecular devices

**Unit 6: Molecular Rearrangements and Transformations (9h)**

Rearrangements occurring through carbocations, carbanions, carbenes and nitrenes such as Wagner-Meerwein, Demjanov, dienone-phenol, benzyl-benzilic acid, Favorskii, Wolff, Hofmann, Curtius, Lossen, Schmidt, Beckmann, Fries, Bayer-Villiger, Wittig, Orton, and Fries rearrangements. Peterson reaction, Woodward and Prevost hydroxylation reactions. Heck, Negishi, Sonogashira, Stille, and Suzuki coupling reactions (mechanism only)

**References:**


1. M. B. Smith, *Organic Synthesis*, 3/e, Academic Press, 2011.
2. R. O. C. Norman and J. M. Coxon, *Principles of Organic Synthesis*, 3/e, CRC Press, 1998.
3. W. Carruthers and I. Coldham, *Modern Methods of Organic Synthesis*, 4/e, Cambridge UniversityPress.
4. R. R. Carey and R. J. Sundburg, *Advanced Organic Chemistry*, Part B, 5/e, Springer, 2007.
5. M. B. Smith, J. March, *March's Advanced Organic Chemistry*, 6/e, John Wiley & Sons, 2007.
6. J. Clayden, N. Greeves, S. Warren and P. Wothers, *Organic Chemistry*, 2/e, Oxford University Press, 2012.
7. J. J. Li, *Name Reactions*, 4/e, Springer, 2009.
8. V. K. Ahluwalia and R. Aggarwal, *Organic Synthesis: Special Techniques*, 2/e, Narosa Publishing House, 2006.
9. G. Odiyan, *Principles of Polymerisation*, 4/e, Wiley, 2004.
10. V.R. Gowariker and Others, *Polymer Science*, Wiley EasternLtd.
11. I.L. Finar, *Organic Chemistry*, Vol. II, 5/e, ELBS, 1975.
12. J. A. Joules and K. Mills, *Heterocyclic Chemistry*, 4/e, Oxford University Press, 2004.
13. T. L. Gilchrist, *Heterocyclic Chemistry*, 3/e, Pearson, 1997.
14. T. H. Lowry and K. S. Richardson, *Mechanism and Theory in Organic Chemistry*, 3/e Addison-Wesley, 1998.
15. F. Vogtle, *Supramolecular Chemistry*, John Wiley & Sons, Chichester, 1991.
16. J.M.Lehn, *Supramolecular Chemistry*,VCH.

**UNIVERSITY OF CALICUT**

**M.Sc. CHEMISTRY (CSS PATTERN) - SEMESTER III**

**CHE3E01 - SYNTHETIC ORGANIC CHEMISTRY (ELECTIVE) (4 Credits, 54h)**

### Unit 1: Reagents for Oxidation and Reduction (9h)

Reagents for oxidation and reduction: Oxone, IBX, PCC, osmium tetroxide, ruthenium tetroxide, selenium dioxide, molecular oxygen (singlet and triplet), peracids, hydrogen peroxide, aluminum isopropoxide, periodic acid, lead tetraacetate. Wacker oxidation, TEMPO oxidation, Swern oxidation, Woodward and Prevost hydroxylation, Sharpless asymmetric epoxidation.
Catalytic hydrogenations (heterogeneous and homogeneous), metal hydrides, Birch reduction, hydrazine and diimide reduction.

### Unit 2: Organometallic and Organo-nonmetallic Reagents (9h)

Synthetic applications of organometallic and organo-nonmetallic reagents. Reagents based on chromium, nickel, palladium, silicon, and born, Gilman reagent, phase transfer catalysts, hydroboration reactions, synthetic applications of alkylboranes. Gilman's reagent, Tri -n-butyl tin hydride, Benzene TricarbonylChromium

### Unit 3: Chemistry of Carbonyl Compounds (9h)

Chemistry of carbonyl compounds: Reactivity of carbonyl groups in aldehydes, ketones, carboxylic acids, esters, acyl halides, amides. Substitution at α-carbon, aldol and related reactions, Claisen, Darzen, Dieckmann, Perkin, Prins, Mannich, Stork-enamine reactions. Conjugate additions, Michael additions and Robinson annulation. Reaction with phosphorous and sulfurylides.
Protecting groups, functional group equivalents, reversal of reactivity (Umpolung), Introduction to combinatorial chemistry.

### Unit- 4. Coupling Reactions (9h)

Coupling Reactions: PalladiumCatalysts for C-N and C-O bond formation, Palladium catalyzed amine arylation (Mechanism and Synthetic applications). Sonogashira cross coupling reaction (Mechanism, Synthetic applications in cyclic peptides) Stille carbonylative cross coupling reaction (Mechanism and synthetic applications). Mechanism and synthetic applications of Negishi, Hiyama, Kumada, Heck and Suzuki-Miyaura coupling reactions.

### Unit 5: Multi step Synthesis (9h)

Multi step Synthesis**:** Synthetic analysis and planning, Target selection, Elements of a Synthesis (Reaction methods, reagents, catalysts, solvents, protective groups for hydroxyl, amino, Carbonyl and carboxylic acids, activating groups, leaving groups synthesis and synthetic equivalents. Types of selectivities (Chemo, regio, stereo selectivities) synthetic planning illustrated by simple

molecules, disconnections and functional group interconversions, umpolung reactions and use in synthesis. Introduction to retrosynthetic analysis, Synthesis of longifolene, Corey lactone, Djerassi Prelog lactone

**Unit 6: Retro Synthetic Analysis and Heterocyclics (9h)**

Retrosynthesis: General principles of retrosynthetic analysis. Synthons and reagents, donor and acceptor synthons, umpolung, protecting group chemistry and functional group interconversions. One group and two group C-X and C-C disconnections, functional group transposition. Examples for a few retrosynthetic analyses- paracetamol from phenol, benzocain from toluene and propranolol from 1-naphthol.
Structure, synthesis and reactions of fused ring heterocycles: Benzofuran, Indole, Benzothiophene, Quinoline, Benzoxazole, Benzthiazole, Benzimidazole, Triazoles, Oxadiazoles and Tetrazole. Structure and synthesis of Azepines, Oxepines, Thiepins, Diazepines and Benzodiazepines Structure and synthesis (Reichstein process) of Vitamin C (Reichstein process).

**References:**


1. M. B. Smith, *Organic Synthesis*, 3/e, Academic Press, 2011.
2. S. Warren and P. Wyatt, *Organic Synthesis: Strategy and Control*, John Wiley
3. S. Warren: *Organic Synthesis: The Disconnection Approach*, JohnWiley
4. H. O. House: *Modern Synthetic Reactions*, W. A.Benjamin
5. W. Carruthers and I. Coldham, *Modern Methods of Organic Synthesis*, 4/e, Cambridge UniversityPress.
6. T. W. Greene and P. G. M. Wuts: *Protecting Groups in Organic Synthesis*, 2nd ed., John Wiley
7. MBSmithandJ.March:*AdvancedOrganicChemistry-Reactions,MechanismsandStructure,* 6th ed., John Wiley
8. T. H. Lowry and K. S. Richardson: *Mechanism and Theory in Organic Chemistry*, 3rded.
9. R. R. Carey and R. J. Sundburg, *Advanced Organic Chemistry*, Part A and B, 5/e, Springer, 2007
10. A. Pross: *Theoretical and Physical Principles of Organic Chemistry*, JohnWiley
11. T.W. Graham Solomons: *Fundamentals of Organic Chemistry*, 5th ed., JohnWiley
12. I. L. Finar: *Organic Chemistry* Volumes 1 (6th ed.),Pearson
13. J. Clayden, N. Green, S. Warren and P. Wothers: *Organic Chemistry*, 2/e, Oxford University Press
14. J. J. Li, *Name Reactions*, 4/e, Springer, 2009.
15. N. K. Terret: *Combinatorial Chemistry*, Oxford University Press, 1998.

**UNIVERSITY OF CALICUT**

**M.Sc. CHEMISTRY (CSS PATTERN) - SEMESTER III**

**CHE3E02 - COMPUTATIONAL CHEMISTRY (ELECTIVE) (4credits, 54 h)**

**Unit 1: Introduction to Computational Chemistry (9 h)**

Theory, computation & modeling – Definition of terms. Need of approximate methods in quantum mechanics. Computable Quantities – structure, potential energy surfaces and chemical properties. Cost & Efficiency – relative CPU time, software & hardware. Classification of computational methods.

**Unit 2: Computer Simulation Methods- I (9 h)**

Introduction – molecular dynamics and Monte Carlo methods, calculation of simple thermodynamic properties - energy, heat capacity, pressure and temperature, phase space, practical aspects of computer simulation, periodic boundary conditions, Monitoring the equilibration, analyzing the results of a simulation, error estimation.

**Unit 3: Computer Simulation Methods- II (9 h)**

Molecular dynamics (MD) method – molecular dynamics using simple models – MD with continuous potentials, finite difference methods, choosing the time step, setting up and running a MD simulation. Monte Carlo (MC) method - calculating properties by integration, Metropolis method, random number generators, MC simulation of rigid molecules.

**UNIT 4: ab intio Methods in Computational Chemistry (9h)**

Review of Hartree – Fock method for atoms, SCF treatment of polyatomic molecules; Closed shell systems - restricted HF calculations; Open shell systems – ROHF and UHF calculations; The Roothan – Hall equations, Koopmans theorem, HF limit & electron correlation, Introduction to electron correlation (post -HF) methods.

**UNIT 5: Density Functional Methods (9 h)**

Introduction to density matrices, N-reprentability & V-represetability problems, Hohenberg – Kohn theorems, Kohn-Sham orbitals, Exchange correlation functionals– Thomas-Fermi-Dirac model, Local density approximation, generalised gradient approximation, hybrid functional. Comparison between DFT and HF methods.

**UNIT 6: Basis Set Approximation (9 h)**

Hydrogen-like, Slater-type & Gaussian type basis functions, classification of basis sets – minimal, double zeta, triple zeta, split-valence, polarization & diffuse basis sets, even tempered &well-tempered basis sets, contracted basis sets, Pople-style basis sets and their

nomenclature, correlation consistent basis sets, basis set truncation error, effect of choice of method/ basis set (model chemistries) on cpu time.

**References:**


11. C. J. Cramer, *Essentials of computational Chemistry: Theories and models*, John Wiley & Sons 2002.
12. Frank Jensen, *Introduction to Computational Chemistry,* John Wiley & Sons LTD1999.
13. J. Foresman &Aelieen Frisch, *Exploring Chemistry with Electronic Structure Methods*, Gaussian Inc., 2000.
14. David Young, *Computational Chemistry- A Practical Guide for Applying Techniques to Real- World Problems"*, Wiley -Interscience, 2001.
15. Errol G. Lewars, *Computational Chemistry: Introduction to the theory and applications of molecular quantum mechanics,* 2 nd edn, Springer2011.
16. I.N. Levine, *Quantum Chemistry*, 6th Edition, Pearson Education Inc., 2009.
17. P.W. Atkins & R.S. Friedman, *Molecular quantum mechanics*, 4th Edition, Oxford University Press, 2005.
18. W. Koch, M.C. Holthausen, *"A Chemist's Guide to Density Functional Theory"*, Wiley-VCH Verlag2000.

**UNIVERSITY OF CALICUT**

**M.Sc. CHEMISTRY (CSS PATTERN) - SEMESTER III**

**CHE3E03- GREEN AND NANOCHEMISTRY (ELECTIVE)**

**(4credits, 54 h)**

**Unit I: Introduction to green chemistry (9h)**

Green chemistry-relevance and goals, Anastas' twelve principles of green chemistry - Tools of green chemistry: alternative starting materials, reagents, catalysts, solvents and processes with suitable examples.

**UNIT-2: Microwave mediated organic synthesis (MAOS) (9h)**

Microwave activation, advantage of microwave exposure, specific effects of microwave – Neat reactions, solid supports reactions, Functional group transformations, condensations reactions, oxidations – reductions reactions, multi-component reactions.

**Unit 3: Alternative synthesis, reagents and reaction conditions (9h)**

Introduction, synthesis of ionic liquids, physical properties, applications in alkylation – hydroformylations , expoxidations , synthesis of ethers, Friedel-craft reactions, Diels-Alder reactions , Knoevengal condensations, Wittig reactions, Phase transfer catalyst - Synthesis – applications. A photochemical alternative to Friedel-crafts reactions - Dimethyl carbonate as a methylating agent – the design and applications of green oxidants – super critical carbon dioxide for synthetic chemistry.

**Unit 4: Nanomaterials – An Introduction & Synthetic Methods (9h)**

Definition of nano dimensional materials - Historical milestones - unique properties due to nanosize, Quantum dots, Classification of Nanomaterials .General methods of synthesis of nanomaterials – Hydrothermal synthesis, Solvothermal synthesis, Microwave irradiation, sol – gel and Precipitation technologies, Combustion Flame-Chemical Vapor Condensation Process, gas Phase Condensation Synthesis, Reverse Micelle Synthesis, Polymer – Mediated Synthesis, Protein Microtube – Mediated Synthesis. Synthesis of Nanomaterials using microorganisms and other biological agents, Sonochemical Synthesis, Hydrodynamic Cavitation. Inorganic nanomaterials – Typical examples –nano TiO2 / ZnO/CdO/CdS, Organic nanomaterials – examples – Rotaxanes and Catenanes

**Unit 5: Techniques for Characterisation of nanoscale materials (9h)**

Principles of Atomic force microscopy (AFM), Transmission electron microscopy (TEM)-Resolution and scanning transition electron microscopy (STEM), Scanning Tunneling Microscopy (STM), Scanning near field optical microscopy (SNOM), Scanning ion

conductance microscope, scanning thermal microscope, scanning probe microscopes and surface plasmon spectroscopy.

**Unit 6: Carbon Clusters and Nanostructures (9h)**

Nature of carbon bond, new carbon structures. Carbon clusters: Discovery of C60, Alkali doped C60, Superconductivity in C60, Larger and smaller fullerenes. Carbon nanotubes: Synthesis, Single walled carbon nanotubes, Structure and characterization, Mechanism of formation. Chemically modified carbon nanotubes, Doping - Functionalizing nanotubes. Application of carbon nanotubes. Nanowires: Synthetic strategies, Gas phase and solution phase growth, Growth control - Properties.

**References:**

**For Units 1, 2 & 3**


1. V. K. Ahluwalia, *Green Chemistry – Environmentally benign reactions,* AneBooks India (Publisher), (2006).
2. V. K. Ahluwalia, *Green Chemistry: A Textbook,* Narosa Publishing House, 2013.
3. *Green Chemistry – Designing Chemistry for the Environment* – edited by Paul T. Anastas& Tracy C. Williamson. Second Edition, (1998).
4. *Green Chemistry–Frontiersinbenignchemicalsynthesisandprocesses*-edited by Paul T. Anastas & Tracy C. Williamson. Oxford University Press, (1998).
5. *Green Chemistry – Environment friendly alternatives*- edited by Rashmi Sanghi& M. M. Srivastava, Narora Publishing House, (2003).


**For Units 4, 5 & 6**


1. C.N.R. Rao, A. Muller, A.K. Cheetam (Eds), *The Chemistry of Nanomaterials*, Vol.1, 2, Wiley –VCH, Weinheim, 2004.
2. C.P. Poole, Jr: F.J. Owens, *Introduction to Nanotechnology* Wiley Interscience, New Jersey, 2003
3. Kenneth J. Klabunde (Ed), *Nanoscale materials in Chemistry*, Wiley- Interscience, New York, 2001.
4. T. Pradeep, *Nano: The Essentials in understanding nanoscience and nanotechnology*, Tata McGraw Hill, New Delhi, 2007.
5. H. Fujita (Ed.), *Micromachines as tools in nanotechnology*, Springer- Verlag, Berlin, 2003.
6. Bengt Nolting, *Methods in modern biophysics*, Springer-Verlarg, Berlin, First Indian Reprint, 2004. (Pages 102-146 for Unit II and 147 – 163 for UnitV)
7. H. Gleiter, *Nanostructured Materials: Basic Concepts, Microstructure and Properties*
8. W. Kain and B. Schwederski, *Bioinorganic Chemistry: Inorganic Elements in the Chemistry of Life*, John-Wiley R Sons, NewYork.
9. T. Tang and p. Sheng (Eds), *Nano Science and Technology Novel Structures*

*andPhenomena*,

Taylor & Francis, New York, 2004.

10. A. Nabok, *Organic and Inorganic Nanostructures*, Artech House, Boston, 2005.

11. Edward A. Rietman, *Molecular engineering of Nanosystems*, Springer- Verlag, New York, 2001.

12. Home page of Prof. Ned Seeman -http://seemanlab4.chem.nyu.edu/

Nano letters - http://pubs.acs.org/journals/nalefd/index.html Nanotation - http://www.acsnanotation.org/

**UNIVERSITY OF CALICUT**

**M.Sc. CHEMISTRY (CSS PATTERN) - SEMESTER IV**

**CHE4C12- INSTRUMENTAL METHODS OF ANALYSIS (4 Credits, 72 h)**

**Unit 1**: **Errors in Chemical Analysis (9h)**

Treatment of analytical data. Accuracy and precision. Absolute and relative errors. Classification and minimization of errors. Significant figures. Statistical treatment- mean and standard deviation, variance, confidence limits, student-t and f tests. Detection of gross errors, rejection of a result-Q test. Least square method, linear regression; covariance and correlation coefficient

**Unit 2**: **Conventional Analytical Procedures (9h)**

Gravimetry: **s**olubility product and properties of precipitates-nucleation, growth and aging, co- precipitation and post precipitation, drying and ignition. Inorganic precipitating agents: $NH_3$, $H_2S$, $H_2SO_4$, $(NH_4)_2MoO_4$ and $NH_4SCN$. Organic precipitating agents: oxine, cupron, cupferron, 1-nitroso-l-naphthol, dithiocarbamates. Acid-Base and precipitation titrations: theory of neutralisation titrations, indicators for acid/base titrations, titration curves of strong acid, strong base, weak acid, weak base and polyprotic acids. Buffer solutions. Titrations in nonaqueous media. Different solvents and their selection for a titration. Indicators for non-aqueous titrations. Redox titrations: Permanganometry, dichcrometry, iodometry, cerimetry. Variation of potential during a redox titration, formal potential during a redox titration, Redox indicators. Precipitation titrations, adsorption indicators. Complexometric titrations: Types of EDTA titrations (direct, back, replacement, alkalimetric and exchange reactions), masking and demasking agents, selective demasking, metal ion indicators - murexide, eriochrome black T, Patton and Reeder's indicators, bromopyrogallol red, xylenol orange, variamine blue.

**Unit 3: Electro Analytical Methods- I (9h)**

Potentiometry: techniques based on potential measurements, direct potentiometric systems, different types of indicator electrodes, limitations of glass electrode, applications in pH measurements, modern modifications, other types of ion selective electrodes, solid, liquid, gas sensing and specific types of electrodes, biomembrane, biological and biocatalytic electrodes as biosensors, importance of selectivity coefficients. Polarography micro electrode and their specialities, potential and current variations at the micro electrode systems, conventional techniques for concentration determination, limitations of detection at lower concentrations, techniques of improving detection limit-rapid scan, ac, pulse, differential pulse square wave polarographic techniques. Applications of polarography.

**Unit 4 Electro Analytical Methods II (9h)**

Amperometry: biamperometry, amperometric titrations. Coulometry-primary and secondary

coulometry, advantages of coulometric titrations, applications. Principle of chronopotentiometry. Anodic stripping voltammetry-different types of electrodes and improvements of lower detection limits. Voltammetric sensors. Organic polarography.

**Unit 5 Optical Methods - I (9 h)**

Fundamental laws of spectrophotometry, nephelometry and turbidometry and fluorimetry. UV- visible and IR spectrophotometry – instrumentation, single and double beam instruments, Spectrophotometric titrations. Atomic emission spectrometry – excitation sources (flame, AC and DC arc), spark, inductively coupled plasma, glue discharge, laser microprobes, flame structure, instrumentation, and qualitative and quantitative analysis. Atomic absorption spectrometry: sample atomization techniques, instrumentation, interferences, background correction, and analytical applications.

**Unit 6 Optical Methods - II (9 h)**

Theory, instrumentation and applications of: - Atomic fluorescence spectrometry, X-ray methods- X-ray absorption and X-ray diffraction, photoelectron spectroscopy, Auger, ESCA. SEM, TEM, and AFM

**Unit 7**: **Thermal and Radiochemical Methods (9h)**

Thermogravimetry (TG), Differential Thermal Analysis(DTA) and Differential Scanning Calorimetry(DSC) and their instrumentation. Thermometric Titrations. Measurement of alpha, beta, and gamma radiations, neutron activation analysis and its applications. Principle and applications of isotope dilution methods.

**Unit 8: Chromatography (9 h)**

Chromatography-classification, column, paper and thin layer chromatography. HPLC-outline study of instrument modules. Ion – exchange chromatography-Theory. Important applications of chromatographic techniques. Gel Permeation Chromatography. Gas chromatography – basic instrumental set up-carriers, columns, detectors and comparative study of TCD, FID, ECD and NPD. Qualitative and quantitative studies using GC, Preparation of GC columns, selection of stationary phases of GLC, Gas adsorption chromatography, applications, CHN analysis by GC.

**References:**


1. J.M. Mermet, M. Otto, R. Kellner, *Analytical Chemistry*, Wiley-VCH, 2004.
2. D.A. Skoog, D.M. West, F.J. Holler, S.R. Crouch, *Fundamentals of Analytical Chemistry*,
    a. 9th Edn ., Cengage Learning., 2014.
3. J.G. Dick, *Analytical Chemistry*, R.E. Krieger Pub.,1978.50
4. J.H. Kennedy, *Analytical Chemistry: Principles*, Saunders College Pub., 1990.
5. G.H. Jeffery, J. Bassett, J. Mendham, R.C. Denney, *Vogel's Text Book of Quantitative Chemical Analysis*, 5th Edn., John Wiley& sons,1989.
6. C.L. Wilson, D.W. Wilson, *Comprehensive Analytical Chemistry*, Elsevier, 1982.
7. G.D. Christian, J.E. O'Reilly, *Instrumental Analysis*, Allyn & Bacon, 1986.
8. R.A. Day, A.L. Underwood, Quantitative Analysis, Prentice Hall, 1967.
9. A.I. Vogel, *A Textbook of Practical Organic Chemistry*, 5/e Pearson, 1989.
10. H.A. Laitinen, W.E. Harris, *Chemical Analysis*, McGraw Hill, 1975.
11. V.K. Ahluwalia, *Green Chemistry: Environmentally Benign Reactions*, CRC, 2008.
12. F.W. Fifield, D. Kealey, *Principles and Practice of Analytical Chemistry*, Blackwell Science, 2000.
13. G.Gringauz, *Introduction to Medical Chemistry*, Wiley-VCH, 1997.
14. Harkishan Singh and V.K.Kapoor, *Medicinal and Pharmaceutical Chemistry*, Vallabh Prakashan, 2008.
15. W.Bannwarth and B.Hinzen, *Combinatorial Chemistry-From Theory to Application, 2nd*
    a. Edition, Wiley-VCH, 2006.
16. A.W.Czarnik and S.H.DeWitt, *A Practical Guide to Combinatorial Chemistry*, 1st Edition, American Chemical Society, 1997.
17. Bansal N K, Kleeman M and Mells M, *Renewable Energy Sources and Conversion Technology*, Tata McGraw-Hill. (1990)
18. Kothari D.P., *"Renewable energy resources and emerging technologies",* Prentice Hall of India Pvt. Ltd., 2008.
19. Rai G.D, *"Non-Conventional energy Sources",* Khanna Publishers, 2000.
20. Michael Grätzel, *J. Photochemistry and Photobiology C: Photochemistry Reviews* 4 (2003) 145–153, *Solar Energy Conversion by Dye-Sensitized Photovoltaic Cells*, Inorg. Chem., Vol. 44, No. 20, 2005 6841-6851.
21. Yoshihiro Hamakawa, Thin-Film Solar Cells-Next *Generation Photovoltaics and Its Applications*, Springer Series in Photonics 13, 2008

## UNIVERSITY OF CALICUT

## M.Sc. CHEMISTRY (CSS PATTERN) - SEMESTER IV

### CHE4E04 - PETROCHEMICALS AND COSMETICS (ELECTIVE) (4Credits, 72h)

#### Unit 1: Introduction to Petrochemistry (9h)

Introduction. Petroleum. Refining of crude oil. Fuels for internal combustion engines. Knocking, Octane number. Unleaded petrol. Diesel Engine and Cetane number. Cracking. Thermal, Catalytic. Mechanism of cracking process. Reforming Activation Gasoline. Petrochemicals.

#### Unit 2: Hydrocarbons from Petroleum (9h)

Introduction. Raw materials. Saturated hydrocarbons from natural gas. Uses of saturated hydrocarbons. Unsaturated hydrocarbons – Acetylene, Ethylene, Propylene, Butylenes. Aromatic hydrocarbons - Benzene. Toluene. Xylenes. Chemical processing of paraffin hydrocarbons. Chemical processing of ethylene hydrocarbons. Chemical processing of acetylene. Chemical processing of aromatic hydrocarbons.

#### Unit 3: Industrial Organic Synthesis (9h)

Introduction. The raw materials and basic processes. Chemical process used in industrial organic synthesis. Petrochemicals- Methanol. Important points. Ethanol. Important points. Rectified spirit from beer. Methylated spirit. Proof spirit. Preparation of the absolute alcohol from rectified spirit. Acetaldehyde. Acetic acid. Isopropanol. Ethylene glycol. Glycerine. Acetone. Phenol. Formaldehyde. Important points. Ethyl acetate. Important points.

#### Unit 4: Composition of Petroleum Crude (9h)

Composition of petroleum crude. Composition of the petroleum products. Isomeric compounds. Classification of petroleum crude. A survey of the world crude. Sulphur compounds in petroleum. Physical Properties and Test Methods. 1. Viscosity: Other methods for finding out viscosity. Viscosity of an oil blend. Use of the figure for finding out viscosity. Viscosities of hydrocarbons. 2. Density, 3. Surface and interfacial tensions. 4. Refractive Index. 5. Flash and fire points. 6. Cloud and pour points. 7. Aniline point. 8. Diesel index. 9. Cetane number. 10. Octane number and knock characteristics. 11. Distillation curves. (a) ASTM (American Society for Testing Materials) distillation curve. (b). Hempel or semi fractionating distillation curve.

#### Unit 5: Distillation of Crude Petroleum (9h)

Preparation of petroleum for processing. Destruction of petroleum emulsion. Electric desalting plants. Fundamentals of preliminary distillation. Methods of petroleum distillation. Distillation of crude petroleum. Treatment of the residual liquid processing of liquid fuels such as petroleum and petroleum products. Petroleum processing equipments. Storage tanks.

Rectification columns. Cap tray or bubble tray columns. Heat exchange apparatus. Steam space heaters or boilers. Condensers. Pipe furnaces. Pipelines. Fitting Compressors and pumps.

**Unit 6: Petroleum Products (9h)**

Introduction. Classification of petroleum products. Liquefied hydrocarbons, gases and fuels. Fuel oils or boiler oils. Fuel for Jet engines and gas turbine engines. Lubricants, products of oil paraffine processing and other petroleum products. Lubricating and other oils. Paraffins, ceresins, petroleum. Miscellaneous petroleum products. Products of petrochemical and basic organic synthesis. Dye intermediates. Lacquers. Solvents. Thinners.

**Unit 7: Purification of Petroleum Products (9h)**

Absorptive and adsorptive purification. Sulphuric acid purification. Alkaline purification. Hydrorefining. Purification in a DC electric field. New methods of purification. De mercaptanisation. Stabilisation.

**Unit 8: Perfumes and Cosmetics (9h)**

**Perfumes:** Introduction. Esters. Alcohols. Ketones. Ionones. Nitromusks. Aldehydes. Diphenyl compounds. Production of natural perfumes. Flower perfume. Fruit flavours. Artificial flavours.

**Cosmetics:** Introduction. Toothpaste. Ingradients. Preparation. Recipe for toothpaste. Shampoos. Ingradients. Recipe. Hair dyeing. Materials used. Colour and Curl of Hair. Creams and Lotions. Skin Chemicals. Their ingradients. Preparation and recipe. Lipsticks. Ingradients. Preparation and recipe. Perfumes, Colognes and after shave preparation. Compounds with flowery and fruity odours used in perfumes with their structures. Compounds with unpleasant odours used to fix delicate odours in perfumes. Deodorants and Antiperspirants.

Cosmetics: Economics and Advertising.

**References:**


1. B. K. Sharma, *Industrial Chemistry*, Goel Publication, Goa.
2. N. K. Sinha, *Petroleum Refining and petrochemicals*,
3. John W. Hill, *Chemistry for Changing times*, Surjeet Publication
4. Uttam Ray Chaudhuri, *"Fundamentals of Petroleum and Petrochemical Engineering",* Boca Raton London New York.
5. S ukumar Maiti, *"Introduction to Petrochemicals"* India Book House Pvt Ltd.
6. Gabriella Baki, Kenneth S. Alexander, *"Introduction to Cosmetic Formulation and Technology",* Wiley.
7. Tony Curtis, David Williams, *"Introduction to Perfumery",* Micelle Press; 2nd edition

**UNIVERSITY OF CALICUT**
**M.Sc. CHEMISTRY (CSS PATTERN) - SEMESTER IV**

## CHE4E05 - INDUSTRIAL CATALYSIS (ELECTIVE) (4 Credits, 72h)

### Unit 1: Introduction to Adsorption process (9h)

Intermolecular interactions, physisorption. The forces of adsorption. Dispersion and repulsive forces. Classical electrostatic interactions. Adsorbate-adsorbate interactions, chemisorption, potential energy curves, thermodynamics of adsorption. Isothermal and adiabatic heats of adsorption. Variation of heats of adsorption with coverage. Adsorption isotherms, Langmuir, BET and Freundlich. Kinetics of chemisorptions. Activated and non-activated chemisorptions. Absolute rate theory. Electronic theories. Hysteresis and shapes of capillaries.

### Unit 2: Kinetics and Catalysis (9h)

Adsorption and catalysis. Adsorption and reaction rate. Strength of adsorption bond and catalysis. Adsorption equilibrium and catalysis. Kinetics of heterogeneous catalysis: diffusion steps neglected. Unimolecular reactions. Bimolecular reactions. Langmuir-Hinshelwood and Eley-Rideal mechanism. Kinetics of heterogeneous catalysis: diffusion controlling. Mechanism of diffusion. Diffusion and reaction in pores. Selectivity and diffusion. Electronic factors in catalysis by metals, electronic factors in catalysis by semiconductors, geometric factors and catalysis.

### References:


1. A. Clark, *"Theory of adsorption and catalysis",* Academic Press, 1970.
2. J.M. Thomas & W.J. Thomas, *"Introduction to principles of heterogeneous catalysis",* Academic Press, New York, 1967.
3. R.H.P. Gasser, *"An introduction to chemisorption and catalysis by metals",* Oxford, 1985.
4. D.K Chakraborthy, *"Adsorption and catalysis by solids",* Wiley Eastern Ltd. 1990.


### Unit 3: Catalyst - Preparative Methods (9h)

Surface area and porosity measurement. Measurement of acidity of surfaces. Support materials. Preparation and structure of supports. Surface properties. Preparation of catalysts. Introduction of precursor compound. Pre-activation treatment. Activation process. General methods of synthesis of zeolites. Mechanism of nuclear formation and crystal growth. Structures of some selected zeolites. Zeolites A, X and Y. Pentasils. ZSM-5. ZSM-11. Shape selective catalysis by zeolites.

**Unit 4: Deactivation of Catalysts (9h)**

Deactivation of catalysts. Classification of catalyst deactivation processes. Poisoning of catalysts. Coke formation on catalysts. Metal deposition on catalysts. Sintering of catalysts. Regeneration of deactivated catalysts. Feasibility of regeneration. Description of coke deposit and kinetics of regeneration.

**References:**


1. J.R. Anderson and M. Boudart (Eds), *"Catalysis, Science and Technology",* Vol 6, Springer- Verlag, Berlin Heildberg, 1984.
2. R.B. Anderson, *"Experimental methods in catalysis research",* Vol I, II, Academic press, NY, 1981.
3. R. Szostak, *"Molecular sieves: principles of synthesis and identification*", Van Nostrand, NY, 1989.
4. R. Hughes*, "Deactivation of catalysts",* Academic press, London, 1984.


**UNIT 5: Phase Transfer Catalysis (9h)**

Basic concepts in phase transfer catalysis. Phase transfer catalyzed reactions. Basic steps of phase transfer catalysis. Effect of reaction variables on transfer and intrinsic rates. Outline of compounds used as phase transfer catalysts. Use of quaternary salts. Macrocyclic and macrobicyclic ligands. PEG's and related compounds. Use of dual phase transfer catalyst or co-catalyst in phase transfer systems. Separation and recovery of phase transfer catalysts. Insoluble phase transfer catalysts.

**UNIT 6: Biocatalysis (9h)**

Enzymes. An introduction to enzymes. Enzymes as proteins. Classification and nomenclature of enzymes. Structure of enzymes. How enzymes work. Effect on reaction rate. Thermodynamic definitions. Catalytic power and specificity of enzymes. Optimization of weak interactions between enzyme and substrate in the transition state. Binding energy, reaction specificity and catalysis. Specific catalytic groups contributing to catalysis. Immobilized biocatalysts. Definition and classification of immobilized biocatalysts. Immobilization of coenzymes.

References:


1. C.M. Starks, C.L. Liotta and M. Halpern, *"Phase Transfer Catalysis – Fundamentals, Applications and Industrial Perspectives"*, Chapman & Hall, New York, 1994.
2. A.L. Lehninger, *"Principles of Biochemistry",* Worth Publishers, USA, 1987.


**UNIT 7: Industrial Catalysis-1 (9h)**

Oil based chemistry. Catalytic reforming. Catalytic cracking. Paraffin cracking. Naphthenic cracking. Aromatic hydrocarbon cracking. Isomerization. Hydrotreatment.

Hydrodesulphurization. Hydrocracking. Steam cracking. Hydrocarbons from synthesis gas. Fisher-Tropsch process. Mobil process for conversion of methanol to gasoline hydrocarbons. Catalysis for environmental protection, removal of pollutants from exhausts, mobile and static sources.

**UNIT 8: Industrial Catalysis-II (9h)**

Hydroformylation of olefins. Carbonylation of organic substrates. Conversion of methanol to acetic acid. Synthesis of vinyl acetate and acetic anhydride. Palladium catalyzed oxidation of ethylene. Acrylonitrile synthesis. Zeigler-Natta catalysts for olefin polymerization. Propene polymerization with silica supported metallocene/MAO catalysts.

**References:**


1. G. Ertl, H. Knozinger and J. Weitkamp, *"Handbook of Heterogeneous Catalysis*" Vol 1-5, Wiley-VCH, Weinheim, 1997.
2. R.J. Farrauto and C.H. Bartholomew, *"Fundamentals of Industrial Catalytic Processes",* Blackie Academic and Professional – Chapman and Hall, 1997.
3. R. Pearce and W.R. Patterson, *"Catalysis and chemical processes*", Academic press, Leonard Hill, London, 1981.

**UNIVERSITY OF CALICUT**

**M.Sc. CHEMISTRY (CSS PATTERN) - SEMESTER IV**

**CHE4E06 - NATURAL PRODUCTS & POLYMER CHEMISTRY (4 Credits, 72 h)**

**UNIT 1: Basic aspects of Natural Products (9 h)**

Classification of Natural Products**:** Classification of Natural products based on chemical structure, physiological activity, taxonomy and Biogenesis. Carbohydrates. Terpenoids. Carotenoids. Alkaloids. Steroids. Anthocyanins etc. Methods of isolation of each class of compound. Essential Oils: Isolation and study of important constituents of lemon grass oil, citronella oil, cinnamon oil, palmarosa oil, turpentine oil, clove oil, sandalwood oil, Essential oils of turmeric and ginger. Oleoresins of pepper, chilly, ginger and turmeric. Aromatherapy.

**UNIT 2: Terpenoids and Steroids (9 h)**

Terpenoids: classification, structure elucidation and synthesis of abietic acid.

Steroids: Classification, structure of cholesterol, conversion of cholesterol to progesterone, androsterone and testosterone. Classification, structure and synthesis of prostaglandins, biosynthesis of fatty acids, prostaglandins, terpenoids and steroids. Structural elucidation of Cholesterol, Ergosterol, Oesterone, Androsterone, Testosterone, Progestrone, Cortisone and Corticosterone.

**UNIT 3: Alkaloids and Anthocyanins (9 h)**

Alkaloids. Classification of alkaloids, structural elucidation based on degradative reactions (quinine and atropine). Biosynthesis of quinine and papaverine.
Anthocyanins**:** Introduction, General Nature and Structure of Anthocyanidins. Flavone, Flavonol, Isoflavone and Chalcone

**UNIT 4: Dyes, Pigments and Supramolecules (9 h)**

Brief introduction to dyes and pigments (natural and synthetic): β-carotene, indigo, cyclic tetrapyrroles (porphyrins, chlorins, chlorophyll, heme). Study of phthalocyanines, squarenes, and cyanine dyes. Introduction to Supramolecular chemistry and Molecular Recognition

**References:**


1. M. B. Smith, *Organic Synthesis*, 3/e, Academic Press, 2011.
2. F. A. Carey and R. J. Sundberg*: Advanced Organic Chemistry (part B),* 3rd ed., Plenum Press.
3. T.W. G. Solomons: *Fundamentals of Organic Chemistry*, 5th ed., John Wiley
4. H. O. House: *Modern Synthetic Reactions*, W. A. Benjamin
5. W. Carruthers: *Some Modern Methods of Organic Synthesis*, 4/e, CambridgeUniversity

Press.

6. I. L. Finar: *Organic Chemistry* Volumes 1 (6th ed.) and 2 (5th ed.), Pearson.
7. J. Clayden, N. Green, S. Warren and P. Wothers: *Organic Chemistry*, 2/e, OxfordUniversity Press
8. N. R. Krishnaswamy: *Chemistry of Natural Products*; A Unified Approach, Universities Press
9. R. J. Simmonds: *Chemistry of Biomolecules: An Introduction*, RSC
10. R. O. C. Norman: *Principles of Organic Synthesis*, 3nd ed., CRC Press, 1998.
11. J. M. Lehn, *Supramolecular Chemistry*

**UNIT 5**: **Polymerization Processes (9 h)**

Polymerization processes. Free radical addition polymerization. Kinetics and mechanism. Chain transfer. Mayo-walling equation of the steady state. Molecular weight distribution and molecular weight control. Radical Atom Transfer and Fragmentation – Addition mechanism. Free radical living polymers. Cationic and anionic polymerization. Kinetics and mechanism, Polymerization without termination. Living polymers. Step Growth polymerization. Kinetics and mechanism. Molecular weight distribution. Linear Vs cyclic polymerization, other modes of polymerization. Group Transfer, metathesis and ring opening polymerization. Copolymerization. The copolymerization equation, Q-e scheme, Gelation and Crosslinking. Copolymer composition drift Polymerization techniques. Bulk Solution, melt, suspension, emulsion and dispersion techniques

.

**UNIT 6**: **Characterization and Stereochemistry of Polymers (9 h)**

Polymer Stereochemistry. Organizational features of polymer chains. Configuration and conformation, Tacticity, Repeating units with more than one asymmetric center. Chiral polymers – main chain and side chain. Stereoregular polymers. Manipulation of polymerization processes. Zeigler-Natta and Kaminsky routes. Coordination polymerization. Metallocene and Metal oxide catalysts. Polymer Characterization. Molecular weights. Concept of average molecular weights, Molecular weight distribution. Methods for determining molecular weights. Static and dynamic methods, Light scattering and GPC. Crystalline and amorphous states. Glassy and Rubbery States. Glass transition and crystalline melting. Spherullites and Lammellac. Degree of Crystallinity, X-ray diffraction,

**UNIT 7: Polymer Solutions, Industrial polymers and Copolymers (9 h)**

Polymer Solutions. Treatment of dilute solution data. Thermodynamics. Flory-Huggins equation. Chain dimension-chain stiffness – End-to-end distance. Conformation-random coil, Solvation and Swelling. Flory-Reiner equation. Determination of degree of crosslinking and molecular weight between crosslinks.

Industrial polymers. Synthesis, Structure and applications. Polyethylene, polypropylene,

polystyrene. Homo and Copolymers. Diene rubbers. Vinyl and acrylic polymers. PVC, PVA, PAN, PMMA and related polymers.
Copolymers. EVA polymers. Flourine containing polymers. Polyacetals. Reaction polymers. Polyamides, polyesters. Epoxides, polyurethanes, polycarbonates, phenolics, PEEK, Silicone polymers.

**UNIT 8**: **Speciality Polymers (9 h)**

Reactions of polymers. Polymers as aids in Organic Synthesis. Polymeric Reagents, Catalysts, Substrates, Liquid Crystalline polymers. Main chain and side chain liquid crystalline polymers. Phase morphology. Conducting polymers. Polymers with high bandwidth. Polyanilines, polypyrrols, polythiophines, poly (vinylene phenylene). Photoresponsive and photorefractive polymers. Polymers in optical lithography. Polymer photoresists. Electrical properties of Polymers, Polymers with NLO properties, second and third harmonic generation, and wave guide devises.

**References:**


1. F.W. Billmayer. *Textbook of Polymer* Science. 3rd Edn, Wiley. N.Y. 1991.
2. G. Odiyan, *Principles of Polymerisation*, 4/e, Wiley, 2004.
3. V.R. Gowriker and Others, *Polymer Science*, Wiley Eastern Ltd.
4. J.M.G Cowie. *Polymers: Physics and Chemistry of Modern Materials*. Blackie. London, 1992.
5. R.J.Young, *Principles of Polymer Science*, 3rd Edn. , Chapman and Hall. N.Y. 1991.
6. P.J. Flory. *A Text Book of Polymer Science.* Cornell University Press. Ithacka, 1953.
7. F. Ullrich, *Industrial Polymers*, Kluwer, N.Y. 1993.
8. H.G.Elias, *Macromolecules,* Vol. I & II, Academic, N.Y. 1991.

**UNIVERSITY OF CALICUT**

**M.Sc. CHEMISTRY (CSS PATTERN) - SEMESTER IV**

**CHE4E07 - MATERIAL SCIENCE (ELECTIVE) (4 credits, 72h)**

### Unit 1: Introduction to Material Science (9h)

Introduction. Classification of materials. Functional classification. Classification based on structure. Environmental and other effects. Material design and selection;
Mechanical properties – significance and terminology, the tensile test, true stress and true strain, bend test, hardness of materials.

### Unit 2: Ceramic Materials (9h)

Definition of ceramics. Traditional and new ceramics. Structure of ceramics. Atomic interactions and types of bonds. Phase equilibria in ceramic systems, one component and multi component systems. Use of phase diagrams in predicting material behavior. Electrical, magnetic, and optical properties of ceramic materials.

### Unit 3: Nanomaterials and Nanotechnology (9h)

Nanomaterials. Nanostructures. Self-assembly. Nanoparticles- methods of synthesis, sol-gel process, hydrolysis of salts and alkoxides, precipitation, condensation reactions, electrokinetic potential and peptization reactions. Gelatin network- xerogels, aerogels, drying of gels. Chemical modifications of nanosurfaces. Applications of sol-gel process, sol-gel coating, porous solids, catalysts, dispersions and powders

### Unit 4: Materials for Special Purposes – I (9h)

Production of ultra-pure materials - zone refining, vacuum distillation and electro refining. Ferroelectric and piezoelectric materials - general properties. Classification of ferroelectric materials. Theory of ferroelectricity, ferroelectric domains, applications. Piezoelectric materials and applications. Metallic glasses - preparation, properties and applications.

### Unit 5: Materials for Special Purposes – II (9h)

Magnetic materials, ferri and ferro magnetism. Metallic magnets, soft, hard & superconducting magnets. Ceramic magnets, low conducting and superconducting magnets. Superconducting materials - metallic and ceramic superconducting materials, theories of superconductivity. Meissner effect. High temperature superconductors - structure and applications.

### Unit 6: Some Special Polymers (9h)

Functional polymers - photoconductive, electroconductive, piezoelectric and light sensitive polymers. Industrial polymers - production, properties, & compounding of industrial polymers. Commodity plastics such as PP, PE, PVC, & PS. Engineering plastics such as

polyacetyl, polyamide (nylon 6 and nylon 66), polyacrylate, polycarbonate, polyester (PET, PBT), polyether ketones. Thermosetting plastics such as PF, UF & MF.

**Unit 7: Composite Materials (9h)**

Definition and classification of composites, fibres and matrices. Composites with metallic matrices – processing, solid and liquid state processing, deposition. Ceramic matrix composite materials – processing, mixing & Pressing, liquid state processing, sol-gel processing & vapor deposition technique. Interfaces in composites - mechanical & microstructural characteristics. Applications of composites.

**Unit 8: Fracture Mechanics (9h)**

Importance of fracture mechanics. Micro structural features of fracture in metals, ceramics, glasses & composites. Weibull statistics for failure, strength analysis. Fatigue, application of fatigue testing - creep, stress rupture & stress behavior, evaluation of creep behavior.

**References:**


1. W.D. Eingery, H.K. Dowen and R.D. Uhlman, *Introduction to Ceramics*, John Wiley.
2. A.G. Guy, *Essentials of Material Science*, McGraw Hill.
3. M.J. Starfield and Shrager, *Introductory Material Science*, McGraw Hill.
4. S.K. Hajra Choudhary, *Material Science and Engineering*, Indian Book Dist. Co., Calcutta.
5. M.W. Barsoum, Fundamentals of Ceramics, McGraw Hill, 1997.
6. M. Tinkham, *Introduction to Superconductivity*, McGraw Hill, 1975.
7. A.V. Narlikar and S.N.Edbote, *Superconductivity and Superconducting Materials*, South Asian Publishers, New Delhi, 1983.
8. S.V. Subramanyan and E.S. Rajagopal, *High Temperature Superconductors*, Wiley Eastern Ltd., 1988.
9. Azaroff and Brophy, *Electronic Processes in Materials*, McGraw Hill, 1985.
10. C.M. Srivastava and C. Srinivasan, Science of Engineering Materials, Wiley Eastern Ltd., 1987. R.J. Young, *Introduction to Polymer Science*, John Wiley and Sons.
11. V.R. Gowriker and Others, *Polymer Science*, Wiley Eastern Ltd.
12. H. Ulrich, *Introduction to Industrial Polymers*, Hansen Publishers, 1982.
13. F.R. Jones, *Handbook of Polymer Fibre Composites*, Longman Scientific and Tech.
14. K.K. Chowla, *Composite Materials*, Springer-Verlag, NY, 1987.

**UNIVERSITY OF CALICUT**

**M.Sc. CHEMISTRY (CSS PATTERN) - SEMESTER IV**

**CHE4E08 – ORGANOMETALLIC CHEMISTRY (ELECTIVE) (4 credits, 72h)**

**UNIT I (9h)**

Organometallic compounds. Classification and nomenclature. The 16 and 18 electron rules. Electron counting-covalent and ionic models. Main group organometallics-alkyl and aryl, groups 1, 2, 12, 13, 14 and 15 synthesis, structure and applications. Transition metal to carbon multiple bond-the metal carbenes and carbynes. Transition metal complexes with chain π ligands – synthesis, structure, bonding and reactions of complexes of ethylene, allyl, butadiene and acetylene.

**UNIT II (9h)**

Metal carbonyls- Bonding modes of CO. IR spectroscopy as a tool to study bonding and structure of metal carbonyls. Synthesis of Metal carbonyls, Direct and reductive Carbonylation. Reactions of Metal carbonyls-Activation of metal carbonyls, Disproportion, Nucleophilic addition, electrophilic addition to the carbonyl oxygen, Carbonyl cation, anions and hydrides. Collmann's reagent, Migratory insertion of carbonyls. Oxidative decarbonylation. Photochemical substitution. Microwave assisted substitution.

**UNIT III (9h)**

General aspects of synthesis. Structure, reactivity and applications of main group organometallic compounds. Metal complexes of NO, $H_2$, CS, RNC and Phosphines. Metal-carbon multiple bonds - Metal carbenes and carbynes, bridging carbenes and carbynes, N-heterocyclic carbons, multiple bonds to hetero atoms.

**UNIT IV (9h)**

Organometallic π complexes – synthesis, structure, bonding (molecular orbital treatment) and reactions of $C_5H_5$, $C_6H_6$, $C_7H_7$ and $C_8H_8^{-2}$. Polyalkyls, polyhydrides and f-block organometallic complexes, Fluxional organometallics.

**UNIT V (9h)**

Applications of organometallic compounds in organic synthesis and homogeneous catalysis, Complex formation and activation of $H_2$, $N_2$, $O_2$, NO by transition metals. Catalytic steps, Oxidative addition, reductive elimination and insertion reactions. Hydrozirconation of alkenes and alkynes. Homogeneous catalysis. Hydrogenation, isomerization of alkenes, alkyne, cycloadditions, Zeigler-Natta catalysis, hydroformylation of alkenes, Monsanto acetic acid process and Wacker process. Metal complexes in enantioselective synthesis

**UNIT VI (9h)**

Organometallic reactions. $SN^2$ Reactions, Radical Mechanisms, Ionic Mechanisms, σ-Bond Metathesis, Oxidative Coupling and Reductive decoupling. Reactions involving CO, Insertions

Involving Alkenes, Other Insertions, α, β, γ and δ Elimination, Deinsertion and Nucleophilic and electrophilic attack on coordinated ligand.

**UNIT VII (9h)**

Applications of organometallic reaction. Homogeneous catalysis. General features of catalysis. Types of catalyst. Catalytic steps. Water-gas shift reaction. Fisher-Tropsch reaction. Hydrosilation of alkenes. Hydrocyanation of alkenes.

**UNIT VIII (9h)**

Organometallic Polymers. Polymers with organometallic moieties as pendant groups. Polymers with organometallic moieties in the main chain. Condensation polymers based on ferrocene and on rigid rod polyynes, poly (ferrocenylsilane)s, applications of oly(ferrocenylsilane)s and related polymers. Applications of rigid-rod polyynes, polygermanes and polystannanes. Polymers prepared by ring opening polymerization. Organometallic dendrimers.

**References:**

1. B. D. Gupta, A .J. Elias, Basic Organometallic Chemistry - Concepts, Synthesis and Applications, Second edition, University Press, 2013.
2. R. H. Crabtree, The Organometallic Chemistry of the Transition Metals, Fourth edn. 2005, Wiley Interscience.
3. J. E. Huheey, Inorganic Chemistry – Principles of Structure and Reactivity, 4th edition, Pearson education, 1993.
4. F.A. Cotton and G. Wilkinson, Advanced Inorganic Chemistry. 5th edition, John and Wiley, 1999.
5. R.S. Drago. Physical Methods in Inorganic Chemistry, 2nd edition, affiliated east west press, 1993.
6. P. Powell, Principles of Organomettalic Chemistry, 2nd edition, Chapman and Hall, London, 1998.
7. S. F. A. Kettle, Concise co-ordination chemistry, Nelson, 1969.
8. S. F. A. Kettle, Physical Inorganic Chemistry-A Co-ordination chemistry Approach, Spectrum academy publishers, 1996.
9. Purcell and Kotz, Inorganic Chemistry. 10. D. J. Shriver, P. W. Atkins, Inorganic Chemistry, 5th edition, Oxford university press, 2010.

**UNIVERSITY OF CALICUT**

**M.Sc. CHEMISTRY – SEMESTER III & IV**

## CHE3L07 & CHE4L10 – INORGANIC CHEMISTRY PRACTICALS– III & IV (3 Credits)

### Unit 1: Estimation of ions in mixture

Estimation involving quantitative separation of suitable binary mixtures of ions in solution ($Cu^{2+}$, $Nl^{2+}$, $Zn^{2+}$, $Fe^{3+}$, $Ca^{2+}$, $Mg^{2+}$, $Ba^{2+}$ and $Cr_2O_7^{2-}$) by volumetric colorimetric or gravimetric methods only one of the components to be estimated.

### Unit 2: Colorimetric Estimations

Colorimetric estimations of Ni, Cu, Fe and Mo, after separation from other ions in solution by solvent extraction. (Minimum two expts.)

### Unit 3: Ion Exchange Methods

Ion-exchange separation and estimation of binary mixtures ($Co^{2+}$ & $Ni^{2+}$, $Zn^{2+}$ & $Mg^{2+}$. Hardness of water).

### Unit 4: Preparation of Inorganic Complexes. (5 Nos)

### References:


1. *Vogel's Text Book of Qualitative InorganicAnalysis*.
2. I.M. Kolthoff and E.A. Sanderson, *Quantitative ChemicalAnalysis.*
3. D.A. Adams and J.B. Rayner, *Advanced Practical InorganicChemistry*.
4. W.G.Palmer, *Experimental InorganicChemistry.*
5. G. Brauer, *Hand book of Preparative InorganicChemistry*.

**UNIVERSITY OF CALICUT**

**M.Sc. CHEMISTRY – SEMESTER III & IV**

## CHE3L08 & CHE4L11 – ORGANIC CHEMISTRY PRACTICALS– III & IV (3 Credits)

### Unit 1: Quantitative Organic Analysis

Estimation of equivalent weight of acids by Silver Salt method, Estimation of nitrogen by Kjeldahl method, Determination of Acid value, iodine value and saponification value of oils and fats (at least one each), estimation of reducing sugars, estimation of amino group, phenolic group and esters. Colourimetric estimations: Vitamins (Ascorbic acid), Drugs – sulpha drug (Sulpha diazine, sulphaguanidine), Antibiotics – Pencillin, Stroptomycin.

**References:**


1. B.S. Furnis, A.J. Hannaford, P.W.G. Smith and A.R. Tatchell, *Vogel's Textbook of Practical Organic Chemistry*, ELBS/Longman, 1989.
2. Beebet, *Pharmacuetical Analysis*.


### Unit 2: Extractions

Extraction of Natural products and purification by column chromatography and TLC – Caffeine from Tea waste, Chlorophyll, Steroids, Flavonoid (Soxhlet extraction), citral from lemon grass (steam distillation). Casein from milk.

### Unit 3: Chromatograhy

Practical application of PC and TLC, preparation of TLC plates, activation, identification of the following classes of compounds using one- and two-dimensional techniques. Identification by using spray reagents and co-chromatography by authentic samples and also from Rf values.

Food additives and Dyes, Artificial sweeteners: Saccharine, cyclamates, Dulcin. Flavour adulterants – piperonal, benzyl acetate, ethyl acetate antioxidants: Butylated hydroxytoluene (BHT) Butylated hydroxy anisole (BHA), Hydroquinone.

Food colours: Permitted – Amaranth, Erythrosine, Tatrazine, susnet yellow, Fast green, Brilliant Blue, Nonpermitted colours: Auramine, Congo red, Malachite green, Metanil yellow, Orange II, Sudan II, Congo red. Amino acids (Protein hydrolysates), Sugars, Terpinoids, Alkaloids, Flavonoids, Steroids.

Pesticides and herbicides: Oragonochlorine pesticides organo phosphates and carbamate pesticides, Herbicides.
Plant growth stimulants: Indole acetic acid.

**References:**


1. B.S. Furnis, A.J. Hannaford, P.W.G. Smith and A.R. Tatchell, *Vogel's Textbook of Practical Organic Chemistry*, 5/e, Pearson, 1989.
2. Beebet, *PharmacueticalAnalysis*
3. E. Hoftmann, *Chromatography*, non Nostrand Reinhold Company, New York, 1975.
4. J. Sherma and G. Zwig, *TLC and LC analysis of pesticides of international importance*, Vol. VI & VII, AcademicPress.
5. H. Wagner, S. Bladt, E.M. Zgainsti – Tram, Th. A. Scott., *Plant Drug Analysis*, Springer- Verlag, Tokyo,1984.
6. Vishnoi, *Practical Organic Chemistry*.

**UNIVERSITY OF CALICUT**

**M.Sc. CHEMISTRY – SEMESTER III & IV**

## CHE3L09 & CHE4L12 – PHYSICAL CHEMISTRY PRACTICALS– III & IV (3 Credits)

### SECTION A

**Unit 1: Chemical Kinetics (4 experiments)**

1. Determination of specific reaction rate of acid hydrolysis of an ester (methyl acetate or ethyl acetate) and concentration of the given acids.
2. Determination of Arrhenius parameters of acid hydrolysis of an ester.
3. Determination of specific reaction rate of saponification of ethyl acetate.
4. Iodination of acetone in acid medium – Determination of order of reaction with respect of iodine and acetone.

**Unit 2: Adsorption (3 experiments)**

1. Verification of Langmuir adsorption isotherm – charcoal-acetic acid system. Determination of the concentration of a given acetic acid solution using the isotherm
2. Verification of Langmuir adsorption isothem – charcoal-oxalic acid system. Determination of the concentration of a given acetic acid solution using the isothem.
3. Determination of surface area of adsorbent.

**Unit 3: Phase Equilibria (2 experiments)**

1. (a)Determination of phase diagram of a ternary liquid system(e.g., chloroform– acetic acid – water, Benzene – acetic acid –water)
   (b) Determination of the composition of a binary liquid mixture (e.g., chloroform-acetic acid, benzene-acetic acid)
2. (a) Determination of mutual miscibility curve of a binary liquid system (e.g., phenol – water) and critical solution temperature (CST).
   (b) Effect of impurities (e.g, NaCl, KCl, succinic acid, salicylic acid) on the CST of water-phenol system
   (c) Effect of a given impurity (e.g., KCl) on the CST of water–phenol system and determination of the concentration of the given solution of ---------

**Unit 4: Cryoscopy – Beckman Thermometer Method (3 experiments)**

1. Determination of cyroscopic constant of a liquid (water, benzene)
2. Determination of molecular mass of a solute (urea, glucose, cane sugar, mannitol) by studying the depression in freezing point of a liquid solvent (water, benzene)

3. Determination of Van't Hoff factor and percentage of dissociation of NaCl.

4. Study of the reaction $2Kl + Hgl_2 \rightarrow .K_2Hgl_4$ and determination of the concentration of the given Kl solution.

**Unit 5: Polarimetry (3 experiments)**

1. Determination of specific and molar optical rotations of glucose, fructose and sucrose.

2. Determination of specific rate of inversion of cane sugar in presence of HCl.

3. Determination of concentration of HCl

**Unit 6: Spectrophotometry (3 experiments)**

1. Determination of equilibrium constants of acid –base indicators.

2. Simultaneous of determination Mn and Cr in a solution of $KMnO_4$ and $K_2Cr_2O_7$

3. Investigation of complex formation between Fe (III) and thiocyanate.

**References:**


1. A. Finlay and J.A. Kitchener, *Practical Physical Chemistry,* Longman.

2. F. Daniels and J.H. Mathews, *Experimental Physical Chemistry,* Longman.

3. A.H. James, *Practical Physical Chemistry,* J.A. Churchil Ltd., 1961.

4. H.H. Willard, L.L. Merit and J.A. Dean, *Instrumental Methods of Analysis,* 4th Education, Affiliated East-West Press Pvt. Ltd., 1965.
5. D.P. Shoemaker and C.W. Garland, *Experimental Physical Chemistry,* McGrawHill.

6. J.B. Yadav, *Advanced Practical Physical Chemistry, Goel Publications,* 1989


**SECTION B**

Use of Computational Chemistry softwares like pc GAMESS (firefly), Gaussian etc., to calculate molecular parameters.

**Unit 7: Computational Chemistry Calculations**

1. Single point energy calculations of simple molecules like $H_2O$ and $NH_3$ at the HF/3-21G level of theory.
2. The effect of basis set on the single point energy of $H_2O$ and $NH_3$ using the Hartree-Fock method (3-21G, 6-31G, 6-31+G, 6-31+G* basis sets can be used).

3. Geometry optimization of molecules like $H_2O$, $NH_3$, HCHO & $C_2H_4$ at the HF/6-31G level of theory.
4. Computation of dipole and quadrupole moments of HCHO & $C_2H_4$ at the HF/6-31G level of theory.
5. Effect of basis set on the computation of H-O-H bond angle in $H_2O$ using the Hartree-Fock method (3-21G, 6-31G, 6-31+G, 6-31+G* basis sets can be used).
6. Computation of the energy of HOMO and LUMO of formaldehyde and ethylene at the HF/6-31G level of theory.
7. Effect of substituent (F & Cl) on the geometric parameters (like C-C bond length) of ethylene at the HF/6-31G level of theory.
8. Comparison of stability of cis-planar and trans-planar conformers of $H_2O_2$ at the HF/6-31G level of theory.
9. Comparison of stability of cis- and trans- isomers of difluoroethylene at the HF/6-31G* level of theory.
10. Computation of the frequencies of normal modes of vibration of molecules like $H_2O$, $NH_3$ and $CO_2$ at the HF/6-31+G* level of theory.
11. Determination of hydrogen bond strength of $H_2O$ dimer and $H_2O$ trimer at the HF/6-31+G* level of theory.
12. Determination of hydrogen bond strength of HF dimer and HF trimer at the HF/6-31+G* level of theory.

**Reference:**


1. J. Foresman &Aelieen Frisch, *Exploring Chemistry with Electronic Structure Methods*, Gaussian Inc., 2000.
2. David Young, *Computational Chemistry- A Practical Guide for Applying Techniques to Real- World Problems"*, Wiley -Interscience, 2001.
3. http://classic.chem.msu.su/gran/gamess/index.html

**QP Code** **Reg. No.....**

**M.Sc Degree (C.S.S) Examination**

**First Semester**

**Time: Three hours** **Max. Weight: 30**

**Section- A**

(Answer any eight questions. Each question carries a weight of 1)

1. What is synergism?
2. Define the term "isolobal".
3. Give an example for a β-elimination reaction.
4. What are Ziegler- Natta catalysts?
5. What is Bohr Effect?
6. What is cis-platin? What are its important applications?
7. What is radiation polymerisation?
8. How is nuclear reaction cross section related to reaction rate?
9. List the important functions of biological membranes.
10. Give an example for the use of palladium catalysts in the formation of C-N bond.

(8 x 1 = 8)

**Section B**

(Answer any six questions. Each question carries a weight of 2)

11. Discuss the bonding in ferrocene.
12. What are oxidative addition reactions? Discuss the important mechanisms involved in oxidative additions.
13. What is Wilkinson's catalyst? What are its uses? Describe alkene hydrogenation using Wilkinson's catalyst with the help of Tolman catalytic loops.
14. Explain the structure and functions of carbonic anhydrase, carboxypeptidase A and superoxide dismutase.
15. Write a note on the synthesis of transuranic elements.
16. Outline the role of chlorophyll in photosynthesis.
17. What are insertion reactions? Discuss insertion of alkenes and alkynes in the Ar-H bond.

18. Write a note on carbonyl clusters. (6 x 2 = 12)

**Section C**

(Answer any two questions. Each question carries a weight of 5.)

19. What are π-bonding ligands? Explain the preparation, properties, structure and bonding of simple mono and binuclear metal carbonyls, metal nitrosyls, metal cyanides and dinitrogen complexes.

20. a) Write a note on carbonylation reactions.

b) Write a note on asymmetric catalysis. Discuss asymmetric hydrogenation, isomerisation and epoxidation.

21. Discuss oxygen transport mechanism. What are the functions of haemoglobin and myoglobin in oxygen transport?

22. a) Discuss important analytical applications of radioisotopes.

b) Outline fluxional isomerism of allyl, cyclopentadienyl and allene systems.

(2 x 5 = 10)