



Chowgule Education Society's
Parvatibai Chowgule College of Arts and Science
Autonomous
Accredited by NAAC with Grade 'A+'
Best Affiliated College-Goa University Silver Jubilee Year Award

MINUTES OF THE MEETING OF THE BOARD OF STUDIES IN CHEMISTRY

Held on 21st February 2024 at 10:30 a. m.

Parvatibai Chowgule College of Arts and Science
(Autonomous)
Margao – Goa

Vide Chowgule College notice, dated 05th February, 2024, a meeting of the BoS of Department of Chemistry was hereby convened on 21st February, 2024 at 10:30 a. m. in the online mode. The link for the meeting was meet.google.com/gfj-moab-bjf. Since the members present represented the quorum, the BoS began its proceedings.

Members present:

1. Dr. G. K. Naik – Chairman
2. Dr. Sunder Dhuri – Vice-Chancellor Nominee
3. Dr. A. K. Srivastava – Expert nominated by Academic Council
4. Dr. Rajesh Pednekar – Expert nominated by Academic Council
5. Dr. Sridhar M. Gurav - Expert from outside the college
6. Dr. Roopa S. Belurkar – Member
7. Dr. Manjita R. Porob – Member
8. Dr. Lactina R Gonsalves – Member
9. Dr. Mayuri M. Naik – Member
10. Miss Kamaksha D. Borker – Member
11. Miss Ashvini Y. Pujari – Member
12. Mr. Anurag Madhukar Naik – Member
13. Miss Limora Nionyka D'Souza – Member
14. Miss Harsha Arun Chari – Member
15. Dr. Sachin B. Kakodkar – Member Secretary

The following members were absent (Leave of absence notified)

1. Dr. Vikas J. Pissurlekar – Expert from outside the college
2. Mr. Yashwant Phadke – Representative from Industry/Corporate sector
3. Ms. Divya Sawant – Postgraduate meritorious alumnus

4. Mrs. Padmini C. Panjekar – Member (On Leave)

Proceedings:

At the outset, Chairman welcomed the BoS members for the 14th BoS meeting and business was transacted as per the agenda.

Agenda items:

1. To approve the revised Nomenclatures for: Major Courses; Multidisciplinary Courses; Skill Enhancement Courses, at Semester I and II, as per NEP 2020.
2. To approve the Nomenclatures for Skill Enhancement Course of Semester II and Minor Course of Semester III as per NEP 2020.
3. To approve the revised syllabi of the Core Courses of Semester I and Semester II as per NEP 2020.
4. To approve the New Syllabi of Skill Enhancement Course of Semester II and Minor Course in Chemistry of Semester III as per NEP 2020.
5. To suggest the Nomenclatures for the Value-Added Courses of Semester I and II; Multidisciplinary Courses at Semester II as per NEP 2020.
6. To suggest correction for the revised syllabi of Multidisciplinary Courses of Semester I and II as per NEP 2020.
7. To approve the CLOs of Semesters I to IV of the PG Courses.
8. A. O. B.

PART A: The BOS passed the resolutions as follows:

1. It was proposed to change the course title of **UG-CHE-101** General Physical and Inorganic Chemistry to **UG-CHE-101** General Chemistry-I.
2. It was proposed to change the course title of **UG-CHE-102** General Organic and Inorganic Chemistry to **UG-CHE-101** General Chemistry-II.
3. It was proposed to shift **UG-CHE-SEC2** Basic Laboratory Methods and Safety in Chemistry from Semester II to Semester I and introduce **UG-CHE-SEC3** Chemistry of Water and Soil in Semester II.
4. The Nomenclatures for Minor Course of Semester III **UG-CHE-207** Concepts in Chemistry -III and Skill Enhancement Course of Semester II Course **UG-CHE-SEC3** Chemistry of Water and Soil in Semester II as per NEP 2020 were approved by the BoS members.
5. It was proposed to change 'Estimation of Calcium by EDTA method' to **Estimation of Calcium from CaCO₃ by EDTA method**'.
6. It was proposed to add '**Concise Inorganic Chemistry by J. D. Lee**' to additional reading and '**Basic Inorganic Chemistry by F. A. Cotton and G. Wilkinson**' instead of '**Advanced Inorganic Chemistry by F. A. Cotton and G. Wilkinson**'.
7. It was proposed to change '**To prepare 0.001 M EDTA solution and separately estimate the amount of Zn²⁺ ion from ZnCO₃, Mg²⁺ ion from MgO to, (1) To estimate the amount of Zn²⁺ ion from ZnCO₃ by EDTA titration; and (2) To estimate the amount of Mg²⁺ ion from MgO by EDTA titration**'.
8. It was proposed to delete '**Volumetric estimation of calcium from anhydrous Calcium Chloride**' to avoid repetition.
9. The revised course syllabi of the Core Courses of Semester I **UG-CHE-101** General Chemistry-I and Semester II **UG-CHE-102** General Chemistry-II as per NEP 2020 was approved by the BoS members.
10. It was proposed to change the '**determination**' in following three experiments to '**detection**' for the experiments to be completed in time.
 - A. Determination of chloride, sulphate, nitrate, and phosphate ions in different water samples.
 - B. Determination of chloride, sulphate, nitrate, and phosphate ions in different soil samples.

- C. Determination of lead, magnesium, calcium and potassium ions in different water and soil samples.
11. It was proposed to add CLO4 to the Course Learning Outcomes to the **CHE-SEC-3** Chemistry of Water and Soil
 12. It was proposed to change '**Purification of Pet ether using Distillation technique and determination of boiling point**' to '**Purification of toluene using Distillation technique and determination of boiling point**' to avoid handling of hazardous pet ether by students.
 13. The New syllabi of Minor Course of Semester III **UG-CHE-207** Concepts in Chemistry -III as per NEP 2020 was approved by the BoS members.
 14. The Nomenclatures for the Value-Added Courses of Semester I and II; Multidisciplinary Courses at Semester II as per NEP 2020 will be taken up in a separate BoS meeting.
 15. The revised syllabi of Multidisciplinary Courses of Semester I and II as per NEP 2020 will be taken up in a separate BoS meeting.
 16. It was proposed to change the CLO4 of the Course **CHOC-402: Laboratory Course in Organic Chemistry** to '**To understand the synthesis of Selected Organic Compounds**' instead of '**Synthesize the studied organic compounds and purify them**'.
 17. It was proposed to rearrange the CLO3 in place of CLO4 and vice versa for the course **CHIC-401: General Inorganic Chemistry**.
 18. It was proposed to make the CLO4 brief for the course **CHPE-401: Topics in Physical Chemistry** and to include Faraday's Method of magnetic susceptibility measurement under the Unit I- Magneto Chemistry, Reference book was suggested for the same.
 19. It was proposed to look for alternative method for the experiment, Estimation of chloride by spectrophotometry using mercury (II) thiocyanate method under the course **CHAC-402: Laboratory Course in Analytical Chemistry** to avoid handling of the mercuric salt and was suggested to carry out the estimation via conductometry.
 20. It was proposed that keeping in mind the completion of allotted practical hours, the experiments to be carried out by TGA analysis should include preparation of the hydrate salt from a given source, and calculation of isothermal weight loss and then study of the interpretation of the data such as 'Preparation of $\text{CaC}_2\text{O}_4 \cdot \text{H}_2\text{O}$ from Calcite Ore'.
 21. For the experiment, DSC study on pharmaceutical product it was proposed to include an example of the pharmaceutical product for the analysis.
 22. It was proposed to delete Bronsted acid and its periodicity under Unit II in **CHIE-401: Topics in Inorganic Chemistry** and make the changes with respect to the font style used for phosphorus cage compounds.
 23. It was proposed that the theoretical aspect of the Course **CHAE-502: Methods of Analysis** to be floated in Semester III should be studied before the practical aspect to be covered in semester II.
 24. It was proposed to include interpretation of the NMR spectra for the Course **CHAE-504: Advanced NMR Spectroscopy**.
 25. It was proposed to include Dealing with impurity profile as one of the CLO for the Course **CHAE-506: Quality Assurance and Quality Control in Analytical Chemistry**.
 26. The changes in CLOs of Semesters I to IV of the PG Courses were approved by the BoS members with corrections as suggested by the BoS members.

PART B: Important Points/ recommendations of BoS that require consideration/ approval of Academic Council:

1. To approve the revised Nomenclatures for: Major Courses; Skill Enhancement Courses, at Semester I and II, as per NEP 2020.
2. To approve the Nomenclatures for Skill Enhancement Course of Semester II and Minor Course of Semester III as per NEP 2020.


3. To approve the revised syllabi of the Core Courses of Semester I and Semester II as per NEP 2020.
4. To approve the New Syllabi of Skill Enhancement Course of Semester II and Minor Course in Chemistry of Semester III as per NEP 2020.
5. The Nomenclatures for the Value-Added Courses of Semester I and II; Multidisciplinary Courses at Semester II as per NEP 2020 will be taken up in a separate BoS meeting.
6. The revised syllabi of Multidisciplinary Courses of Semester I and II as per NEP 2020 will be taken up in a separate BoS meeting.
7. To approve the CLOs of Semesters I to IV of the PG Courses.


The following members of the Board of Studies in Chemistry were present for the meeting.

1. Dr. G. K. Naik – Chairman
2. Dr. Sunder Dhuri – Vice-Chancellor Nominee
3. Dr. A. K. Srivastava – Expert nominated by Academic Council
4. Dr. Rajesh Pednekar – Expert nominated by Academic Council
5. Dr. Sridhar M. Gurav - Expert from outside the college
6. Dr. Roopa S. Belurkar – Member
7. Dr. Manjita R. Porob – Member
8. Dr. Lactina R Gonsalves – Member
9. Dr. Mayuri M. Naik – Member
10. Miss Kamaksha D. Borker – Member
11. Miss Ashvini Y. Pujari – Member
12. Mr. Anurag Madhukar Naik – Member
13. Miss Limora Nionyka D'Souza – Member
14. Miss Harsha Arun Chari – Member
15. Dr. Sachin B. Kakodkar – Member Secretary

The following members were absent (Leave of absence notified)

1. Dr. Vikas J. Pissurlekar – Expert from outside the college
2. Mr. Yashwant Phadke – Representative from Industry/Corporate sector
3. Ms. Divya Sawant – Postgraduate Meritorious Alumnus
4. Mrs. Padmini C. Panjekar – Member (On Leave)


Member Secretary
Board of Studies


Chairperson
Board of Studies
29.02.2024

Date: 29th February, 2024

PART C: The remarks of the Dean of the Faculty:

- a. The minutes are in order.
- b. The minutes may be placed before the Academic Council with remark, if any.
- c. Important points of the minutes which need clear policy decision of the Academic Council to be recorded.

Date: 29th February, 2024

Signature of the Dean:
(Faculty of Arts/Science)



Dr. Meghana Devli

PART D: The remarks of the Members Secretary of the Academic Council:

- a. The minutes are in order.
- b. The minutes may be placed before the Academic Council with remark, if any.
- c. Important points of the minutes which need clear policy decision of the Academic Council to be recorded.

Date: 29th February, 2024

Signature of the Member Secretary
of Academic Council



Mr. V.C. Kumaresh

Annexure A (UG Programme)
Name of the Programme: B. Sc. in Chemistry
(Summary of changes incorporated in the existing approved syllabus)

Semester	Course Title	Existing	Changes Suggested	Reason
I	UG-CHE-101 General Chemistry-I	UG-CHE-101 General Physical and Inorganic Chemistry	Change in course title and syllabus	Modification of syllabus
	UG-CHE-SEC2 Basic Laboratory Methods and Safety in Chemistry	SEMESTER II UG-CHE-SEC2 Basic Laboratory Methods and Safety in Chemistry	Shift from Semester II to Semester I	As per the needs of course structure
II	UG-CHE-102 General Chemistry-II	UG-CHE-102 General Organic and Inorganic Chemistry	Change in course title and syllabus	Modification of syllabus
	UG-CHE-SEC3 Chemistry of Water and Soil	-	New Course	-
III	Semester III UG- CHE-207 Concepts in Chemistry -III	-	New Course	As per the needs of course structure

REVISED SYLLABUS
(To be implemented w.e.f. Academic Year 2024 - 2025)

SEMESTER- I

CORE COURSE

THEORY

Course Code: UG-CHE-101

Course Title: General Chemistry-I

Credits: 3

Duration: 45 Hours

Maximum Marks: 75

Course Objectives:

1. To have a working knowledge of the main areas of Physical Chemistry, will develop critical thinking abilities and be able to work in chemical or related fields.
2. To get better understanding about the basics of Chemical kinetics.
3. To name organic compounds of different classes using IUPAC nomenclature.
4. To learn about the basic concepts in organic chemistry, like the hybridization in organic molecules, molecular interactions, types of reactions, reactive intermediates, and reaction mechanisms etc.
5. To understand the atomic structure and learn about the elements in the periodic table.
6. To gain knowledge about the covalent bonding in compounds and apply the VSEPR and MOT theories to explain the bonding.

Course Learning Outcomes:

On successful completion of the course, students will be able to:

CLO1: Apply mathematical concepts to solve the chemical reaction problem, to determine the rate of the reaction and investigate its order.

CLO2: Understand the fundamentals of organic chemistry and apply the theoretical knowledge to synthesize alkanes and cycloalkanes.

CLO3: Apply the VSEPR and MOT theories to explain covalent bonding in different molecules.

CLO4: Explain the atomic structure, periodic trends and the principles related to the periodic table.

CLO5: Perform experiments based on theoretical concepts.

MODULE I: PHYSICAL CHEMISTRY

15 hours

Unit 1: Mathematical Concepts in Chemistry

Logarithmic relations; Rules of logarithm, Characteristic and mantissa, change of sign and base, problems based on pH and pOH; Graphical representation of equations: Curve sketching, linear graphs, and calculation of slopes; Differentiation of functions: Kx , ex (exponential), $\sin x$, $\log x$, maxima, and minima; Integration of some useful functions; Interconversion of units.

Unit 2: Chemical Kinetics

Rate of reaction, factors influencing rate of the reaction- concentration, temperature, pressure, solvent, and catalyst; Mathematical characteristics: zero, first and second order reactions; Determination of order of reaction: Integrated rate equation method, graphical method, differential method, half-life method and isolation method; Effect of temperature on the rate of the reaction, Arrhenius equation (derivation not expected) and concept of activation energy (Numerical expected).

MODULE II: ORGANIC CHEMISTRY

15 hours

Unit 1: IUPAC Nomenclature of Organic Compounds

Basic rules of IUPAC nomenclature, nomenclature of the compounds- alkanes, cycloalkanes, alkenes,

alkynes, haloalkanes, acids, alcohols, ethers, aldehydes, ketones, nitriles, acid halides, esters, anhydrides, amides. Nomenclature of aromatic compounds, mono and di substituted benzene with two functional groups, bridged cycloalkanes.

Unit 2: Fundamentals of Organic Compounds

Bond formation in organic compounds; sp , sp^2 , sp^3 with respect to methane, ethene and acetylene (hybridization concept), discussion on shape, bond length, bond angles of organic molecules; polar covalent bonds, electronegativity and bond dipoles in organic molecules, introduction and examples of Van der Waal's forces, inductive effect, field effect, hyperconjugation and resonance, hydrogen bonding; curved arrows in organic chemistry, homolytic and heterolytic bond breaking; types of reagents: electrophiles and nucleophiles; types of organic reactions: addition, elimination, substitution, oxidation, reduction and rearrangement with examples; introduction to reactive intermediates: carbocations, carbanions, free radicals, carbenes, arynes and nitrenes with shape, stabilities, methods of formation and reactions; methods of determination of reaction mechanisms: determination of structure, intermediates, isotope effects, kinetic and stereochemical studies.

Unit 3: Study of alkanes and cycloalkanes

Alkanes and Cycloalkanes: Physical properties of alkanes and cycloalkanes, sources of alkanes and cycloalkanes, chemical properties: combustion and pyrolysis of alkanes, methods of preparation: Corey-House reaction, Wurtz reaction.

MODULE III: INORGANIC CHEMISTRY

15 hours

Unit 1: Atomic Structure and the Periodic Table

Atomic spectra of hydrogen, Bohr's model of hydrogen atom, probability picture of electron, dual nature of electrons, Heisenberg uncertainty principle, Schrodinger wave equation, quantum numbers, shapes of s, p, d, orbitals, Aufbau and Pauli exclusion principles, Hund's rule of maximum multiplicity, sequence of energy levels and arrangement of elements in groups in the periodic table, periodic trends, and effective nuclear charge.

Unit 2: Covalent Bonding

Covalent bond: Valence Bond Theory (VBT) and its limitations, directional characteristics of covalent bond, various types of hybridization and shapes of simple inorganic molecules and ions, Valence Shell Electron Pair Repulsion Theory (VSEPR) applied to NH_3 , H_3O^+ , SF_4 , ClF_3 , ICl_3 and H_2O , Molecular Orbital Theory, homonuclear and heteronuclear diatomic molecules (CO and NO), multi center bonding in electron deficient molecules, bond strength and bond energy, percentage ionic character from dipole moment and electronegativity difference.

PRACTICALS

Course Code: UG-CHE-101

Course Title: General Chemistry-I

Credit: 1

Duration: 30 Hours

Maximum Marks: 25

LIST OF EXPERIMENTS

PHYSICAL CHEMISTRY

1. Preparation of standard solutions based on normality, molarity, molality. Also, further dilutions from a standard solution to a volume of 50 mL. [Multiple solutes may be used] **(04 hours)**
2. To determine the relative strength of two acids i.e., HCl and H_2SO_4 by using them as catalysts for the hydrolysis of methyl acetate. **(02 hours)**
3. To study the hydrolysis of methyl acetate using two different initial concentrations in presence of mineral acid (HCl) as catalyst. **(04 hours)**

ORGANIC CHEMISTRY

1. Purification of solid organic compounds by recrystallization followed by determination of melting point:
 - a. Benzoic acid from water; b. m-Dinitrobenzene from ethanol (02 hours)
2. Purification of solid organic compounds by sublimation:
 - a. Naphthalene b. Anthracene c. Camphor (any two) (02 hours)
3. Organic Synthesis:
 - a. Benzoylation of β -naphthol and aniline. (02 hours)
 - b. Bromination of aromatic compounds using KBrO_3 (02 hours)
 - c. Anthraquinone from anthracene (Oxidation reaction) (02 hours)

INORGANIC CHEMISTRY

1. Estimation of Calcium from CaCO_3 by EDTA method. (02 hours)
2. To prepare 100 ppm Manganese solution using KMnO_4 and carry out the further dilutions like 5, 10, 20 ppm. (02 hours)
3. To prepare 0.1 N $\text{Na}_2\text{C}_2\text{O}_4$ solution and use it to standardize the given KMnO_4 solution. (02 hours)
4. Preparation of chrome Red. (02 hours)
5. Preparation of ferrous ammonium sulphate. (02 hours)

REFERENCE BOOKS:

Mandatory:

1. Atkins, P., Paula, J. D. Atkins' Physical Chemistry, Oxford University Press.
2. Morrison, R. T., Boyd, R. N. and Bhattacharjee, S. K., Organic Chemistry, Pearson India.
3. Atkins, P., Overton, T., Rourke, J., Weller, M., Armstrong, F., Shriver and Atkins' Inorganic Chemistry, Oxford University Press.
4. Concise Inorganic Chemistry, J. D. Lee; 5th Edition, Chapman and Hall

Supplementary:

1. Bahl A., Bahl B. S. and Tuli, G. D. Essentials of Physical Chemistry, S. Chand and Company Ltd., New Delhi.
2. Puri B. R., Sharma L. R. and Pathania M. S., Principles of Physical Chemistry, Vishal Publishing Co.
3. Raj G., Advanced Physical Chemistry, Goel Publishing House, Meerut.
4. Bhattacharjee J. et al, Textbook of Chemistry, First edition, Rajhauns Vitaran, Panaji Goa.
5. Bruise P. Y., Organic Chemistry, 7th Edition, Pearson Education Pvt. Ltd. New Delhi India.
6. Carey F., Organic Chemistry; 8th Edition, Tata McGraw Hill Education Pvt. Ltd. New Delhi India.
7. Greenwood, N. N., Earnshaw, A., Chemistry of Elements, Pergamon, Oxford.
8. Huheey, J. E., Keiter, E. A., Keiter, R. L., Medhi, O. K. Inorganic Chemistry: Principles of Structure and Reactivity, Pearson.
9. Cotton, F. A., Wilkinson, G., Basic Inorganic Chemistry, Wiley Publications.
10. Puri, B. R., Sharma, L. R., Kalia, K. C. Principles of Inorganic Chemistry, Vishal Publishing Co.
11. Housecroft, C. E. and Sharpe, A. G., Inorganic Chemistry, Prentice Hall.

PRACTICAL BOOKS:

1. Khosla B. D., Garg V. C., Gulati A., Senior Practical Physical Chemistry, S. Chand and Co., New Delhi
2. Mendham J., Barnes J. D., Denney R. C., Thomas M. J., Sivasankar B., Vogel's Text book of Quantitative Chemical Analysis, Pearson.

WEB REFERENCES:

1. http://alpha.chem.umb.edu/chemistry/ch115/Mridula/CHEM%20116/documents/chapter_14auLectureSlides_000.pdf

2. <https://www.livescience.com/53304-gases.html>
3. https://www.slideshare.net/kumar_vic/solid-state-chemistry-17237117
4. [https://chem.libretexts.org/Bookshelves/Physical_and_Theoretical_Chemistry_Textbook_Maps/Supplemental_Modules_\(Physical_and_Theoretical_Chemistry\)/Physical_Properties_of_Matter/States_of_Matter/Properties_of_Gases/Kinetic_Theory_of_Gases/Basics_of_Kinetic_Molecular_Theory](https://chem.libretexts.org/Bookshelves/Physical_and_Theoretical_Chemistry_Textbook_Maps/Supplemental_Modules_(Physical_and_Theoretical_Chemistry)/Physical_Properties_of_Matter/States_of_Matter/Properties_of_Gases/Kinetic_Theory_of_Gases/Basics_of_Kinetic_Molecular_Theory)
5. <https://www.khanacademy.org/science/organic-chemistry/gen-chem-review>
6. <https://www.khanacademy.org/science/organic-chemistry/substitution-elimination-reactions>
7. <https://www.khanacademy.org/science/organic-chemistry/bond-line-structures-alkanes-cycloalkanes>
8. <https://www.thoughtco.com/valence-shell-electron-pair-repulsion-theory-605773>
9. <https://www.britannica.com/science/covalent-bond>
10. <https://www.electrical4u.com/schrodinger-wave-equation/>
11. http://www.chem4kids.com/files/atom_structure.html
12. <https://pubchem.ncbi.nlm.nih.gov/periodic-table/>

SEMESTER- II

CORE COURSE

THEORY

Course Code: UG-CHE-102

Course Title: General Chemistry-II

Credits: 3

Duration: 45 Hours

Maximum Marks: 75

Course Objectives:

1. To have a knowledge of the main areas of Physical Chemistry, will develop critical thinking abilities and be able to work in chemical or related fields.
2. To get better understanding about the basics of Solid-state Chemistry and Gaseous state.
3. To represent 3 D structures of organic molecules on 2 D surfaces.
4. To gain knowledge about two important classes of organic compounds, i.e., alkenes and alkynes.
5. To learn the chemistry of s-block and p-block elements and their compounds.

Course Learning Outcomes:

On successful completion of the course, the student will be able to:

CLO1: Understand and apply the different properties of liquids, gas laws and PV Isotherms

CLO2: Apply the theoretical knowledge to synthesize alkenes, alkynes and delineate the concept of Stereochemistry.

CLO3: To compare and explain the properties of elements within the s-block and p-block in the periodic table in relationship with the other elements.

CLO4: Apply the theoretical knowledge to perform experiments.

MODULE I: PHYSICAL CHEMISTRY

15 hours

Unit 1: Liquid State and Applications

The Inter molecular forces, structure of liquids (qualitative description), structural differences between solids, liquids and gases, Physical properties of liquids: vapour pressure, surface tension, surface tension by capillary rise method, drop number method using stalagmometer, Viscosity of liquids, Poiseuille's equation, determination of viscosity using Ostwald's viscometer. Introduction to liquid crystals (Numerical expected).

Unit 2: The Gaseous State

Kinetic molecular theory of gases, its postulates and derivation of kinetic gas equation. Gas laws, ideal gas equation, compressibility factor, the van der Waal's correction factors, and its equation of state; Liquefaction of gases: critical phenomena, PV isotherms of CH₄ and CO₂, relationship between critical constants and van der Waal's constants, the law of corresponding states and reduced equation of state; Maxwell distribution of molecular velocities and its use in evaluating average, root mean square and most probable velocities. (Numerical expected)

MODULE II: ORGANIC CHEMISTRY

15 hours

Unit 1: Study of alkenes and alkynes

Alkenes: Physical properties and relative stabilities of alkenes; preparation of alkenes: elimination reactions (regioselectivity to be explained using The Zaitsev rule)- dehydration of alcohols and dehydrohalogenation of alkyl halides (E1 and E2 mechanisms); reactions of alkenes: hydrogenation, addition of halides and hydrogen halides, regioselectivity of hydrogen halide addition, hydroboration and oxidation reactions, oxymercuration-demercuration reactions, epoxidation of alkenes, ozonolysis of alkenes.

Alkynes: Sources of alkynes, physical properties of alkynes, acidity of acetylene and terminal alkynes, preparation of alkynes by elimination reactions (from tetra halides and vicinal dihalides), conversion of acetylene and terminal alkynes into higher alkynes; reactions of alkynes: hydrogenation, reactions with Lindlar catalyst, metal-ammonia reduction, addition of hydrogen halides, hydration of alkynes.

Unit 2: Stereochemistry

Concept of isomerism, types of isomers: constitutional, conformational (ethane, butane and cyclohexane) and configurational isomerism; chirality (upto two chiral carbons), enantiomers and diastereomers (with example of threo and erythro diastereomers, D and L, meso compounds); representation of configuration by- 3D Projection (Wedge and dotted projection), Fischer projection, Newmann projection and Saw horse projection and their interconversions; Cahn-Ingold-Prelog sequence rules: R/S configuration (for upto two chiral carbons) and E/Z nomenclature (for up to two C=C systems).

MODULE III: INORGANIC CHEMISTRY

15 hours

Unit 1: Chemistry of s-block elements

General properties, comparative study within groups, diagonal relationship, salient features of hydrides, solvation and complexation tendencies and biological importance, introduction to alkyls and aryls.

Unit 2: Chemistry of p-block Elements

Comparative study within group and diagonal relationship of groups 13, 14, 15, 16, 17; Hydrides of Boron, diborane and higher boranes, borazine, borohydrides, fullerenes, carbides, fluorocarbons, silicates (structural principle), phosphazenes, tetra sulfur tetranitride, basic properties of halogens, inter halogens and poly halides.

PRACTICALS

Course Code: UG-CHE-102

Course Title: General Chemistry-II

Credit: 1

Duration: 30 Hours

Maximum Marks: 25

LIST OF EXPERIMENTS

PHYSICAL CHEMISTRY

1. To standardize hydrochloric acid against sodium carbonate.

(02 hours)

2. To standardize sodium hydroxide against potassium hydrogen phthalate (02 hours)
3. To determine viscosity of a given liquids using Ostwald's Viscometer. (03 hours)
4. To determine the surface tension of a liquid by drop number method using stalagmometer (03 hours)

ORGANIC CHEMISTRY

1. Qualitative Analysis (any five solids): (10 hours)
 Acids: Benzoic, salicylic, phthalic Phenols: α -Naphthol, β -naphthol
 Bases: p-Toluidine, diphenylamine, o-, m- and p-nitro anilines, Anilides: Acetanilide, benzanilide
 Hydrocarbons: Naphthalene, anthracene
 Amides: Benzamide, urea Haloarenes: p-Dichlorobenzene
 Nitro Compounds: m-Dinitrobenzene, p-nitrotoluene Carbohydrates: Glucose, fructose, mannose.

INORGANIC CHEMISTRY

1. To estimate the amount of Zn^{2+} ion from $ZnCO_3$ by EDTA titration. (02 hours)
2. To estimate the amount of Mg^{2+} ion from MgO by EDTA titration. (02 hours)
3. Volumetric estimation of Fe^{2+} using internal indicator by potassium dichromate method. (02 hours)
4. To determine the alkali content in antacid tablet using standard HCl solution. (02 hours)
5. To determine the Total Dissolved Solids (TDS) of Magnesium Sulphate. (02 hours)

REFERENCE BOOKS:

Mandatory:

1. Atkins, P., Paula, J. D. Atkins' Physical Chemistry, Oxford University Press.
2. Morrison, R. T., Boyd, R. N. and Bhattacharjee, S. K., Organic Chemistry, Pearson India.
3. Lee, J. D., Concise Inorganic Chemistry, ELBS Publications.
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Supplementary:

1. Bahl A., Bahl B. S. and Tuli, G. D. Essentials of Physical Chemistry, S. Chand and Company Ltd., New Delhi.
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3. Raj G., Advanced Physical Chemistry, Goel Publishing House, Meerut.
4. Bhattacharjee J. etal, Textbook of Chemistry, First edition, Rajhauns Vitaran, Panaji Goa.
5. Bruise P. Y., Organic Chemistry, 7th Edition, Pearson Education Pvt. Ltd. New Delhi India.
6. Carey F., Organic Chemistry; 8th Edition, Tata McGraw Hill Education Pvt. Ltd. New Delhi India.
7. Greenwood, N. N., Earnshaw, A. Chemistry of Elements, Pergamon, Oxford. Huheey, J. E., Keiter, E. A., Keiter, R. L., Medhi, O. K.; Inorganic Chemistry: Principles of Structure and Reactivity, Pearson.
8. Cotton, F. A., Wilkinson, G., Basic Inorganic Chemistry, Wiley Publications.
9. Puri, B. R., Sharma, L. R., Kalia, K. C., Principles of Inorganic Chemistry, Vishal Publishing Co.
10. Sharpe and Emilus, Inorganic Chemistry.
11. Housecroft, C. E. and Sharpe, A. G. Inorganic Chemistry, Prentice Hall.

PRACTICAL BOOKS:

1. Khosla B. D., Garg V. C., Gulati A., Senior Practical Physical Chemistry, S. Chand and Co., New Delhi.
2. Furniss, B., Brian, S., Vogel's Textbook of Practical Organic Chemistry, Pearson Education.
3. Mendham J., Barnes J. D., Denney R. C., Thomas M. J., Sivasankar B., Vogel's Text book of Quantitative Chemical Analysis, Pearson.

WEB REFERENCES:

1. <https://www.khanacademy.org/science/organic-chemistry/gen-chem-review>
2. <https://www.khanacademy.org/science/organic-chemistry/stereochemistry-topic>
3. <https://www.khanacademy.org/science/organic-chemistry/alkenes-alkynes>
4. <https://depts.washington.edu/eoopic/linkfiles/The%20Elements.pdf>
5. <https://www.sciencedirect.com/topics/chemistry/stereochemistry>
6. <https://www.sciencedirect.com/topics/chemistry/detailed-reaction-mechanisms>
7. http://web.chem.ucla.edu/~harding/notes/notes_14D_additionpi_bonds.pdf
8. <http://www.chem.ucalgary.ca/courses/350/Carey5th/Ch05/ch5-4.html>
9. https://www.slideshare.net/kumar_vic/solid-state-chemistry-17237117
10. [https://chem.libretexts.org/Bookshelves/Physical_and_Theoretical_Chemistry_Textbook_Maps/Supplemental_Modules_\(Physical_and_Theoretical_Chemistry\)/Physical_Properties_of_Matter/States_](https://chem.libretexts.org/Bookshelves/Physical_and_Theoretical_Chemistry_Textbook_Maps/Supplemental_Modules_(Physical_and_Theoretical_Chemistry)/Physical_Properties_of_Matter/States_)

Annexure C (UG Programme)
Name of the Programme: B. Sc. in Chemistry
NEW SYLLABUS
(To be implemented w.e.f. Academic Year 2024 - 2025)

SEMESTER II

SKILL ENHANCEMENT COURSE

THEORY

Course Code: CHE-SEC-3

Course Title: Chemistry of Water and Soil

Credits: 2

Duration: 30 Hours

Maximum Marks: 50

Course Objectives:

1. To make students understand about the chemistry of water.
2. To provide the knowledge of chemistry to soil
3. To provide basic practical knowledge by doing experiments in laboratory.

Course Learning Outcomes:

On successful completion of the course, the student will be able to:

CLO1: Understand the chemistry of water and soil.

CLO2: Discuss the chemistry of soil.

CLO3: Explain the parameters tested for water and soil analysis.

CLO4: Develop practical skill by performing experiments in laboratory.

MODULE I: Chemistry of Water

15 hours

Introduction and structure of water molecule, various fresh and sea water resources; physical and chemical properties of water: colour, odour, turbidity, total salt content, total suspended solids in water; composition of different types of water such as surface, ground, and sea water; dissolved gases, factors affecting natural waters.

Analysis of Water: Collection and preservation of water samples, measurement of temperature, transparency, turbidity, determination of pH, conductance, salinity, dissolved oxygen, free carbon dioxide, total alkalinity, total hardness, calcium, magnesium, inorganic nitrogen (ammonium and nitrate) and phosphorus; water quality criteria and requirements for aquaculture.

Water Pollution: Definition of water pollution, water pollutants and its sources, trace element in water, water quality parameters and standards, purification of domestic and industrial water.

MODULE II: Chemistry of Soil

15 hours

History of soil origin, nature, classification, and composition of soil; important soil forming minerals; soil as ecosystem; Properties of soil: colour, texture, temperature, pH, porosity, bulk density, water holding capacity, soil salinity and soil density; types of soil and their distribution, organic carbon, Carbon - Nitrogen ratio, soil fertility and productivity.

Soil erosion: Definition, causes, control of erosion, soil conservation practices, causes of soil pollution and remedies.

Analysis of soil: collection and preparation of soil samples; determination of soil texture, water holding capacity, pH, conductivity, organic carbon, nitrogen, phosphorus, lime requirement.

Soil and water amendments: lime manures, fertilizers, micronutrients, zeolites, alum, gypsum.

PRACTICAL

Course Code: CHE-SEC-3

Course Title: Chemistry of Water and Soil

Credits: 1

Duration: 30 Hours
Maximum Marks: 25

EXPERIMENTS

1. Detection of chloride, sulphate, nitrate, and phosphate ions in different water samples.
2. Detection of chloride, sulphate, nitrate, and phosphate ions in different soil samples.
3. Detection of lead, magnesium, calcium and potassium ions in different water and soil samples.
4. Determination of carbonate and bicarbonate in the given water sample.
5. Determination of pH of different water and soil samples using pH paper and pH meter.
6. Determination of temperature of the given water samples.
7. Determination of salinity of different water samples.
8. Estimation of residual chlorine in water by Iodometric method.
9. Determination of the total dissolved solids of given water sample.
10. Determination of moisture content in different soil samples.
11. Determination of bulk density of the given soil samples.
12. Determination of specific gravity of the given soil samples.
13. Determination of alkalinity of the given soil sample.
14. Determination of chloride in the given soil sample.
15. Determination of carbonate and bicarbonate in the soil sample.

*Each practical is of two Hours.

REFERENCE BOOKS:

Mandatory:

1. Trivedi, P. R. and Raj, G.; Environmental water and soil analysis, Akashdeep Publishing House, New-Delhi.
2. Chhatwal, G. R.; Environmental Analysis: air, water, and soil.
3. De, A. K.; Environmental Chemistry; New age international publishers.

Supplementary:

1. Gupta, P. K.; Methods in environmental analysis: water, soil, and air, 2nd Edition, Agrobios India.

PRACTICAL BOOKS:

1. Khosla B. D., Garg V. C., Gulati A., Senior Practical Physical Chemistry, S. Chand and Co., New Delhi.
2. Mendham J., Barnes J. D., Denney R. C., Thomas M. J., Sivasankar B., Vogel's Text book of Quantitative Chemical Analysis, Pearson.
3. Elias, A. J.; General Chemistry Experiments, 2002, Sangam Books Ltd.

WEB REFERENCES:

1. https://pdf.usaid.gov/pdf_docs/PNABY897.pdf
2. [https://www.stannescet.ac.in/cms/staff/qbank/CSE/Notes/CY8151-Engineering%20Chemistry-1098045625-unit_1%20\(1\).pdf](https://www.stannescet.ac.in/cms/staff/qbank/CSE/Notes/CY8151-Engineering%20Chemistry-1098045625-unit_1%20(1).pdf)
3. https://www.uaeu.ac.ae/en/cavm/doc/aridland/methods_of_analysis.pdf
4. https://epgp.inflibnet.ac.in/epgpdata/uploads/epgp_content/S000944AC/P001638/M027122/ET/152396498219QuadrantIE-TEXT.pdf

SEMESTER III

MINOR COURSE

THEORY

Course Code: UG-CHE-207

Course Title: Concepts in Chemistry-III

Credits: 3

Duration: 45 Hours

Maximum Marks: 75

Course Objectives:

1. To understand the mechanism and applications of catalytic processes.
2. To have practical knowledge of synthesis and characterization of catalysts.
3. To learn the chemistry of alcohols and diols.
4. To understand the chemistry of aromatic compounds and learn the mechanisms involved in electrophilic aromatic substitution reactions.
5. To develop experimental skills required in Organic Chemistry Laboratory.
6. To understand the acid and base concepts with respect to aqueous and non-aqueous solvent systems.
7. To understand ionic solids in terms of their structure, ionic radii, packing efficiency, coordination number and their defects.

Course Learning Outcomes:

On successful completion of the course, the student will be able to:

CLO1: Predict the mechanistic behaviour of catalytic reactions.

CLO2: Synthesize and characterize the catalysts.

CLO3: Classify alcohols, diols and analyse their chemical reactivity.

CLO4: Understand the concept of aromaticity and aromatic compounds and learn the mechanisms involved in electrophilic aromatic substitution reactions.

CLO5: Explain the concepts of Acids and Bases and apply them to chemical reactions in aqueous and non-aqueous solvents.

CLO6: Describe crystalline solids in terms of their structure, ionic radii, coordination and explain the type of defects in their crystal structures.

CLO7: Perform experiments to develop experimental skills.

MODULE I: PHYSICAL CHEMISTRY

15 hours

Unit 1: Catalysis

Introduction to catalysis, Types of catalysis, Characteristics of catalysts, Classification of catalysis. Theory of Homogenous catalysis; function of a catalyst in terms of Gibbs Free energy of activation; theory of heterogeneous catalysis; quantitative treatment of adsorption theory; kinetics of heterogeneous reactions; effect of temperature on heterogeneous reactions; absolute rate theory in heterogeneous gas reactions; enzyme catalysis; Characteristics of enzyme catalysis; factors governing rate of enzyme catalysed reactions; mechanism and kinetics of enzyme catalysed reactions; Michaelis-Menten equation; Acid-base catalysis; mechanism and kinetics of acid-base catalysis; catalytic coefficients; Hammett and Bronsted equation (derivation not needed); acidity function. Some important classes of catalysts.

MODULE II: ORGANIC CHEMISTRY

15 hours

Unit 1: Study of Alcohols and Diols

Alcohols: Classification, structure and bonding, physical properties, methods of preparation- catalytic hydrogenation, metal hydride reduction, Grignard reaction (using formaldehyde, other aldehydes, and ketones), reactions of alcohols- oxidation reactions using chromic acid, KMnO_4 , PCC and PDC, conversion of alcohols to ethers, Fischer esterification; Diols: Classification, methods of preparations;

reaction of vicinal diols- Pinacol-Pinacolone rearrangement with mechanism.

Unit 2: Arenes and Aromaticity

Structure of benzene: Molecular formula and Kekule structure, stability and carbon-carbon bond lengths of benzene, resonance structure, molecular orbital picture, criteria for aromaticity, polycyclic aromatic hydrocarbons, physical properties of arenes, electrophilic aromatic substitution reactions- reactions and mechanisms of nitration, halogenations, sulphonation, and Friedel Craft's reactions, activating and deactivating substituents, orientation, and ortho/para ratio.

MODULE III: INORGANIC CHEMISTRY

15 hours

Unit 1: Acids, Bases, and Non-Aqueous Solvents

Acids and Bases: Arrhenius theory, Bronsted-Lowry theory, Lewis's concept of acid and bases; Solvent System: Physical properties of a solvent; Solvents and their general characteristics; Reactions in non-aqueous solvent with respect to liquid NH_3 and liquid HF.

Unit 2: Ionic Solids: Structure and Bonding

Introduction to bonding in solids, types of bonds, properties of ionic substances, structure of ionic solids (NaCl , CsCl , ZnS , CaF_2), lattice energy, factors affecting radii of ions, packing efficiency, radius ratio and coordination number, limitations of radius ratio, Fajan's rules, defects in solids: point defects, color centers, extended defects, non-stoichiometric defects, conductivity in ionic solids.

PRACTICALS

Course Code: UG-CHE-207

Course Title: Concepts in Chemistry-III

Credit: 1

Duration: 30 Hours

Maximum Marks: 25

LIST OF EXPERIMENTS

PHYSICAL CHEMISTRY:

1. To study the acid catalysed inversion of cane sugar by polarimetry.
2. To synthesize ZnO from ZnCO_3 by decomposition method and determine the amount of zinc in ZnO by complexometric method.
3. To calculate band gap of any three catalysts using their UV-DRS data.
4. To determine the energy of activation of the autocatalytic reaction between KMnO_4 and oxalic acid.
5. To calculate the Scherrer particle size of any three catalysts using their X-ray diffractograms spectra.

*Each practical is two hours duration.

ORGANIC CHEMISTRY:

1. Purification of toluene using Distillation technique and determination of boiling point. **(02 hours)**
2. Purification of Ethyl acetate using Distillation technique and determination of boiling point. **(02 hours)**
3. Synthesis of *p*-bromo acetanilide from acetanilide. **(02 hours)**
4. Qualitative Analysis (any two liquids): **(04 hours)**
Alcohols: Ethanol, 1-propanol, 2-propanol, 1-butanol, 1-hexanol, cyclohexanol.
Esters: Methyl acetate, ethyl acetate, ethyl benzoate, methyl salicylate

INORGANIC CHEMISTRY:

1. Preparation of Hexamine nickel (II) chloride complex.
2. Estimation of Nickel in hexamine nickel (II) chloride by EDTA method.

3. Preparation of Tetraamine copper (II) sulphate monohydrate.
4. Estimation of Copper (II) from tetraamine copper (II) sulphate by iodometry.
5. Gravimetric estimation of Fe as Fe_2O_3
*Each practical is of two hours.

REFERENCE BOOKS:

Mandatory:

1. Raj G., Advanced Physical Chemistry, Goel Publishing House
2. Morrison, R. T., Boyd, R. N. and Bhattacharjee, S. K., Organic Chemistry, Pearson India.
3. Lee, J. D., Concise Inorganic Chemistry, ELBS Publications.

Supplementary:

1. Adamson A. W., Physical Chemistry of Surfaces, Inter science Publishers.
2. Bowker M., The Basis and Applications of Heterogeneous Catalysis, Oxford University Press.
3. Somorjai G. A., Introduction to Surface Chemistry and Catalysis, Wiley, New York.
4. Cotton, F. A., Wilkinson, G., Basic Inorganic Chemistry, Wiley Publications.

PRACTICAL BOOKS:

1. Rajbhog S. W. and Chondhekar T. K., Systematic Experimental Physical Chemistry.
2. Furniss, B., Brian, S., Vogel's Textbook of Practical Organic Chemistry, Pearson Education.
3. Mendham J., Barnes J. D., Denney R. C., Thomas M. J., Sivasankar B., Vogel's Text book of Quantitative Chemical Analysis, Pearson.

WEB REFERENCES:

1. <https://www.britannica.com/science/catalysis/Classification-of-catalysts>
2. <https://www.scienceofhealthy.com/enzyme-catalysis/>
3. https://www.mlsu.ac.in/econtents/1334_Benzene_Introduction.pdf
4. <https://www.dalalinstitute.com/wp-content/uploads/Books/A-Textbook-of-Organic-Chemistry-Volume-1/ATOOCV1-8-0-Aromatic-Electrophilic-Substitution.pdf>
5. <https://egyankosh.ac.in/bitstream/123456789/59588/1/Unit15.pdf>
6. <https://byjus.com/chemistry/pinacol-pinacolone-rearrangement/>

Annexure I: (PG Programme)

Name of the Programme: M. Sc. Analytical Chemistry

(Summary of changes incorporated in the existing approved syllabus)

Semester	Course Title	Existing (Indicate only the unit where the change is proposed)	Changes Proposed	Specify the reason for the change
I	CHIC – 401: General Inorganic Chemistry	-	Rearrange CLO3 in place of CLO4	Updation in CLOs
	CHPE – 401: Topics in Physical Chemistry	MODULE I	Summarization of CLO4 and include Faraday’s magnetic susceptibility	Updation in CLOs and course content
II	CHOC-402: Laboratory Course in Organic Chemistry	-	Change CLO4 from synthesize the studied organic compounds and purify them to understand the synthesis of selected organic compounds	Updation in the CLOs
	CHAC – 402: Laboratory Course in Analytical Chemistry	MODULE I	Find alternative method for experiment “Estimation of chloride by spectrophotometry using mercury (II) thiocyanate”	Alternative method in experiment
	CHAC – 402: Laboratory Course in Analytical Chemistry	MODULE III	TGA analysis must include the preparation of hydrated salt, calculation of isothermal weight loss and interpretation of data	Addition of content in the experiment
	CHAC – 402: Laboratory Course in Analytical Chemistry	MODULE III	Example must be included in the DSC experiment	Specification of tablet name in the experiment
	CHIE – 401: Topics in Inorganic Chemistry	MODULE II	Removal of Bronsted acid and change in the font style of phosphorous cage compounds	Updation in the content of the course
III	CHAE – 502: Methods of Analysis	-	Rearrangement of the courses between Semester II and Semester III	Updation in semester courses
	CHAE – 504: Advanced NMR Spectroscopy	MODULE I and II	Include interpretation of NMR Spectra	Updation in the content
	CHAE – 506: Quality Assurance and Quality Control in Analytical Chemistry	-	Analysis of impurity profile to be included	Updation in CLO

REVISED SYLLABUS
(To be implemented w.e.f. Academic Year 2024 - 2025)

SEMESTER I

Course Code: CHOC-401

Course Title: Fundamentals of Organic Chemistry

Credits: 4

Duration: 60 Hours

Maximum Marks: 100

Course Objectives:

1. To develop the knowledge of students on the molecular orbital theory
2. To develop the knowledge of students on the concepts of topicity, pro stereoisomerism and chemo-, regio- and stereoselectivity in organic reactions
3. To develop the knowledge of students on mechanisms of reactions in organic synthesis

Course Learning Outcomes:

On successful completion of the course, the student will be able to:

CLO1: Identify the presence of aromaticity, chirality and topicity in organic compounds

CLO2: State methods for determining reaction mechanisms

CLO3: Understand and apply HSAB concept

CLO4: Explain stereochemistry involved in various addition and elimination reactions

MODULE I: Stereochemistry

15 Hours

Configurational nomenclature: *R* and *S*; *D*- and *L*- ; *E* and *Z*; *cis* and *trans*; *syn* and *anti* nomenclature; chirality in molecules with two and more chiral centres; conformational analysis of open chain compounds; *erythro* and *threo* nomenclature; structure, conformation and stereochemistry of monocyclic cycloalkanes (cyclopropane, cyclobutane, cyclopentane, cyclohexane, cycloheptane and cyclooctane) with simple substituents; topicity and prostereoisomerism- topicity of ligands and faces; homotopic, enantiotopic and diastereotopic ligands and faces; chemoselective, regioselective and stereoselective reactions;

stereochemistry of *cis*- and *trans*-decalins; conformation and reactivity of cyclohexane, substituted cyclohexanes 'stereochemistry of cyclohexene and cyclohexanone' 2-alkyl and 3- alkyl ketone effect; introduction to stereochemistry of compounds containing N, S and P.

MODULE II: Molecular orbitals, delocalized chemical bonding, Structure and Reactivity

15 Hours

Molecular orbitals of simple acyclic and monocyclic systems, qualitative description; frontier orbitals; importance of FMOs in organic reactions; conjugation, cross conjugation, resonance, hyper conjugation and tautomerism; alternant and non-alternant hydrocarbons; aromaticity in benzenoid and non-benzenoid compounds; Huckel's rule; annulenes, aromatic, non-aromatic and anti-aromatic compounds; Acidity and basicity- different concepts, HSAB concept and factors affecting it; effect of structure and medium on acid and base strength; concept of super acids and super bases; electrophilicity and nucleophilicity, ambident nucleophiles and electrophiles, concepts and examples; tautomerism- concept, tautomeric equilibrium, relation with isomerism; types of tautomerism including ring, chain tautomerism and valence tautomerism; proto tropic shift in different systems.

MODULE III: Reaction Mechanism

15 Hours

Generation, structure, stability and reactivity of carbocations, carbanions, free radicals, carbenes and nitrenes; types of- reactions, mechanisms; thermodynamic and kinetic- requirements, control; the Hammond postulate and principle of microscopic reversibility; methods for determining reaction mechanisms like identification of products; determination of the presence of intermediates(isolation,

detection, trapping and addition of suspected intermediate); isotopic labeling; stereochemical evidence; kinetic evidence and isotope effect (sufficient reactions to exemplify each method be studied).

MODULE IV: Addition to carbon-carbon multiple bonds and elimination reactions 15 Hours

Mechanism and stereochemistry of addition reactions involving electrophiles, nucleophiles and free radicals; addition of HCl, HBr, HI, HOH, R-OH, NH₃, H₂SO₄, and halogen Br₂ to carbon-carbon double and triple bonds in open chain and cyclic compounds; addition of H₂ to C-C multiple bonds; hydroboration-oxidation and oxymercuration/ demercuration; elimination reaction- the E₂, E₁ and E₁cb mechanisms; orientation of the double bond, Saytzeff and Hofmann rule; effects of changes in the substrate, base, leaving group and medium on overall reactivity; comparison between E₁, E₂ and E₁cb; elimination verses substitution; mechanism and orientation in pyrolytic syn elimination; various examples involving cyclic and acyclic substrates.

REFERENCE BOOKS:

Mandatory:

1. Advanced Organic Chemistry Reaction, Mechanism and Structure, J. March, 4th Edition, John Wiley

Supplementary:

1. Stereochemistry and Chemistry of Natural Products, I. L. Finar; ELBS, Longmans
2. Stereochemistry, V. M. Potapov, MIR Publishers, Moscow
3. Organic Chemistry, F. A. Carey
4. Organic Chemistry, S.H. Pine; 5th Edition, McGraw-Hill International
5. Advanced Organic Chemistry, F. A. Carey, R. J. Sundberg; Vol I and II, Plenum Press
6. Fundamentals of Organic Reaction Mechanisms, M. Hamis, Carl C. Wamser, John Wiley and Sons
7. Organic Chemistry- A Concise Approach, F. M. Menger, D. J. Goldsmith and L. Mendell
8. Organic Laboratory Techniques; R. J. Fessenden, J. S. Fessenden, Brookes/Cole Publishing Company
9. Stereochemistry of Organic Compounds- Principles and Application, D. Nassipuri, 2nd Edition, Wiley Eastern Limited
10. Mechanism and Structure in Organic Chemistry, E. S. Gould et al.
11. Stereochemistry of Carbon Compounds, E. L. Eliel, Tata MacGraw Hill

WEB REFERENCES:

1. <https://www.sciencedirect.com/topics/chemistry/stereochemistry>
2. <https://www.sciencedirect.com/topics/chemistry/detailed-reaction-mechanisms>
3. http://web.chem.ucla.edu/~harding/notes/notes_14D_additionpi_bonds.pdf
4. <http://www.chem.ucalgary.ca/courses/350/Carey5th/Ch05/ch5-4.html>
5. <http://home.iitk.ac.in/~madhavr/CHM102/Lec13.pdf>

Course Code: CHOC-402

Course Title: Laboratory Course in Organic Chemistry

Credits: 2

Duration: 60 Hours

Maximum Marks: 50

Course Objectives:

1. To enable the students to apply certain theoretical concepts experimentally
2. To provide students with hands on experience on the basic laboratory techniques required for

organic syntheses

Course Learning Outcomes:

On successful completion of the course, the student will be able to:

CLO1: Gain the understanding of stoichiometric requirements during organic syntheses

CLO2: Understand safe and good laboratory practices, handling of laboratory glassware, chemical reagents and equipment

CLO3: Learn common laboratory techniques including reflux, distillation, steam distillation, vacuum distillation, and aqueous extraction

CLO4: To understand the synthesis of selected organic compounds

I. Laboratory Techniques

1. Introduction to safety techniques: First aid; Fire extinguishers; usage of hazardous chemicals
2. Simple distillation: Ethanol-water mixture using water condenser, Nitrobenzene and aniline using air condenser
3. Steam distillation: Clove oil from cloves or separation of *o*- and *p*- nitro phenols
4. Crystallization: Concept of induction of crystallization
 - i. Crystallization of phthalic acid from hot water using fluted filter paper and stem less funnel
 - ii. Acetanilide from boiling water
 - iii. Decolourisation and crystallization of brown sugar (sucrose) with activated charcoal using gravity filtration
5. Sublimation: Simple sublimation of camphor and succinic acid

II. Organic Synthesis

1. Aliphatic electrophilic substitution: Preparation of iodoform from ethanol and acetone
2. Aromatic electrophilic substitution: Preparation of *p*-bromoacetanilide
3. Oxidation: i. Benzoic acid from toluene ii. Iso-borneol to camphor using Jones reagent iii. Cyclohexanone from cyclohexanol (any one)
4. Reduction: *p*-nitrophenyl methylcarbinol from *p*-nitro acetophenone by NaBH₄ and purification of the product through distillation under reduced pressure.
5. Bromination of an alcohol using KBr/ KBrO₃ (at micro scale level)
6. Aldol condensation: Dibenzal acetone from Benzaldehyde
7. Cannizzaro reaction using 4-chlorobenzaldehyde as substrate
8. Preparation of benzylideneaniline from benzaldehyde
9. Preparation of chalcone from benzaldehyde and acetophenone
10. Esterification: Preparation of Butyl acetate from 1-Butanol

III. Extractions of:

11. Cinnamaldehyde from cinnamon sticks
12. Caffeine from tea bags

PRACTICAL BOOKS:

1. Experiments and Techniques in Organic Chemistry, D. Pasto, C. Johnson and M. Miller; Prentice Hall
2. Organic Experiments, K. L. Williamson, D. C. Heath
3. Experimental Organic Chemistry, Vol I and II, P. R. Singh, D. S. Gupta, K. S. Bajpai; Tata McGraw Hill
4. Laboratory Manual in Organic Chemistry, R. K. Bansal; Wiley Eastern
5. Green Chemistry, Samuel Delvin; IVY Publishing House, Delhi
6. Organic Chemistry Laboratory, O. R. Rodig, C. E. Bell Jr. and A. K. Clark; Saunders College Publishing, New York
7. Organic Analytical Chemistry, Jag Mohan; Narosa Publishing House, New Delhi
8. Vogel's Textbook of Practical Organic Chemistry, A. R. Tatchell; John Wiley

Course Code: CHPC-401
Course Title: General Physical Chemistry
Credits: 4
Duration: 60 Hours
Maximum Marks: 100

Course Objectives:

1. To enable students to understand the mechanism of reactions in nature
2. To enable students to understand the concept of micro-objects and its solutions with the help of quantum chemistry
3. To provide students with detail knowledge about thermodynamics and equilibrium systems

Course Learning Outcomes:

On successful completion of the course, the student will be able to:

CLO1: Propose the mechanism of different reactions taking place in the environment.

CLO2: Interpret the significance of internal energy, enthalpy, entropy, and free energy in thermodynamic processes.

CLO3: Apply the Hückel Molecular Orbital theory to analyze and predict molecular properties for conjugated molecules

CLO4: Analyze critically the role of various factors in achieving desired outcomes in electrochemical processes.

MODULE I: Quantum Chemistry

15 Hours

Historical development of quantum theory, principle of quantum mechanics, wave particle duality, uncertainty principles; operators, functions, Eigen value equations; Schrodinger equation, application to simple system viz. free particle, particle in one dimensional, two dimensional and three dimensional box (quantization, separation of variables, degenerate wave functions); Hydrogen like atoms, Schrodinger equation and its solutions; atomic orbital wave function and interpretation; Hückel MO theory, secular equations, secular determinant, delocalization energy, charge density, pi-bond order, free valence, applications to C₂H₄, C₃H₅(radical), C₄H₆, C₄H₄, C₆H₆, C₆H₈.

MODULE II: Thermodynamics

15 Hours

Thermodynamic properties- state and path properties; intrinsic and extrinsic properties, exact and inexact differentials, internal energy, enthalpy, entropy, free energy and their relations and significances; Gas laws, Real gases, Boyle temperature; Maxwell's relation; thermodynamic equations of state; Joule-Thomson effect; Joule-Thomson coefficient for van der Waals' gas, Joule-Thomson effect and production of low temperature; adiabatic demagnetization, inversion temperature; third law of thermodynamics; need for the third law; Nernst heat theorem, apparent exceptions to third law, application of third law, use of thermodynamic functions E, H, S and G in predicting direction of chemical change; entropy probability and its relation to partition function; numerical on calculation of entropy.

MODULE III: Chemical Kinetics

15 Hours

General introduction to various types of order of reaction including fractional order; comparative study of transition state and collision state theory (derivation not required); Eyring equation; free radical reactions, complex reactions like decomposition of acetaldehyde and ozone; reaction between H₂ and Br₂; homogeneous, heterogeneous, and acid-base catalysis; elementary enzyme reactions; autocatalysis and oscillatory reaction.

MODULE IV: Electrochemistry and Phase equilibria

15 Hours

EMF series, decomposition potential and overvoltage, electrogravimetry, basic principles,

completeness in deposition; separation with controlled potentials; constant current electrolysis; composition of electrolyte; potential buffers; physical characteristics of metal deposits; electroplating and electroless plating; electro synthesis; potentiostatic and dynamic related numerical problems; Phase rule- discussion of two component systems forming solid solutions with and without maximum or minimum in freezing point curve; systems with partially miscible solid phases; three component systems- graphical representation; three component liquid systems with one pair of partially miscible liquids, influence of temperature; systems with two pairs and three pairs of partially miscible liquids; the role of added salts.

NOTE: Numerical to be solved in possible units

REFERENCE BOOKS:

Mandatory:

1. Physical Chemistry, P. W. Atkins and Julio De Paula, 8th Edition, Oxford University Press
2. Quantum Chemistry, Ira N. Levine

Supplementary:

1. Physical Chemistry, J. M. Castellan.
2. Chemical Kinetics, K. J. Laidler, Tata McGraw Hill
3. Quantum Chemistry, R. K. Prasad, 3rd Edition, New Age International
4. Electrochemical Methods, A. J. Bard
5. Text Book of Physical Chemistry, Volume 1- 4; K. L. Kapoor; Macmillan India Limited

WEB REFERENCES:

1. [https://chem.libretexts.org/Bookshelves/Physical_and_Theoretical_Chemistry_Textbook_Maps/Supplemental_Modules_\(Physical_and_Theoretical_Chemistry\)/Kinetics/Modeling_Reaction_Kinetics/Transition_State_Theory/Eyring_equation](https://chem.libretexts.org/Bookshelves/Physical_and_Theoretical_Chemistry_Textbook_Maps/Supplemental_Modules_(Physical_and_Theoretical_Chemistry)/Kinetics/Modeling_Reaction_Kinetics/Transition_State_Theory/Eyring_equation)
2. <https://www.lenntech.com/library/ozone/decomposition/ozone-decomposition.htm>
3. <https://www.britannica.com/science/phase-rule>
4. [https://chem.libretexts.org/Bookshelves/Analytical_Chemistry/Supplemental_Modules_\(Analytical_Chemistry\)/Electrochemistry/Basics_of_Electrochemistry](https://chem.libretexts.org/Bookshelves/Analytical_Chemistry/Supplemental_Modules_(Analytical_Chemistry)/Electrochemistry/Basics_of_Electrochemistry)

Course Code: CHPC- 402

Course Title: Laboratory Course in Physical Chemistry

Credits: 2

Duration: 60 Hours

Maximum Marks: 50

Course Objectives:

1. To give students an overview of the different techniques and instruments used in physical chemistry laboratory

Course Learning Outcomes:

On successful completion of the course, the student will be able to:

CLO1: Analyze and evaluate the experimental data and determine the energy of activation, entropy and free energy change involved in the given experiments

CLO2: Apply experimental techniques, such as conductometric measurements, titration, and viscosity measurements, to determine properties such as hydrolysis constants, molecular weight, critical temperature.

EXPERIMENTS:

1. To study the kinetics of hydrolysis of ethyl acetate and to determine: Energy of activation;

Entropy of activation and Free energy change

2. To study the kinetics of the reaction between $K_2S_2O_8$ and KI and to determine: Energy of activation; Entropy of activation and Free energy change.
3. To determine the order of reaction between potassium $K_2S_2O_8$ and KI by graphical, fractional change and differential methods
4. To determine the degree of hydrolysis and hydrolysis constant of a salt obtained from weak base and strong acid using conductometer
5. To determine the composition of a mixture of acetic acid, monochloroacetic acid and hydrochloric acid by conductometric titration
6. To determine the equivalence point from derivative plot and determine the dissociation constants of a dibasic, malonic acid
7. To determine the dissociation constants from the derivative plot and the of a tribasic, phosphoric acid
8. To determine the formal redox potential from the derivative plot of Fe^{2+} / Fe^{3+} and Ce^{3+} / Ce^{4+} system by potentiometric method
9. To study three component system of $C_6H_5CH_3$; C_2H_5OH and H_2O and obtain tie line
10. To study three component system of CH_3COOH ; $CHCl_3$ and H_2O and obtain tie line
11. To determine the molecular weight of high molecular weight polymer (Polystyrene) by viscosity measurement
12. To determine CMC of soap by conductometric measurements
13. To determine the surface tension of liquid at different temperatures and hence the critical temperature of the liquid
14. To determine: i. the phase of naphthalene and diphenyl system ii. Freezing point diagram of *o*-nitro phenol and *p* - toluidine
15. To determine the composition of copper and iron (III) by photometric titration using disodium salt of EDTA

PRACTICAL BOOKS:

1. Practical Physical Chemistry, A. Finlay and J. A Kitchener; Longman
2. Experimental Physical Chemistry, F. Daniels, J. H. Mathews; Longman
3. Practical Physical Chemistry, A. M. James, J. A. Churchil
4. Experimental Physical Chemistry, D. P. Shoemaker, C. W. Garland; McGraw-Hill
5. Advanced Physical Chemistry, J. B. Yadav; Goel Publishing House, Meerut
6. Systematic Experimental Physical Chemistry, S. W. Rajbhoj, T. K. Chondhekar; Anjali Publication, Aurangabad

Course Code: CHIC-401

Course Title: General Inorganic Chemistry

Credits: 4

Duration: 60 Hours

Maximum Marks: 100

Course Objectives:

1. To enable students to know about the atomic structure and different properties of atom and elemental chemistry
2. To enable students to study the fundamentals of Inorganic Chemistry

Course Learning Outcomes:

On successful completion of the course, the student will be able to:

CLO1: Recall fundamental concepts related to chemistry of boron and its derivatives.

CLO2: Explain the principles of molecular symmetry, matrix representations of symmetry operations, and predict the symmetry properties of molecules.

CLO3: Analyze and assess the synthesis, structure, bonding, and important reactions of various organo-transition metal complexes

CLO4: Apply the principles of molecular structure and bonding to predict the geometry of molecules using different theory for a variety of molecular configurations.

CLO5: Evaluate and compare the characteristics of metals, alloys, and ionic solids

MODULE I: Atomic Structure, Molecular structure and Bonding **15 Hours**

Atomic Structure- Recapitulation; Atomic parameters: Atomic and ionic radii, ionization energy, electron affinity, electro negativity (Pauling, Allred-Rochow definition, Mulliken definition); Molecular structure and bonding: Lewis structures and bond properties; the VSEPR Model- Walsh diagrams (tri and penta-atomic molecules); Valence bond theory- hydrogen molecule, homonuclear diatomic molecules, polyatomic molecules, hybridisation; Molecular orbital theory: approximations of the theory (LCAO-MO), bonding and anti-bonding orbitals, homonuclear and heteronuclear diatomic molecules.

MODULE II: Molecular Symmetry and Solid-State Chemistry **15 Hours**

Molecular symmetry, representation of symmetry operation as matrices. Definition of groups, set of symmetry operations of molecules satisfying the condition of point groups. Representation, basis of representation, reducible and irreducible representation. The great orthogonality theorem, character tables.

Packing of spheres: Unit cell and description of crystal structure; close packing of spheres; holes in closed-packed structures; structure of metals: polytypism, structures other than closed packed; polymorphism of metals, atomic radii of metals, alloys; Ionic solids: characteristic structures of ionic solids, the rationalization of structures, the energetics of ionic bonding, consequences of lattice enthalpy; defects in crystals.

MODULE III: Boron and Coordination Chemistry **15 Hours**

Boron - introduction, borane, carboranes, borazine and its derivatives; halides of boron. Coordination Chemistry- Recapitulation; shapes of coordination compounds; bonding in coordination compounds- valence bond theory and crystal field theory; magnetism in coordination compounds; colour of coordination compounds; reaction mechanisms of transition metal complexes (in brief).

MODULE IV: Bioinorganic and Organometallic Chemistry **15 Hours**

Bioinorganic Chemistry- metal ions in biological systems; deficiency of trace metal ions (Fe, Zn, Cu and Mn); proteins and their functions- Heme proteins, synthetic oxygen carriers, electron transfer proteins-cytochromes, metalloproteins as enzymes-carboxypeptidase and Vitamin B12 coenzyme; chlorophyll and its use in photosynthesis.

Organometallic Chemistry- Definitions, classification of organo-transition metal complexes; the EAN, 18-electron and 16-electron rules; synthesis, structure, bonding and important reactions of metal carbonyls, metal nitrosyls, dinitrogen and dioxygen complexes.

REFERENCE BOOKS:

Mandatory:

1. Inorganic Chemistry; D. F. Shriver and P. W. Atkins; 5th Edition, Oxford University Press
2. Concise Inorganic Chemistry, J. D. Lee; 5th Edition, Chapman and Hall

Supplementary:

1. Principles of Solid State Chemistry, H. V. Keer; New Age International Ltd, New Delhi
2. Inorganic Chemistry: Principles of Structure and Reactivity, J. E. Huheey, E. A. Keiter; 4th Edition, Addison-Wesley Publishing House
3. Basic Inorganic Chemistry, F. A. Cotton and G. Wilkinson; 6th Edition, Wiley Eastern, New Delhi

4. Chemical Applications of Group Theory, 2nd Edn-F. A. Cotton, Wiley Eastern Ltd.
5. Symmetry and Spectroscopy of Molecules; K. Veera Reddy, New Age International,(2011).
6. Group Theory in Chemistry; M. S. Gopinathanan and V. Ramakrishnan, VishalPublishing Co. (2007)
7. Nature of Chemical Bond, L. Pauling; 3rd Edition, Cornell University Press
8. Solid State Chemistry, D. K. Chakrabarty; 2nd Edition, New Age Publishers
9. Coordination Chemistry, D. Banerjea, Tata McGraw-Hill, New Delhi
10. Solid State Chemistry and Its Applications, A. R. West; John Wiley and Sons,Singapore
11. Basic Inorganic Chemistry, F. A. Cotton and G. Wilkinson; 3rd Edition, John Wileyand Sons, Singapore

WEB REFERENCES:

1. <https://byjus.com/jee/atomic-structure/>
2. [https://chem.libretexts.org/Bookshelves/Inorganic_Chemistry/Supplemental_Modules_\(Inorganic_Chemistry\)/Coordination_Chemistry](https://chem.libretexts.org/Bookshelves/Inorganic_Chemistry/Supplemental_Modules_(Inorganic_Chemistry)/Coordination_Chemistry)
3. http://www.chemistry.wustl.edu/~edudev/LabTutorials/naming_coord_comp.html
4. <https://www.toppr.com/guides/chemistry/coordination-compounds/bonding-in-metal- carbonyls/>

Course Code: CHPE-401

Course Title: Topics in Physical Chemistry

Credits: 2

Duration: 30 Hours

Maximum Marks: 50

Course Objectives:

1. To enable students to study the physical behaviour and some chemical reactions under the influence of visible and ultraviolet light
2. To enable students to understand the concepts of magnetism
3. To enable students to understand the mechanism of the polymerization and its applications

Course Learning Outcomes:

On successful completion of the course, the student will be able to:

CLO1: Understand the thermodynamics and conformers of polymers and explore their diverse applications.

CLO2: Classify and differentiate between various types of magnetism.

CLO3: Analyze and interpret Jablonski diagrams, illustrating fluorescence and phosphorescence.

CLO4: Evaluate the principles and theories behind magnetic susceptibility.

MODULE I: Magneto chemistry

15 Hours

Introduction; types of magnetism- diamagnetism, paramagnetism, ferromagnetism, anti-ferromagnetism and ferrimagnetism; electron spin and magnetic moment; theory of diamagnetism; Langevins theory; magnetic susceptibility and its measurements- Guoy's, Faraday's and Quinke's method; Ranking's transition metal complexes; ferromagnetism- domain theory; hysteresis in magnetism; ferrimagnetisms; magnetic anisotropy, magnetic exchange interactions; magnetic transition- Curie and Neel temperature; ceramic magnetic materials; applications of magnetic materials.

MODULE II: Photochemistry and Polymers

15 Hours

Absorption and emission radiation of photochemical interest (Einstein's derivation equation, not expected); Frank-Condon principle; laws of photochemistry; Jablonski diagram illustrating fluorescence and phosphorescence; long range and short-range energy transfer; flash photolysis and lasers; photo reduction; photo oxidation; photosensitized reactions and photosynthesis; mechanism

of chemiluminescence; Polymers- introduction, types; molecular weight distributions; mechanism of free radical; determination of chain length; condensation polymerization; degree of polymerization from kinetic data (derivation not expected); polymers- conformers, thermodynamics; conducting polymers and applications.

REFERENCE BOOKS:

Mandatory:

1. Polymer Science, V. R. Gowarikar, V. N. Viswanathan, Jayadev Sreedhar; New Age International Publishers
2. Fundamentals of Photochemistry, K. K. Rohatgi-Mukherjee; Wiley Eastern, New Delhi

Supplementary:

1. Magnetic susceptibility, L. N. Muley; Inter science Publishers, New York
2. Instrumental Methods of Chemical Analysis, B. K. Sharma; Goel Publishing House
3. Polymer Science and Technology, Joel R. Fried; Prentice- Hall of India Private Limited

WEB REFERENCES:

1. http://www.irm.umn.edu/hg2m/hg2m_b/hg2m_b.html
2. https://www.google.com/url?sa=t&source=web&rct=j&url=https://www.britannica.com/science/polymer&ved=2ahUKEwitpqAx5HnAhVExTgGHQv8C24QFjAmegQIBxAB&usg=AOvVaw0-_N41elqjLur5vCql3p8z&cshid=1579501965101
3. <http://www.ccl.net/cca/documents/dyoung/topics-orig/magnet.html>
4. <https://plastics.americanchemistry.com/plastics/The-Basics/>
5. <https://www2.chemistry.msu.edu/faculty/reusch/VirtTxtJml/photchem.htm>

Course Code: CHOE-401

Course Title: Reaction Mechanisms in Organic Chemistry

Credits: 2

Duration: 30 Hours

Maximum Marks: 50

Course Objectives:

1. To enable students to understand electrophilic substitution reactions and mechanisms
2. To enable students to apply mechanistic concepts of nucleophilic addition to carbonyl group

Course Learning Outcomes:

On successful completion of the course, the student will be able to:

CLO1: Understand organic reactions and be able to propose plausible mechanisms

CLO2: Choose appropriate reagents to carry out substitution reactions

CLO3: Understand the concepts of aromatic electrophilic and nucleophilic substitution reactions

CLO4: Utilize the knowledge of various name reactions to devise reaction pathways for various chemical transformations.

MODULE I: Aliphatic Nucleophilic and Electrophilic Substitution

15 Hours

The SN₂, SN₁, mixed SN₁ and SN₂ and SET mechanisms; neighbouring group mechanism, neighbouring participation by π and σ bonds, anchimeric assistance; classical and non-classical carbocations, phenonium ions, norbornyl system, common carbocation rearrangements; the S_Ni mechanism; nucleophilic substitution at an allylic, aliphatic and vinylic carbon; reactivity effects of substrate structure, attacking nucleophiles, leaving group and reaction medium; bimolecular mechanisms- S_E2 and S_Ei; S_E1 mechanism; electrophilic substitution accompanied by double bond

shifts; effects of substrates; leaving group and the solvent polarity on the reactivity.

MODULE II: Aromatic electrophilic, nucleophilic substitution and addition to Carbon-Oxygen multiple bonds **15 Hours**

Introduction to general mechanisms involved, reactivity of arenes, product distribution; ipso attack and orientation in benzene with more than one substituent; Friedel-Crafts and related reactions- alkylation, acylation, formylation; Vilsmeier reaction, Gattermann-Koch reaction; Fries rearrangement and Prins reaction; diazotization, nitrosation, nitration, sulphonation, mercuration; introduction to addition-elimination mechanisms and elimination-addition mechanism in aromatic nucleophilic substitution; Ullmann reaction; Schiemann reaction; Von Richter reaction; Sommelet-Hauser rearrangement; Smiles rearrangement; Mechanism of condensation reactions involving enolates- Aldol, Knoevenagel, Claisen, Darzen, Stobbe, Perkin and Benzoin reactions; hydrolysis of esters and amides; aminolysis of esters.

REFERENCE BOOKS:

Mandatory:

1. Advanced Organic Chemistry Reaction, Mechanism and Structure, J. March; 4th Edition, Wiley.

Supplementary:

1. Organic Chemistry, F. A. Carey
2. A Guidebook to Mechanisms in Organic Chemistry, P. Sykes; 6th Edition, Pearson Education.
3. Organic Chemistry, Clayden, Greeves, and Warren; Oxford University Press.
4. Mechanism and Structure in Organic Chemistry, E.S. Gould et al.
5. Organic Chemistry, S. H. Pine; 5th Edition, McGraw-Hill International.
6. Advanced Organic Chemistry, F. A. Carey, and R. J. Sundberg; Vol. I and II, Plenum Press.

WEB REFERENCES:

1. <https://www.organic-chemistry.org/namedreactions/nucleophilic-substitution-sn1-sn2.shtm>
2. <https://www.sciencedirect.com/topics/chemistry/nucleophilic-aliphatic-substitution>
3. http://www.chem.ucla.edu/~harding/notes/notes_14D_EAS01.pdf
4. <https://www.sciencedirect.com/topics/chemistry/electrophilic-aromatic-substitution>
5. <https://www.masterorganicchemistry.com/2018/08/20/nucleophilic-aromatic-substitution-nas/>

SEMESTER II

Course Code: CHAC-401

Course Title: Spectroscopy in Chemistry

Credits: 4

Duration: 60 Hours

Maximum Marks: 100

Course Objectives:

1. To enable students to identify and characterize the samples
2. To enable students to identify the organic compounds using spectroscopic methods

Course Learning Outcomes:

On successful completion of the course, the student will be able to:

CLO1: Understand the basic concepts of spectroscopic techniques

CLO2: Explain working mechanism involved for operating spectroscopic instruments

CLO3: Analyze representation of spectra's for each spectroscopic technique

CLO4: Identify and characterize organic compounds using combined spectroscopic methods

MODULE I: General Introduction and Infrared Spectroscopy 15 Hours

Interaction of electromagnetic radiation with matter and characterization; quantization of energy; regions of spectrum; atomic and molecular spectra; representation of spectra; electronic spectra, molecular structure; radiation sources; monochromators; signal-to-noise; resolving power; width and intensity of spectral transitions; Infrared spectroscopy- introduction, infrared absorption and molecular structure; near- Infrared spectrometry; molecular vibrations, factors influencing vibrational frequencies; instrumentation of FT-IR and sampling techniques; characteristic vibrational frequencies of various functional groups and frequency shifts associated with structural changes.

MODULE II: Atomic Absorption, Emission and Electronic Spectroscopy 15 Hours

Atomic Absorption Spectroscopy- introduction, theory, instrumentation; Internal Standard and Standard Addition Calibration; applications; Flame Emission Spectrometry- introduction, theory, instrumentation; distribution between ground and excited states- atoms in the ground state; flame and electro thermal atomizers; ICP-AES theory, plasma sources, atomization and ionization, interferences in plasma and flame; Electronic spectroscopy- introduction, theory, chromophore and auxochrome; instrumentation; deviation from Beer-Lambert Law; Electronic spectroscopy- introduction; Woodward-Fischer rule; conjugated dienes, trienes, polyenes; α , β - unsaturated carbonyl compounds; aromatic hydrocarbons; stereochemical factors.

MODULE III: NMR Spectroscopy 15 Hours

Introduction, theory, instrumentation; chemical shift, factors influencing chemical shift; solvents used in NMR; theory of spin-spin splitting and simple spin systems, AB, A2B2, A2B3; factors influencing coupling constant; introduction and principle to ^{13}C ; off resonance decoupled spectra.

MODULE IV: Mass Spectrometry, various techniques for structure determination 15 Hours

Basic principles; instrumentation; isotope abundances; molecular ion; metastable ions; fragmentation processes; fragmentation associated with simple components like alcohols, amines, alkenes, simple aromatic and aliphatic hydrocarbons, aldehydes, ketones, halogen compounds; structure elucidation using UV-VIS, IR, NMR, mass spectra.

REFERENCE BOOKS:

Mandatory:

1. Analytical Chemistry, G. D. Christian; 5th Edition, John Wiley

Supplementary:

1. Instrumental Methods of Chemical Analysis; G. W. Ewing, 5th Edition McGraw-Hill
2. Instrumental Methods of Chemical Analysis, H. H. Willard, L. L. Merritt, J. A. Dean, F. A. Settle; 7th Edition CBS Publishing New Delhi
3. Analytical Chemistry: Principles, J. H. Kennedy, 2nd Edition; Saunders College Publishing
4. Spectroscopy of Organic Compounds, P. S. Kalsi; 2nd Edition; New Age International
5. Organic Chemistry, R. T. Morrison, R. N. Boyd; 4th Edition; Prentice Hall India
6. Organic Spectroscopy, William Kemp, Palgrave; 3rd Edition
7. Fundamentals of Molecular Spectroscopy, C. N. Banwell, E. M. McCash; 4th Edition Tata McGraw-Hill, New Delhi
8. Vogel's Textbook of Quantitative Inorganic Analysis, J. Mendham, R. C. Denney, J. D. Barnes and M. Thomas; 6th Edition, Pearson Education Asia
9. Spectrometric Identification of Organic Compounds, R. M. Silverstein, and F. X. Webster; 6th Edition, Wiley India
10. Introduction to Spectroscopy, D. L. Pavia, G. M. Lampman; 4th Edition; Brooks/Cole

WEB REFERENCES:

1. <http://www.chem.ucalgary.ca/courses/350/Carey5th/Ch13/ch13-ir-1.html>
2. <https://www.sciencedirect.com/topics/agricultural-and-biological-sciences/infrared-spectroscopy>
3. <https://www.sciencedirect.com/topics/materials-science/atomic-absorption-spectrometry>
<https://www.cis.rit.edu/htbooks/nmr/inside.html>

Course Code: CHAC-402**Course Title: Fundamentals of Chemical Analysis****Credits: 4****Duration: 60 Hours****Maximum Marks: 100****Course Objectives:**

1. To enable students to understand the concept of titrimetry
2. To enable students to understand fundamental concepts in acid-base, precipitation, complex formation, redox system

Course Learning Outcomes:

On successful completion of the course, the student will be able to:

CLO1: Determine equivalence point of various titrations theoretically

CLO2: Make basic quantitative calculations regarding a number of chemical concepts

CLO3: Understand and analyze the chemical reactions involved in different types of titrations

CLO4: Master the concepts like chemical equilibria, complexation, solubility, acidity and basicity and applications involved with respect to each type of titration methods.

MODULE I: Acid-Base Titrations and Conductometric Titrations**15 Hours**

Acid-Base titrations- introduction, theory of acid-base indicators; range of indicator; selection of proper indicator; indicator errors; colour change; neutralization curves for strong acid-strong base, weak acid-strong base and weak base-strong acid weak acid-weak base titrations; poly functional acids and bases; titration curves for poly functional acids and bases; titration curves for amphiprotic species; determining the equivalence point; feasibility of acid- base titrations; magnitude of the equilibrium constant; effect of concentration; typical applications of acid-base titrations. Basic aspects of conductometric titration; types of conductometric titration; advantages and disadvantages of conductometric titration; Introduction; theory; instrumentation; advantages, disadvantages and applications of High frequency titrations.

MODULE II: Precipitation and Redox Titrations**15 Hours**

Precipitation titrations -introduction; feasibility; titration curves- effect of reaction completeness,

effect of titrant and analyte concentration, for mixture of anions; indicators for precipitation titrations; the Volhard, the Mohr and the Fajans methods; typical applications of standard silver nitrate solution; Redox titration- introduction, equilibrium constants; electrode potentials in equilibrium systems; calculation of equilibrium constants; redox titration curves- formal redox potentials; derivatives of titration curves; factors affecting the shape of titration curves- concentration; completeness of reaction; titration of mixtures- feasibility of redox titrations; detection of end point and redox indicators; choice of indicator; structural aspect of redox indicators; specific and nonspecific indicators; sample preparation- pre-reduction and pre-oxidation; applications.

MODULE III: Complexometric Titrations

15 Hours

Introduction; complex formation reactions; stability of complexes; stepwise formation constants; inorganic complexing agents; titrations involving unidentate ligands; organic complexing agents; amino carboxylic acid titration; EDTA-acidic properties of EDTA, EDTA complexes with metal ions, equilibrium calculations involving EDTA in solution, EDTA titration curves; conditional formation constants; effect of other complexing agents on EDTA; factors affecting the titration curves; indicators for EDTA titrations; titration methods using EDTA- direct titration, back titration and displacement titration; indirect determinations; selectivity, masking and demasking agents; applications of EDTA titrations-hardness of water; magnesium and aluminium in antacids; magnesium and zinc in a mixture; analysis of ores and foods.

MODULE IV: Gravimetric Analysis

15 Hours

Introduction; properties of precipitates and precipitating reagents; conditions for precipitation; completeness of precipitates; super saturation and precipitate formation; particle size and filterability of precipitates; colloidal precipitates; crystalline precipitates; purity of the precipitate; co-precipitation, post precipitation; fractional precipitation; precipitation from homogenous solution; organic reagent as precipitant- dimethyl glyoxime; washing of precipitates; drying and ignition of precipitates; calculation from gravimetric data, applications of gravimetric method

REFERENCE BOOKS:

Mandatory:

1. Fundamentals of Analytical Chemistry, D. A. Skoog, D. M. West, F. J. Holler, S. R. Crouch; 8th Edition
2. Quantitative Analysis, R. A. Day, A. L. Underwood; Prentice-Hall

Supplementary:

1. Principles and Practice of Analytical Chemistry, F. W. Fifield, D. Kealy; Backwell Science Ltd., London
2. Vogel's Text Book of Quantitative Chemical Analysis; 6th Edition
3. Analytical Chemistry, G. D. Christian; 5th Edition, John Wiley, NY
4. Instrumental Methods of Chemical Analysis, H. Kaur; Pragati Prakashan
5. Quality in the Analytical Chemistry Laboratory, E. Prichard; John Wiley and Sons, NY

WEB REFERENCES:

1. [https://chem.libretexts.org/Bookshelves/Analytical_Chemistry/Book%3A_Analytical_Chemistry_2.1_\(Harvey\)/08%3A_Gravimetric_Methods/8.02%3A_Precipitation_Gravimetry](https://chem.libretexts.org/Bookshelves/Analytical_Chemistry/Book%3A_Analytical_Chemistry_2.1_(Harvey)/08%3A_Gravimetric_Methods/8.02%3A_Precipitation_Gravimetry)
2. <http://www.wiredchemist.com/chemistry/instructional/laboratory-tutorials/gravimetric-analysis/>
3. https://chem.libretexts.org/Bookshelves/Ancillary_Materials/Demos%2C_Techniques%2C_and_Experiments/General_Lab_Techniques/Titration/Acid-Base_Titrations
4. <https://opentextbc.ca/chemistry/chapter/14-7-acid-base-titrations/>
5. https://chem.libretexts.org/Courses/Northeastern_University/09%3A_Titrimetric_Methods/9.5%3A_Precipitation_Titrations
6. [https://chem.libretexts.org/Bookshelves/Analytical_Chemistry/Supplemental_Modules_\(Analytical_Chemistry\)/Quantifying_Nature/Volumetric_Chemical_Analysis_\(Shiundu\)/1](https://chem.libretexts.org/Bookshelves/Analytical_Chemistry/Supplemental_Modules_(Analytical_Chemistry)/Quantifying_Nature/Volumetric_Chemical_Analysis_(Shiundu)/1)

Course Code: CHAC-403

Course Title: Spectral Methods of Analysis

Credits: 4

Duration: 60 Hours

Maximum Marks: 100

Course Objectives:

1. To provide students with basics about the characterization of materials using XRD
2. To enable students to understand the concept of emission measurement for quantification of related compounds.
3. To provide students with basic knowledge about spectroscopy for identification of inorganic compounds.

Course Learning Outcomes:

On successful completion of the course, the student will be able to:

CLO1: Remember the basic concept involved in the spectroscopy techniques

CLO2: Understand and evaluate the strength and weaknesses of the different spectroscopy techniques

CLO3: Apply the knowledge of Mossbauer and electron spin spectroscopy in identification of compounds

CLO4: Analyze and interpret data of the various spectroscopic techniques.

MODULE I: X-ray Absorption, Diffraction; Neutron Diffraction, Fluorescence Spectroscopy

15 Hours

X-ray absorption- introduction, theory, origin and interaction of X-ray with matter; X-ray spectrometer; Bragg's law; X-ray diffraction- introduction, theory; comparison of X-ray absorption and X-ray diffraction; X-ray diffraction by crystal; determination of crystal structure (single crystal and powder); interpretation of X-ray diffraction pattern; calculation of lattice parameters; neutron diffraction- introduction; theory; instrumentation and applications; X-ray fluorescence- introduction, applications; X-ray photoelectron spectroscopy.

MODULE II: Molecular Fluorescence, Phosphorescence and Chemiluminescence

15 Hours

Fluorescence and phosphorescence- introduction, definition; principles of fluorescence, chemical structure and fluorescence; theory of molecular fluorescence; instrumentation- single and double beam filter fluorimeters; relationship between intensity of fluorescence and concentration; factors influencing fluorescence and phosphorescence; basic differences in measurement of fluorescence and phosphorescence; advantages; limitations and precautions; spectrofluorometer; phosphorimeter; selection of excitation wavelength for analysis; reporting fluorescence spectra; applications of fluorimetric analysis- inorganic, pharmaceutical, agricultural, biochemical and biomedical materials; Chemiluminescence- introduction, principle, types; meaning of luminescence, chemiluminescence; instrumentation; chemiluminescence titrations, chemiluminescence measurement; quantitative chemiluminescence; gas phase chemiluminescence analysis; electro- chemiluminescence.

MODULE III: Mossbauer Spectroscopy and Raman Spectroscopy

15 Hours

Mossbauer Spectroscopy- introduction; principle; theory; instrumentation; line width; isomer shift; quadrupole interaction; magnetic interaction; information on spin and oxidation states; structure and bonding; spin transition from spectra of different Mossbauer active nuclei in various environments; Mossbauer effect; application of Mossbauer effect to the investigations of compounds of iron and tin; Raman spectroscopy- introduction, light scattering by molecules, Raman effect- in solids, liquids, gases; mechanism; molecular structure; nature of Raman spectra; Raman activity of molecular vibrations; dynamic light scattering and determination of colloidal particle size.

MODULE IV: Microscopy and Electron Spin Resonance Spectroscopy

15 Hours

Chemical microscopy- microscope; parts and optical path; numerical aperture and significance; Kofler's hot stage microscope; fluorescence, polarizing; interference and phase microscopy; applications, qualitative and quantitative study; Electron microscopy- principle, operation, sample preparation, replicas, shadowing, application to analysis; electron probe analyzer, ion microscope; metallography- metallurgy, microscopic examination; specimen preparation and examination; interpretation of micrographs by SEM, EDAX, TEM, AFM; Electron Spin Resonance Spectroscopy- introduction; instrumentation, difference between ESR and NMR, Hyperfine interactions and qualitative analysis, study of free radicals, study of inorganic compounds, transition elements, structural determination.

REFERENCE BOOKS:

Mandatory:

1. Fundamentals of Molecular Spectroscopy, C. N. Banwell, E. M. McCash; 4th Edition Tata McGraw-Hill, New Delhi

Supplementary:

1. Elements of X- ray Diffraction; B. D. Cullity, Addison Wisley
2. Diffraction Method, Wormald, Oxford University Press
3. Neutron Scattering in Chemistry, E. Butleworth Baun, G, London
4. Mossbauer Spectroscopy, N. N. Greenwood, T. C. Gibbs, Chapman Hall
5. Chemical Application of Mossbauer Spectroscopy, V. I. Goldanski and R. H. Harber, Academic Press
6. Spectroscopy in Inorganic Compounds, CNR Rao, G. R. Ferraro; Academic Press
7. Basic Principles of Spectroscopy, Cheney R. MacGraw Hill
8. Principles of Instrumental Analysis, D. A. Skoog, F. J. Holler; 5th Edition
9. Instrumental Methods of Analysis, B. K. Sharma, Goel Publishing House

WEB REFERENCES:

1. https://serc.carleton.edu/research_education/geochemsheets/techniques/XRD.html
2. [https://chem.libretexts.org/Bookshelves/Analytical_Chemistry/Map%3A_Principles_of_Instrumental_Analysis_\(Skoog_et_al.\)/15%3A_Molecular_Luminescence_Spectrometry](https://chem.libretexts.org/Bookshelves/Analytical_Chemistry/Map%3A_Principles_of_Instrumental_Analysis_(Skoog_et_al.)/15%3A_Molecular_Luminescence_Spectrometry)
3. <https://www.sciencedirect.com/topics/earth-and-planetary-sciences/mossbauer-spectroscopy>
4. https://serc.carleton.edu/research_education/geochemsheets/techniques/mossbauer.html
5. <https://www.google.com/url?sa=t&source=web&rct=j&url=https://www.nanoscience.com/techniques/atomic-force-microscopy/&ved=2ahUKEwjSenSyJHnAhWXTX0KHWw1BqoQFjAaegQIAhAB&usq=AOvVaw2ou89f5fahKqUBqZgmLuIc&cshid=1579502355346>

Course Code: CHIC-402

Course Title: Laboratory Course in Inorganic Chemistry

Credits: 2

Duration: 60 Hours

Maximum Marks: 50

Course Objectives:

1. To enable students to prepare different coordination compounds and determine its purity
2. To enable students to analyse various inorganic analytes by various methods

Course Learning Outcomes:

On successful completion of the course, the student will be able to:

CLO1: Understand the chemistry of coordination compounds

CLO2: Apply volumetric methods to accurately estimate of various content involved in quantitative analysis techniques.

CLO3: Quantitatively analyse various metal ions from coordination compounds.

Preparation and Characterization of following Complexes

1. $K_3[Cr(SCN)_6] \cdot 4H_2O$
2. $K_3[Cr(C_2O_4)_3]$ and estimate volumetrically the oxalate in the complex
3. Solid phase synthesis of trans-bis glycinato copper (II)
4. Potash alum from scrap aluminium (at micro scale level); to calculate the yield and percent purity
5. To prepare Mohr's salt and determine the number of water molecules of crystallization by titrating against potassium permanganate solution

Quantitative Estimations

1. Estimation of Nitrite by volumetric method
2. Estimation of Calcium from Calcite ore
3. Estimation of Copper in Gun Metal alloy iodometrically
4. Titrate the Zn (II) by $K_4[Fe(CN)_6]$ and verify the composition of the complex $K_3Zn_3[Fe(CN)_6]_2$
5. To estimate the amount of Cu/Fe/ Zn from the soil sample by AAS method
6. To determine the amount of copper from copper ammonia complex by Spectrophotometric method.
7. To determine the amount of phosphate from water sample by heteropoly blue method.
8. To determine the amount of total chromium from water sample using 1, 5- diphenyl carbazide by spectrophotometry.
9. Spectrophotometric determination of chloride by methyl orange indicator

PRACTICAL BOOKS:

1. Vogel's Text Book of Quantitative Chemical Analysis; 3rd and 4th Edition
2. Handbook of preparative Inorganic Chemistry; G. Brauer, Volume: 1 and 2

Course Code: CHAC-402

Course Title: Laboratory Course in Analytical Chemistry

Credits: 2

Duration: 60 Hours

Maximum Marks: 50

Course Objectives:

1. To provide students with an overview of the different analytical techniques for analysis

Course Learning Outcomes:

On successful completion of the course, the student will be able to:

CLO1: Recall the various analytical instrumentation techniques.

CLO2: Understand the quantitative approach towards various instruments.

CLO3: Perform qualitative and quantitative analysis.

CLO4: Analyze and interpret the data.

I. UV-visible Spectrophotometer

1. To estimate the amount of D-glucose in given solution using Anthrone reagent
2. To determine the molar absorptivity of $KMnO_4$ and $K_2Cr_2O_7$ and simultaneously determine the amount of Manganese and Chromium in the solution
3. To estimate the amount of chloride by UV Visible spectrophotometer.

II. Flame Spectrophotometer

1. To estimate amount of Na/K from the given sample

III. Thermal Studies

1. TG-DTA studies on $\text{CaC}_2\text{O}_4 \cdot \text{H}_2\text{O}$ (Preparation of hydrate salt, Calculation of Iso thermal weight loss, Interpretation)
2. TG-DTA studies on $\text{CuSO}_4 \cdot 5\text{H}_2\text{O}$
3. TG-DTA studies on Zn EDTA
4. DSC study on pharmaceutical product (Carbamazepine)

IV. Volumetric Method

1. To estimate the amount of Aluminium, Calcium and Magnesium from pharmaceutical sample.
2. Determination of Nickel by direct titration.

V. Ion Exchange Chromatography

1. To separate and estimate the amount of Ni and Co from the given mixture.
2. To separate and estimate the amount of chloride and bromide from the given mixture.

VI. Solvent Extraction

1. To extract copper as copper dithiocarbamate (DTC) from CuSO_4 using solvent extraction and estimate the amount of copper by spectrophotometric method.
2. To extract copper from CuSO_4 as neocuproin complex by solvent extraction and estimation by spectrophotometric method.

VII. Conductometric Titration

1. To study all types of strong and weak acid and base titrations by conductometric method using standard 0.1 N strong and weak acid and base solution.

PRACTICAL BOOKS:

1. Analytical Chemistry, G. D. Christian; 5th Edition, John Wiley and Sons
2. Vogel's Textbook of Quantitative Inorganic Analysis, 6th Edition, Pearson Education, Asia
3. Collection of Interesting Chemistry Experiments, A. J. Elias, University Press
4. Quantitative Analysis, Day and Underwood; 6th Edition, Prentice Hall
5. Analytical Chemistry for Technicians, John Kenkel; 3rd Edition, Lewis Publishers.

Course Code: CHIE-401

Course Title: Topics in Inorganic Chemistry

Credits: 2

Duration: 30 Hours

Maximum Marks: 50

Course Objectives:

1. To provide students with an overview of important topics in Inorganic Chemistry
2. To provide students with in-depth knowledge of various inorganic elements

Course Learning Outcomes:

On successful completion of the course, the student will be able to:

CLO1: Recall and remember various allotropes of carbon, the intercalation compounds of graphite, carbon nanotubes, and zeolites.

CLO2: Understand the chemistry of: p-block elements, d-block elements, lanthanide and actinides

CLO3: Apply knowledge of Bronsted acidity and Lewis acidity to classify and predict the reactivity of acids and bases in different scenarios

CLO4: Analyze the chemical behavior of nitrogen, phosphorous, and sulphur compounds, exploring the connections between their structures and reactivity

MODULE I: Main group elements and their selected compounds**15 Hours**

Carbon group: allotropes of carbon, C₆₀ and compounds (fullerenes), intercalation compounds of graphite, carbon nano tubes, carbides; compounds of silicon: silanes, silicates and silicones, Zeolites; Nitrogen, phosphorous and sulphur compounds: Hydrides, oxides and oxy acids of nitrogen, phosphorous, sulphur and halogens. Phosphazines, phosphazene polymers, sulphur, nitrogen compounds: Binary sulphur nitrides: S₄N₄, S₂N₂ and (SN)_x, P-O and P – S cage compounds. Oxygen group, Chemistry of halogens and xenon: Interhalogens, psuedohalogens, polyhalide ions, oxyhalogen species. Xenon oxides and fluorides.

MODULE II: Chemistry of transition and inner transition elements**15 Hours**

Transition elements: metallic character, oxidation states, atomic and ionic size, colour, melting points and boiling points, ionization energy, density, magnetic properties, catalytic properties, important compounds and complexes, biological importance, difference between first row and subsequent row elements.

Inner-transition elements: lanthanides and actinides- occurrence, properties, oxidation states, electronic structure, colour and spectra, magnetic properties, lanthanide contraction, compounds of lanthanides and actinides, separation techniques.

REFERENCE BOOKS:**Mandatory:**

1. Inorganic Chemistry, D. F. Shriver and P. W. Atkins; 5th Edition, Oxford University Press

Supplementary:

1. Inorganic Chemistry: Principles of Structure and Reactivity, J. E. Huheey, E. A. Kiter; 4th Edition, Addison-Wesley Publishing House
2. Chemistry of the Elements, N. N. Greenwood and A. Earnshaw; Pergamon Press, Exeter, Great Britain
3. Advanced Inorganic Chemistry, F. A. Cotton, G. Wilkinson, Hurillo and Bochmann, 6th Edition, Wiley Inter science
4. Concise Inorganic Chemistry, J. D. Lee, 5th Edition, Chapman and Hall
5. Basic Inorganic Chemistry, F. A. Cotton and G. Wilkinson, Paul L. Gaus, 3rd Edition, John Wiley and Sons

WEB REFERENCES:

1. <https://chemed.chem.purdue.edu/genchem/topicreview/bp/ch11/acidbase.php>
2. <https://www.visionlearning.com/en/library/Chemistry/1/Acids-and-Bases/58>
3. <https://byjus.com/jee/lanthanides/>
4. <https://people.wou.edu/~courtna/ch462/tmcolors.htm>
5. <https://byjus.com/jee/f-block-elements>

Course Code: CHAE-502**Course Title: Methods of Analysis****Credits: 2****Duration: 30 Hours****Maximum Marks: 50****Course Objectives:**

1. To provide students with knowledge of thermal analysis to enable them to understand the principle of operation.
2. Obtaining basic knowledge on thermos-analytical methods
3. Application of thermos-analytical instruments in practice

Course Learning Outcomes:

On successful completion of the course, the student will be able to:

CLO1: Define and recall the fundamental concepts of thermogravimetric Analysis and Differential Thermal Analysis

CLO2: Apply theoretical knowledge for practical analysis

CLO3: Analyze the experimental conditions for the measurements and combine different Thermos-analytical techniques.

CLO4: Proficiently solve numerical problems related to different gravimetric technique and evaluate the thermal and electrochemical properties of materials.

MODULE I: Thermogravimetric Analysis and Differential Thermal Analysis 15 Hours

Thermogravimetric Analysis- introduction; definition; instrumentation (all components to be discussed); interpretation of TGA curve; factors affecting TGA curves- instrumental, characteristics of sample; advantages and limitation of TGA; calculation of compound composition, percent decomposition; applications of thermogravimetry; Derivative Thermogravimetry (DTG)- definition, comparison between TG and DTG.

Differential Thermal Analysis- introduction, definition; theoretical basis of DTA; DTA instrumentation (all components to be discussed); factors affecting the DTA curve; advantages and disadvantages of DTA; applications of DTA.

MODULE II: Differential Scanning Calorimetry, Thermometric Titrations and Electrogravimetry 15 Hours

Differential Scanning Calorimetry- definition; instrumentation of DSC, types, factors affecting DSC curves; comparison between DTA and DSC techniques; applications. Thermometric Titrations- introduction; definition; instrumentation (all components to be discuss); Electro gravimetry- basic principles, completeness in deposition, composition of electrolyte, separation with controlled potentials, constant current electrolysis;

Numerical based on TGA and DTA curves to calculate percent loss and fix the formula of the sample are to be solved.

REFERENCE BOOKS:**Mandatory:**

1. Fundamentals of Analytical Chemistry, D. A. Skoog, D. M. West, F. J. Holler, S. R. Crouch; 8th Edition

Supplementary:

1. Principles and Practice of Analytical Chemistry, F. W. Fifield, D. Kealy; Backwell Science Ltd., London
2. Vogel's Textbook of Quantitative Chemical Analysis; 6 th Edition
3. Analytical Chemistry, G. D. Christian; 5 th Edition, John Wiley, NY
4. Instrumental Methods of Chemical Analysis, H. Kaur; Pragati Prakashan
5. Instrumental Methods of Chemical Analysis, Chatwal and Anand, Himalaya Publishing House

WEB REFERENCES:

1. http://web.abo.fi/instut/biofuelsGS2/kursen/%C5A/lectures/Lecture_Thermal%20Analysis.pdf
2. <https://www.pslc.ws/macrog/dsc.htm>
3. [https://www.brainkart.com/article/Thermometric-Titrations-\(TT\)_30858/](https://www.brainkart.com/article/Thermometric-Titrations-(TT)_30858/)

SEMESTER III

DISCIPLINE SPECIFIC ELECTIVES (DSE)

Course Code: CHAE-501

Course Title: Calibrations and Validation

Credits: 2

Duration: 30 Hours

Maximum Marks: 50

Course Objectives:

1. To enable students to understand the validation characteristics of some procedures used in laboratory
2. To enable students to have an idea about ICH guidelines used in pharmaceutical industry

Course Learning Outcomes:

On successful completion of the course, the student will be able to:

CLO1: Understand the role of quantification, regulation and calibration in analytical methods.

CLO2: Apply the principles of method validation to various analytical equipment.

CLO3: Evaluate the robustness of various analytical techniques.

CLO4: Develop a calibration strategy for various instruments used in drug analysis.

MODULE I: Regulations and Qualifications

15 Hours

Regulations: Regulatory requirements for analytical method validation; validation of analytical methods; complete method validation package, analytical data, protocol, plan, revisions and change controls; International Conference on Harmonization (ICH) Guideline Q2A: Validation of analytical procedures; linearity and range criteria and their role in instrumental method validation; GMP (US), Qualification: Overview of qualification of instruments; installation, operation and performance qualification (IQ, OQ, PQ) of analytical equipments; method validation for UV Visible Spectrophotometer, IR Spectrophotometer, Spectrofluorometer, HPTLC, GC, HPLC; qualitative and quantitative method validation; parameters of validation; statistics in validation; detailed discussion on accuracy and precision role in method validation; protocols and interpretation.

MODULE II: Calibration

15 Hours

Calibration of analytical balance and pH meter; role of quantification limit and specificity; Limit of Detection (LOD) and Limit of Quantification (LOQ); Robustness and method validation; Ruggedness of chromatographic method; Ruggedness of sample preparation procedure; Calibration verses Qualification verses Validation; Case study for HPLC, UV; calibration of various instruments used for drug analysis like HPTLC, UV-Visible Spectrophotometer, IR Spectrophotometer, Spectro fluorimeter, GC, HPLC.

REFERENCE BOOKS:

Supplementary:

1. The Theory and Practice of Industrial Pharmacy Lachman Edition
2. Web Resources in Pharmacy, In Pharma Publication, Bangalore
3. Schedule M
4. WHO Guideline
5. Analytical Method Development and Validation, Michael E. Swartz
6. Pharmaceutical Process Validation, Loftus and Nash
7. Vogel's Textbook of Quantitative Chemical Analysis, J. Mendham, R. C. Denny, J.D. Banes, Thomas; 6th Edition, ELBS
8. Pharmaceutical Process Validation, Alfred H. Wachter

9. Validation and Qualification in Analytical Laboratories, Ludwig Huber; 2nd Edition, Wiley Publisher.
10. Wiley Publisher.

WEB REFERENCE:

1. <https://uc.xyz/1mhmZR?pub=link>
2. https://www.researchgate.net/publication/8508200_Qualification_of_analytical_instruments_for_use_in_the_pharmaceutical_industry_A_scientific_approach/link/02bfe50f872c59f953000000/download
3. <https://www.slideshare.net/mobile/dhavalrock24/concept-of-ursdqiqoqq>
4. <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4670047/>
5. <https://www.pharmaguideline.com/2010/05/calibration-of-uv-visible.html?m=1>
6. <https://nvlpubs.nist.gov>

Course Code: CHOE-502**Course Title: Reagents in Organic Synthesis****Credits: 2****Duration: 30 Hours****Maximum Marks: 50****Course Objectives:**

1. To provide students with knowledge of oxidation processes used in organic syntheses
2. To provide students with knowledge of reduction processes used in organic syntheses

Course Learning Outcomes:

On successful completion of the course, the student will be able to:

CLO1: Study chemical reactivity of oxidizing and reducing agents

CLO2: Choose appropriate oxidizing agents for oxidation and reducing agent for reduction of a particular functional group

CLO3: Propose the mechanism of oxidation and reduction reactions

CLO4: Analyze different chemical transformations involving oxidizing and reducing reagents.

MODULE I: Oxidation reactions**15 Hours**

Oppenauer oxidation, aromatization and dehydrogenation, oxidation of hydroxyl group with Triphenylbismuth carbonate, O₂/Pt catalyst, silver carbonate/celite, sodium bromate/CAN and NaOCl/CH₃COOH; chromium and manganese compounds: oxidation of alcohols, aldehydes, C-C double bonds and C-H bonds in hydrocarbons; peracids and other peroxides; types of peracids and preparation; oxidation of C-C double bonds in acyclic and cyclic systems, carbonyl compounds, amines and sulfides, allylic C-H bonds and oxidation with molecular oxygen; other methods of oxidation involving periodic acid, Na/K metaperiodate, lead tetra acetate, mercuric acetate, selenium dioxide, ruthenium tetroxide, osmium tetroxide, DMSO, thallium nitrate, DDQ, Prevost's reagent and Woodward conditions; ozonolysis, catalytic oxidation over Pt; photosensitised and palladium-catalysed oxidation of alkenes.

MODULE II: Reduction reactions**15 Hours**

Catalytic hydrogenation- different catalysts, solvents and equipment; functional group reductions and homogeneous catalytic hydrogenation; reductions by hydride-transfer reagents and related reactions- MPV reduction, NaBH₄, NaB(CN)₂, Trialkyl borohydrides, LAH and lithium hydride alkoxyaluminates, mixed LAH-AlCl₃ reagents, DIBALH and Reductions with borane and dialkylboranes; enzymatic reduction involving liver alcohol dehydrogenase/ NADH and Baker's yeast; other methods of reduction- Wolff-Kishner, Raney Ni desulphurisation, di-imide, low-valent titanium species, trialkyl tin hydrides and trialkyl silanes; Green chemistry- principles; phase transfer

catalysis; microwave synthesis; green reagents for oxidation, reduction processes; ultrasound synthesis; Electro-organic synthesis.

REFERENCE BOOKS:

Mandatory:

1. Some Modern Methods of Organic Synthesis, W. Carruthers; Cambridge University Press, Cambridge

Supplementary:

1. Modern Synthetic Reactions, Herbert O. House, W. A. Benjamin, 2nd Edition
2. Green Chemistry- Environment Friendly Alternatives, Rashmi Sanghi, M. M. Srivastava, Narosa Publishing House, New Delhi
3. Green Chemistry- Frontiers in Benign Chemical Synthesis and Processes, Paul T. Anastas and Tracy C. Williamson, Oxford University Press, Oxford
4. Advanced Organic Chemical Reaction, Mechanism and Structure, Jerry March, Mc Graw Hill International Books Company.
5. Advanced Organic Chemistry. F. A. Carey, R. J. Sundberg; Vol I and II, Plenum Press

WEB REFERENCES:

1. <https://www.organic-chemistry.org/namedreactions/meerwein-ponndorf-verley-reduction.shtm>
2. <https://www.organic-chemistry.org/namedreactions/wolff-kishner-reduction.shtm>
3. <https://www.organic-chemistry.org/namedreactions/prevost-reaction.shtm>
4. <https://chem.pg.edu.pl/documents/614792/2c6c0579-c52b-400e-a396-07a03363f4e0>
5. <https://www.organic-chemistry.org/namedreactions/oppenauer-oxidation.shtm>

Course Code: CHAE-503

Course Title: Diffraction Methods

Credits: 2

Duration: 30 Hours

Maximum Marks: 50

Course Objectives:

1. To give students an overview of diffraction methods in solid state chemistry for solving structural problem
2. To enable students to learn the use of excel in solving problems on X-ray diffraction

Course Learning Outcomes:

On successful completion of the course, the student will be able to:

CLO1: Understand the working of Spreadsheet based and Gaussian software in determining crystal structure.

CLO2: Interpret and analyze X-ray diffraction pattern.

CLO3: Evaluate the scope and limitations of single-crystal X-ray diffraction methods.

CLO4: Create comprehensive spreadsheets in Microsoft Excel to model and visualize crystal structures.

MODULE I: X-ray diffraction analysis

15 Hours

Introduction, packing of spheres - cubic and hexagonal close packing; radius ratio rule, unit cell, types of unit cells and their characteristics; description of crystal structure; Bravais lattice; Bragg's Law, powder method, single-crystal X-ray diffraction; principle, instrumentation, scope and limitations of the method; X-ray scattering factors; calculations of unit cell dimensions from powder diffraction patterns for cubic, tetragonal and orthorhombic systems; reciprocal lattice concept; X-ray intensity calculations to decide the ionic configurations.

MODULE II: Problem solving through diffraction methods**15 Hours**

Introduction to spreadsheet-based software; Microsoft Excel; development of spreadsheets for some simple test cases like Gaussian curve (study the effect of standard deviation and centre of Gaussian), plotting of trigonometric functions like sin, cos and their linear combinations (Fourier synthesis for crystal structure determination); precise lattice parameter measurements; crystal structure determination- cubic; FCC, BCC, Hexagonal and other important crystal structure.

REFERENCE BOOKS:**Mandatory:**

1. Solid State Chemistry and its Applications; A. R. West, John-Wiley and Sons, Chichester

Supplementary:

1. X-ray diffraction: A practical Approach, C. Suryanarayana and M. Grant, Norton Plenum Press, New York
2. Elements of X-ray Diffraction, B. D. Cullity; Addison Wesley
3. Principles of Solid-State Chemistry, H. V. Keer; New Age International Ltd, New Delhi

WEB REFERENCES:

1. <https://www.originlab.com/Origin>
2. <https://books.google.co.in/books?id=vk9fnLH56DYC&printsec=frontcover&dq=powder+diffraction+theory+and+practice&hl=en&sa=X&ved=0ahUKEwisvu--mpHnAhXPyDgGHW3XDMoQ6AEIZzAJ#v=onepage&q&f=false>
3. https://link.springer.com/chapter/10.1007/978-1-4614-3954-7_12
4. <https://epdf.pub/queue/powder-diffraction-theory-and-practice.html>

Course Code: CHAE-504**Course Title: Advanced NMR Spectroscopy****Credits: 2****Duration: 30 Hours****Maximum Marks: 50****Course Objectives:**

1. To enable students to understand basic aspects of nuclear magnetic resonance spectroscopy
2. To enable students to understand one-dimensional NMR, Chemical shifts, J-coupling, Interpretation of 1D NMR spectrum, basics of 2D NMR, different 2D NMR experiments and their application/interpretation

Course Learning Outcomes:

On successful completion of the course, the student will be able to:

CLO1: Define the basic principles of NMR spectroscopy.

CLO2: List the fundamental components and processes involved in NMR experiments.

CLO3: Interpret NMR spectra to extract information about chemical shifts, coupling constants, and peak integration.

CLO4: Evaluate the appropriateness of NMR spectroscopy as a tool for solving particular chemical problems.

CLO5: Innovate in the integration of NMR with other analytical techniques to solve interdisciplinary research problems.

MODULE I: ^{13}C -NMR, ^{19}F -NMR and ^{31}P -NMR Spectroscopy**20 Hours**

Nuclear magnetic resonance- theory, quantum description; classical description of NMR; types of

NMR spectra and its interpretation; applications of proton NMR in qualitative and quantitative analysis (in general); CW and PFT techniques; Types of CMR spectra-undecoupled- proton decoupled-off-resonance decoupled (SFORD)-selectivity decoupled and gated ^{13}C) and heteronuclear (^{13}C - ^1H , ^{13}C - ^2H) J couplings, nuclear overhauser effect, ATP (attached proton test), DEPT and Interpretation.

^{19}F and ^{31}P NMR Spectroscopy and Interpretation: Introduction, Fluorine coupling, coupling between Fluorine and Carbon, single fluorine and the CF_2 group substituents- alkyl fluorides, carbonyl compounds, phosphorus compounds, multifluoroalkenes; Trifluoromethyl group. Origin of the ^{31}P NMR spectra, coupling with hydrogen, carbon, metals, transition metal complexes containing phosphorus.

MODULE II: 2D-NMR Spectroscopy

10 Hours

Classification and Interpretation of 2D experiments- 2DJ resolved spectroscopy- HOMO and HETERO- 2DJ Resolved Spectra: correlation spectroscopy (COSY) - HOMO-COSY, 2D-INADEQUATE and NOESY.

REFERENCE BOOKS:

Mandatory:

1. Spectroscopic Identification of Organic Compounds, R. M. Silverstein, G. C. Bassler and T. M. Morrill
2. Introduction to Spectroscopy, Donald I. Pavia, Gary M. Lampman, George S. Kriz, James A. Vyvyan.

Supplementary:

1. Spectroscopic Identification of Organic Compounds, R. M. Silverstein and Webster
2. NMR in Chemistry- A Multinuclear Introduction, William Kemp
3. ^{13}C NMR for Organic Chemists, G. C. Levy, G. L. Nelson
4. Understanding NMR Spectroscopy, James Keeler; 2nd Edition
5. Guide to Fluorine NMR for Organic Chemists. By William R. Dolbier
6. Phosphorus-31 NMR Spectroscopy-A Concise Introduction for the Synthetic Organic and
7. Organometallic Chemist, Olah Kühl, 2008 Springer-Verlag Berlin Heidelberg

WEB REFERENCES:

1. <http://chem.ch.huji.ac.il/nmr/techniques/2d/2d.html>
2. <http://chem.ch.huji.ac.il/nmr/techniques/2d/noesy/noesy.html>

Course code: CHAE-505

Course Title: Separation Techniques

Credits: 2

Duration: 30

Maximum Marks: 50

Course Objectives:

1. To give students a theoretical and practical introduction to the techniques of separation
2. To address modern challenges across the chemical, biological, and physical sciences as it is often necessary to isolate and examine chemical and biological species as pure substances

Course Learning Outcomes:

On successful completion of the course, the student will be able to:

CLO1: Describe the chromatography methods of separation and its applications

CLO2: Acquire and understand technical knowledge and practical experience of different separation technique

CLO3: Evaluate the principles of inorganic molecular sieves, categorize different types of sieves, and assess their applications.

CLO4: Create approaches for solving analytical challenges using hyphenated techniques.

MODULE I: Advanced Chromatographic Techniques **15 Hours**

Introduction to theory and principle of chromatographic technique; terms and parameters used in chromatography, band broadening and column efficiency; variables that affect column efficiency; Gas Chromatography- introduction, principle, theory, instrumentation; columns in GC; detectors- ionization, flame ionization, thermal conductivity, electron capture; evaluation of gas chromatogram; identification of chromatogram; comparison of GSC and GLC; applications; High Performance Liquid Chromatography- introduction; principle; instrumentation; pumps, column and column packing; column efficiency and selectivity; characteristics of liquid chromatography; types of detectors- UV, RI, and fluorescence detectors; advantages, comparison of HPLC and GLC; applications.

MODULE II: Miscellaneous Separation Techniques and Hyphenated Techniques **15 Hours**

Gel chromatography- introduction, theory; principle of gel permeation chromatography- instrumentation and applications; theory and mechanism of ion exclusion; applications of ion exclusion technique; inorganic molecular sieves; principle; types of sieves; applications. Supercritical Fluid Chromatography- introduction; theory, principle; properties of supercritical-fluids; instrumentation and operating variables; comparison of SFC and other column methods, applications; Field-flow fractionation - theory, mechanism, types, and applications; Hyphenated Techniques- introduction; principle, instrumentation, applications of GC-FTIR; GC-MS; LC-MS, TG-MS.

REFERENCE BOOKS:

Mandatory:

1. Fundamentals of Analytical Chemistry, D. A. Skoog, D. M. West, F. J. Holler; 9th Edition

Supplementary:

1. Analytical Chemistry, G. D. Christian; 5th Edition, John Wiley and Sons, NY
2. Khopkar, S. M. (1998). *Basic concepts of analytical chemistry*. New Age International.
3. Harvey, D. (2000). *Modern analytical chemistry*. McGraw Hill.
4. Chemical Instrumentation: A Systematic Approach, H. A. Strobel
5. Instrumental Methods of Chemical Analysis, H. Kaur; Pragati Prakashan
6. Vogel's Text Book of Quantitative Chemical Analysis; 6th Edition
7. Instrumental Methods of Analysis, H. H. Willard, L. L. Merritt, J. A. Dean
8. Instrumental Methods of Chemical Analysis, B. K. Sharma; Goel Publishing House

WEB REFERENCES:

1. <https://www.nottingham.ac.uk/~sczsteve/Ohlendieck%20and%20Harding%202018.pdf>
2. <http://www.chem1.com/acad/webtext/solut/solut-5.html>
3. <https://www.ijarnd.com/manuscripts/v2i4/V2I4-1168.pdf>
4. Column Chromatography Made Simple: An Easy to Follow Guide (bitesizebio.com)
5. What is Column Chromatography ? A Beginners guide (studyread.com)
6. Types of distillation columns | Headlands Distilling Co.
7. Raoult's Law and ideal mixtures of liquids (chemguide.co.uk)
8. <https://www.pharmatutor.org/pharma-analysis/explain-electrophoresis-its-principle-and-factors-governing-it>
9. https://www.iitk.ac.in/dordold/index.php?option=com_content&view=category&layout=blog&id=220&Itemid=239

Course Code: CHAE-506

Course Title: Quality Assurance and Quality Control in Analytical Chemistry

Credits: 2

Duration: 30 Hours

Maximum Marks: 50

Course Objectives:

1. To enable students to understand the basics of quality control and quality assurance
2. To enable students to describe the types of packaging and regulatory aspects in food and pharmaceutical industries

Course Learning Outcomes:

On successful completion of the course, the student will be able to:

CLO1: Understand the basic concepts of quality assurance, significance of specifications and tolerances in ensuring product quality

CLO2: Analyze the process of method verification and regulatory aspects in the context of food and pharmaceutical industries.

CLO3: Evaluate the impurity profile using prescriptive and performance-based approaches.

CLO4: Develop comprehensive approaches to solve quality-related issues in a laboratory setting

MODULE I: Introduction to Quality Assurance and Quality Control 15 Hours

Introduction to basic concepts, quality assurance; aspect of specification and tolerance; quality acceptance; sampling reality; cost aspect of quality decisions; quality control in raw materials; finished product; laws related to quality control; case studies of quality control in various industries like pharmaceuticals, agrochemicals, petrochemicals, dyes, plastics, polymers; safety in laboratory; importance of laboratory note book; cleaning and marking laboratory ware; measuring volume; calibrating volumetric flask; selecting and handling reagents and chemicals; methods of quality assessment- internal and external; evaluating quality assurance data- prescriptive approach and performance based approach.

MODULE II: Standard Method, Analysis; Packaging and Regulatory Aspects 15 Hours

Development of a standard method and analysis- introduction; optimizing experimental procedure (Standard Operating Procedures); verifying the method- single-operator characteristics; blind analysis of standard samples; ruggedness testing; validating standard method; two-sample collaborative testing and analysis of variance.

Packaging and Regulatory Aspects- introduction; types of packing material and regulations; acts in food and pharmaceutical industries; testing of material for packing; legal aspects in packing; regulatory aspects of foods, drugs and cosmetics; food safety and Standards Act, 2006; I.S.I., AGMARK, Government authorities concerned with testing, G.M.P. and C.G.L.P.S.; Department of WHO certification.

REFERENCE BOOKS:

Mandatory:

1. Fundamentals of Analytical Chemistry, D. A. Skoog, D. M. West, F. J. Holler, S. R. Crouch; 8th Edition

Supplementary:

1. Quality Assurance in Analytical Chemistry, W. Funk, V. Dammann, G. Donnevert; VCH Weinheim
2. Principles and Practice of Analytical Chemistry, F. W. Fifield, D. Kealy; Backwell Science Ltd. London
3. Vogel's Textbook of Quantitative Chemical Analysis; 6th Edition

4. Modern Analytical Chemistry, D. Harvey; McGraw-Hill Education
5. Analytical Chemistry, G. D. Christian; 5th Edition, John Wiley and Sons, NY
6. Instrumental Methods of Chemical Analysis, H. Kaur; Pragati Prakashan
7. Pharmacopeia of India, Volume I and II
8. Quality in the Analytical Chemistry Laboratory, E. Prichard; John Wiley
9. Principals of Package Development, Gribbinetal
10. Modern Packaging Encyclopaedia and Planning Guide- MacqraWreyco
11. Government of India Publications of Food Drug Cosmetic Acts and Rules

WEB REFERENCES:

1. <https://asq.org/quality-resources/quality-assurance-vs-control>
2. <https://nvlpubs.nist.gov/nistpubs/Legacy/IR/nbsir85-3105.pdf>
3. https://www.who.int/water_sanitation_health/resourcesquality/wqmchap9.pdf
4. https://www.who.int/medicines/areas/quality_safety/quality_assurance/control/en/
5. <https://www.who.int/tdr/publications/documents/glp-handbook.pdf>

Course Code: CHAE - 507

Course Title: Chemometrics

Credits: 2

Duration: 30 Hours

Maximum Marks: 50

Course Objectives:

1. To provide students with a basic tool in solving problems

Course Learning Outcomes:

On successful completion of the course, the student will be able to:

CLO1: Understand the different statistical approach and multivariate methods used in chemometric analysis

CLO2: Demonstrate a sound understanding of various multivariate methods and its application

CLO3: Analyse a comprehensive understanding of linear algebra to solve problems related to data analysis

CLO4: Develop and execute factorial and half-factorial designs using Matlab

MODULE I: Introduction to Data and Statistics

15 Hours

Introduction; univariate statistics review; probability; variance and sampling, linear regression and calibration data, digitization, and the Nyquist Theorem, detection limit, S/N ratio, and signal filtering; review of linear algebra: scalars, vectors, and matrices, matrix notation and matrix operations orthogonality, analysis of variance (ANOVA)- 1 variable, analysis of variance- 2 variables; introduction to MatlabTM: programmed, basics and layout, matrix operations in MatlabTM the diary command and examples, ANOVA in MatlabTM experimental design: factorial design, simple versus complex models, factorial design in MatlabTM; half-factorial design.

MODULE II: Multivariate Methods

15 Hours

Introduction to various multivariate methods; the six habits of a chemometrician; principle component analysis (PCA); data pretreatment- mean centering and normalization; PCA in MatlabTM. Classical least squares (CLS), CLS in MatlabTM, inverse least squares (ILS). Multiple linear regression (MLR); principle component regression (PCR); partial least squares, examples in MatlabTM; summary of multivariate methods; pattern recognition- supervised versus unsupervised pattern recognition, K nearest neighbours (KNN); soft independent modelling for chemical analysis (SIMCA), summary of pattern recognition.

REFERENCE BOOK:

Mandatory:

1. Chemometrics, A Practical Guide; Kenneth R. Beebe, Randy J. Pell, and Mary Beth Seasholtz, JohnWiley and Sons, Inc., New York

Supplementary:

1. The computer program MATLAB™ will be required for some portions of the course

WEB REFERENCES

1. [https://chem.libretexts.org/Bookshelves/Analytical_Chemistry/Chemometrics_Using_R_\(Harvey\)/00%3A_Front_Matter/What_is_Chemometrics_and_Why_Study_it%3F](https://chem.libretexts.org/Bookshelves/Analytical_Chemistry/Chemometrics_Using_R_(Harvey)/00%3A_Front_Matter/What_is_Chemometrics_and_Why_Study_it%3F)
2. <https://www.frontiersin.org/articles/10.3389/fchem.2018.00576/full>
3. https://www.mn.uio.no/astro/english/services/it/help/mathematics/matlab/matlab_prog.pdf

Course Code: CHAE-508

Course Title: Bio analytical Chemistry

Credits: 2

Duration: 30 Hours

Maximum Marks: 50

Course Objectives:

1. To enable students to the techniques routinely used in bio analytical laboratories
2. To enable students to study various bio analytical techniques used for diagnosis of diseases

Course Learning Outcomes:

On successful completion of the course, the student will be able to:

CLO1: Understand various bio analytical techniques used for medical diagnosis and research.

CLO2: Analyze the principles and mechanisms behind different biosensors and its application.

CLO3: Evaluate the analytical applications of secondary antibody-antigen interactions and examining the keys to immunochemical measurements.

CLO4: Design and critically evaluate the principle and applications of immunoassays.

MODULE I: Antibodies, Spectroscopic Methods for Matrix Characterization 15 Hours

Antibodies- Introduction, structural, functional properties of antibodies, polyclonal and monoclonal antibodies; antibody- antigen interactions; analytical applications of secondary antibody-antigen interactions: agglutination reactions and precipitation reactions; keys to immunochemical measurements; analytical applications of biological tracers; principle and applications of radioimmunoassay (RIA); enzyme linked immune sorbent assay (ELISA); Introduction to the concept of RTPCR; immuno histochemistry- important diagnostic tool; introduction to protein; method for total protein- Lowry, Smith, Bradford; protein quantification methods; methods for total DNA- fluorometric, diphenylamine; total RNA; determination of total carbohydrate- ferricyanide, phenol sulphuric acid; Purpald assay for bacterial polysaccharides; free fatty acids.

MODULE II: Biosensors and Bio Analytical Approaches 15 Hours

Introduction to biosensors; examples of biosensor; configurations; response of enzyme-based biosensors; ferrocene-mediated amperometric glucose sensor; potentiometric biosensor for phenyl acetate; potentiometric immune sensor for digoxin; evanescent-wave fluorescence biosensor for bungaro toxin; optical biosensor for glucose based on fluorescence energy transfer; piezoelectric sensor for nucleic acid detection, enzyme thermistors; clinical genomics; proteomics and metabolomics; clinical diagnosis and screening; research and development; emerging pharmaceutical products, future perspectives; structure and characteristics of key transition metals, importance of

transition metals in physiological processes, transition metals as mediators of disease processes, therapeutic implications of transition metals, determination of transition metals in nature

REFERENCE BOOK:

Mandatory:

1. Understanding Bio analytical Chemistry, V. A. Gault; John-Wiley and Sons

Supplementary:

1. Analytical Biochemistry, D. J. Holme; Pearson Education Ltd.
2. The principles of ion-selective electrodes and membrane transport, W. E. Morf
3. Bio analytical Chemistry, S. R. Mikkelsen; John-Wiley and Sons

WEB REFERENCES:

1. <https://www.elprocus.com/what-is-a-biosensor-types-of-biosensors-and-applications/>
2. Mehrotra, P. (2016, January 6). Biosensors and their applications – A review. Journal of Oral Biology and Craniofacial Research. doi:10.1016/j.jobcr.2015.12.002
3. <https://www.radiologyinfo.org/en/info.cfm?pg=bodymr>
4. <https://www.iaea.org/topics/radiotracers>
5. <https://www.antibodies-online.com/resources/17/1215/radioimmunoassay-ria/>

GENERIC ELECTIVES (GE)

Course code: CHGE-501

Course Title: Food Chemistry and Nutrition

Credits: 2

Maximum marks: 50

Duration: 30 Hours

Course Objectives:

The Course will enable the students to

1. Recall the essential macronutrients and micronutrients required for human nutrition.
2. Identify the classification of carbohydrates, proteins, fats, vitamins, minerals, and water in the diet.
3. Explain the functions and roles of carbohydrates in the human body, including dietary fiber.
4. Describe the different types of lipids and their significance in nutrition.
5. Analyze the nutritional significance of macro and micro nutrients in maintaining overall health.
6. Infer the effects of natural colors and flavouring agents on consumer choices and food safety.

Course Learning Outcomes:

On successful completion of the course, the student will be able to:

CLO1: Identify the major classifications of dietary fibers, lipids, water-soluble and fat-soluble vitamins, major minerals, and trace minerals.

CLO2: Explain the functions of macro and micro nutrients in the human body, specifically in digestion, absorption, and overall health.

CLO3: Apply knowledge of intentional additives, incidental additives, natural colors, flavoring agents, and their roles in food products.

CLO4: Analyze the hazards in the food supply chain and identify potential sources of contamination.

MODULE I: Macro and Micro Nutrients

15 hours

Introduction to macro and micro nutrients- Carbohydrates - Introduction, classification and dietary fibers; Proteins introduction, classification; Fats- Introduction and types of lipids; Vitamins- water

soluble and fat-soluble vitamins; Minerals - Major minerals and trace minerals and their functions; Water and its functions. Role in human body-digestion and absorption. Nutritional significance and changing trends in dietary intake. Recommended dietary allowances.

MODULE II: Additives and Contaminants

15 hours

Intentional additives, Incidental additives or contaminants, Natural colors and flavouring agents, Toxic trace elements, Metal uptake in canned foods, Plant protective agents- Pesticides; monitoring pesticides in food, Veterinary drugs, Persistent environmental chemicals, Naturally occurring toxicants; control and measures, Hazard identification in the food supply chain, Organic and inorganic contaminants in food- metals and metalloids, nitrates, hydrocarbons, Chemical migration from food packaging.

REFERENCE BOOKS:

Mandatory:

1. Srilakshmi, B. (2006). *Nutrition Science*. New Age International.
2. Principles of food chemistry third edition by John M.deMan, Phd
3. Basic food chemistry, 2nd edition, Frank A. Lee, PhD

Supplementary:

1. Annual Reviews of Nutrition. Annual Review Inc, California, USA.
2. Shils, M.E.; Olson, J.; Shike, M. and Roos, C. (1998): *Modern Nutrition in Health and Disease*, 9th edition. Williams and Williams. A Beverly Co. London.
3. Bodwell, C.E. and Erdman, J.W. (1988) *Nutrient Interactions*. Marcel Dekker Inc. New York
4. *World Reviews of Nutrition and Dietetics*.
5. WHO Technical Report Series.
6. Indian Council of Medical Research. *Recommended Dietary Intakes for Indians - Latest Recommendations*.
7. Indian Council of Medical Research. *Nutritive Value of Indian Foods - Latest Publication*.
8. Berdanier, C.D. and Haargrove, J.L. (ed) (1996): *Nutrients and Gene Expression: Clinical Aspects*. Boca Raton, FL CRC Press.
9. Baurle, P.A. (ed) (1994) *Inducible Gene Expression. Part I: Environmental Stresses and Nutrients*. Boston: Birkhauser.
10. Chandra, R.K. (ed) (1992): *Nutrition and Immunology*. ARTS Biomedical. St. John's Newfoundland.
11. International Life Sciences Institute *Present Knowledge in Nutrition – latest edition*

JOURNALS:

1. *Nutrition Reviews*
2. *Journal of Nutrition*
3. *American Journal of Clinical Nutrition*
4. *British Journal of Nutrition*
5. *European Journal of Clinical Nutrition*
6. *International Journal of Vitamin and Nutrition Research*
7. *International Journal of Food Science and Nutrition*
8. *Nutrition Research*
9. *Annals of Nutrition and Metaboli*

Course Code: CHGE-502

Course Title: Environmental Chemistry

Credits: 2

Duration: 30 Hours

Maximum Marks: 50

Course Objectives:

The Course will enable the students to

1. Identify and define various types of pollution, such as air, water, soil, noise, radioactive and microplastic pollution.
2. Recall key pollutants associated with each type of pollution.
3. Explain the causes and sources of different types of pollution.
4. Interpret the environmental and health impacts of pollution on ecosystems and human populations.
5. Evaluate the effectiveness of pollution control measures in various industries and sectors.

Course Learning Outcomes:

On successful completion of the course, the student will be able to:

CLO1: Study the monitoring of air pollution, Water Pollution, Soil Pollution, Noise Pollution, Radioactive pollution and occurrence of Microplastics.

CLO2: Explain the causes and sources of different types of pollution. including air, water, soil, noise pollution etc

CLO3: Identify methods to control the various types of pollution.

CLO4: Summarize the impact of pollution on ecosystems, human health, the environment and techniques for the waste disposal.

MODULE I: Air Pollution, Water Pollution and Soil Pollution**15 Hours**

Air pollution- natural and anthropogenic sources of pollution, primary and secondary pollutants, transport and diffusion of pollutants, Methods of monitoring and control of air pollution, SO₂, NO_x, CO, SPM.

Water pollution – Introduction to water pollution; sources and consequences, types of pollutants in ground water, Geological and anthropogenic pollutants in ground water - movements of contaminants in ground water; Heavy metals in aquatic systems - cycling, interactions and transport - factors affecting, sewage and wastewater treatment and recycling; advanced waste water treatment.

Soil pollution: Types, sources and consequences, Transport processes — biological process-microbial transformation of heavy metals, industrial waste effluents and heavy metals and their interactions with soil components, analysis of soil quality, soil pollution control.

MODULE II: Noise Pollution, Radioactive Pollution and Microplastics**15 Hours**

Noise pollution - sources of noise pollution, measurement and indices, Marine pollution, sources of marine pollution and its control, Effects of pollutants on human beings, plants, animals and climate, air quality standards and air pollution

Radioactive Pollution- Radioactivity in the environment, Radionuclides- sources, types of radiation, Radioactive fallout, Ecological risks from radiation, effects on humans, exposure standards. nuclear power plants and fuel production; waste generation from nuclear power plants; radioactive waste treatment, disposal options.

Microplastic: occurrence, fate and waste management, The Microplastic Cycle: An Introduction, Microplastics in Terrestrial and Freshwater Environments, Marine Microplastics, Exposure, The interactions of microplastics and chemical pollutants, Analysis and Techniques for Collection, Removal and Degradation.

REFERENCE BOOK:**Mandatory:**

1. De Anil, K. (2003). *Environmental chemistry*. New Age International.

Supplementary:

1. Murali Krishna, K. V. S. G. (1995). Air pollution and control. Kaushal & Co., Kakinda AP, 215215. Manahan, S. E. (2022). Environmental chemistry. CRC press.
2. Bell, L. H., & Bell, D. H. (2017). Industrial noise control: Fundamentals and applications. CRC Press.
3. Bank, M. S. (2022). Microplastic in the environment: pattern and process (p. 354). Springer Nature.
4. Masters, G. M. (1998). Introduction to environmental engineering and science.
5. Andrady, A. L. (2011). Microplastics in the marine environment. Marine pollution bulletin, 62(8), 1596-1605.
6. Cole, M., Lindeque, P., Halsband, C., & Galloway, T. S. (2011). Microplastics as contaminants in the marine environment: a review. Marine pollution bulletin, 62(12), 2588-2597

REFERENCE LINK:

1. Water pollution | Definition, Causes, Effects, Solutions, Examples, & Facts | Britannica
2. Causes, Effects and Solutions of Groundwater Pollution - Conserve Energy Future (conserve-energy-future.com)
3. Soil Pollution: Definition, Causes, Effects and Solutions - Conserve Energy Future (conserve-energy-future.com)
4. Soil - Detoxification, Pathways, Microorganisms | Britannic

Course code: CHGE-503

Course Title: Application of Chemistry in Everyday Life

Credits: 2

Duration: 30 Hours

Maximum Marks: 50

Course Objective:

The course will enable the students to

1. Identify common chemical compounds found in everyday products.
2. Impart knowledge of Chemistry and related sciences.
3. Describe the significance of pH in household applications and environmental impact.
4. Develop scientific attitude to make the students open minded, critical and curious.
5. Examine chemical processes in household products and their impact on health and the environment.

Course Learning Outcomes:

On successful completion of the course students will be able to

CLO1: Recall common chemical concepts and terminology used in daily life.

CLO2: Explain how chemical processes affect various aspects of daily life, such as health, environment, and technology.

CLO3: Analyze the impact of chemical processes on society, the environment, and industry.

CLO4: Evaluate the safety and ethical considerations associated with the use of chemicals in everyday life.

MODULE I: Applications, Uses and Impact of Chemistry

15 Hours

Pharmaceuticals- Historical developments in medicine, Contribution of chemistry to human health, Classification of drugs and some common drugs used in our daily life.

Plastics and Polymers - Introduction, types of polymers, Plastic in daily use: HDPE, LDPE, PVC, PET, PP. Environmental Hazards of plastics, Biodegradable plastics.

Cosmetics - Basic concepts-composition and classification of creams-sunscreen and suntan Lotions, deodorants, talcum powder- Identifiers, lipsticks, oils, face creams, skin products, dental cosmetics, hair dyes, shaving cream, shampoo.

MODULE II: Impact Of Chemistry in Other Fields

15 Hours

Chemistry & Art – History of colour, Use of colour to decorate the body and surroundings. Relationship between light and colour. Electromagnetic Spectrum, Cause of colour in objects, Properties of Light.

The Nature and behaviour of light, mixing colours: Light vs. Pigments, Colorants: Pigments and Dyes. Chemistry of art conservation and restoration, Fakes and Forgeries in art.

Chemistry and Sports - Chemistry of sports materials, Use of performing enhancing drugs in sports
Gobar gas: Production, feasibility and importance of Biogas with special reference to Rural India;
Fertilizers: Definition, classification - Urea, NPK and Super phosphates, uses and hazards.

REFERENCE BOOKS:

Mandatory:

1. Singh, K. (2012). Chemistry in daily life. PHI Learning Pvt. Ltd.

Supplementary:

1. Chemical Process Industries - Norris Shreve Joseph A. Brine. Jr.
2. Environmental Chemistry - A. K. DE.
3. Industrial Chemistry, B. K. Sharma- Goel publishing house Meerut.
4. Food Science - B. Srilakshmi - III Edition - New Age International Publishers, 2005.
5. Food Chemistry, Lillian Hoagland Meyer - CBS publishers & distributors, 2004.
6. Fundamental Concepts of Applied Chemistry - Jayashree Ghosh, S. Chand & Co Ltd., New Delhi - 2010.
7. Applied chemistry - K. Bagavathi Sundari - MJP Publishers (2006). Course Materials

WEB REFERENCES

1. <https://ncert.nic.in/ncerts/l/lech207.pdf>
2. https://www.researchgate.net/publication/244480193_An_Introduction_to-Toothpaste_-_Its_Purpose_History_and_Ingredients
3. https://www.academia.edu/29067197/Plastic_pdf
4. https://www.susana.org/_resources/documents/default/2-1799-biogasplants.pdf

RESEARCH SPECIFIC ELECTIVES (RSE)

Course Code: CHRE-501

Course Title: Research Methodology and Academic writing

Credit: 4

Duration: 60 Hours

Maximum Marks: 100

Course Objectives:

The Course will enable the students to

1. Understand the fundamental concepts and components of research methodology, including research types, approaches, and the significance of research.
2. Apply knowledge to design sample surveys, considering sampling errors, measurement scales, data collection methods and the development of measurement tools.
3. Recognize the components of an academic paragraph and their role in conveying ideas effectively.
4. Recall the importance of referencing and citing sources in academic writing.
5. Understand the concept of plagiarism and its ethical implications.
6. Synthesize information from various sources to construct a well-structured academic paper.

Course Learning Outcomes:

Upon successful completion of this course students will

CLO1: Study the research objectives, types, and approaches through the analysis of research significance and the application of criteria for quality research.

CLO2: Compare and choose between various research writing styles, tools for measurement with respect to specific contexts.

CLO3: Write a compelling theory for a given research challenge in accordance with research ethics

CLO4: Evaluate and critique academic writing to ensure adherence to established rules and standards.

CLO5: Assess the credibility of sources, including journals and digital content, for research purposes

CLO6: Design a research paper using proper referencing and citation techniques:

MODULE I: Understanding Research

15 Hours

Research methodology – introduction, objectives, types of research, research approaches, significance of research, research process, criteria of a good research

Defining a research problem- selecting the problem, necessity of defining the problem, technique involved in defining the problem

Research design – meaning, need of research design, features of a good design, concepts related to research design, types

Design sample surveys- Introduction, sample design, sampling and non- sampling errors, types of sampling designs.

MODULE II: Tools and Techniques of Research Writing

15 Hours

Measurement and scaling, quantitative and qualitative data, classification of measurement scales, goodness of measurement scales, sources of errors in measurement, techniques of developing measurement tools, scaling – classification and techniques

Data collection – introduction, experiments in surveys, collection of primary and secondary data, selection of appropriate methods for data collection, case study method

Data preparation process – questionnaire checking, editing, coding, classification, tabulation, graphical representation, data cleaning, data adjusting, problems in preparation process, types of analysis

Interpretation and report writing- techniques, different steps in writing report, layout of research report, types of report, oral presentation, precautions for writing research reports

MODULE III: Introduction to Scientific Writing and Literature Review

15 Hours

Importance and Rules of Academic Writing, styles of research writing, paragraph structure, Quotation plagiarism, sources- journals, digital content; Author metrics, style of research writing, impact factors, types of index, challenged in research Process and Source of Literature- journal, digital, web, periodicals; referencing, citations, the writing process.

MODULE IV: Thesis and Model Writing

15 Hours

Inclusions - cover and title pages, abstract, introduction, table and figure formats, text, objectives, methodology, analysis, summary, conclusion, bibliography; plagiarism, Layouts – fonts, spacing, visual effects, labelling, visual presentation of data, creating images using apps, and related aspects, paraphrasing; Writing model-formal letter, CVs, designing in report surveys, and comparison essay.

REFERENCE BOOKS:

Mandatory:

1. Kotahri, C.R. (2009): Research Methodology: Methods and Techniques, 2nd Revised Ed.Reprint, New Age International Publishers
2. Singh YK. 2006. Fundamentals of Research Methodology and Statistics. New Age International Publishers.

Supplementary:

1. Krishnan V. 2011. Statistics for Beginners. Atlantic Publishers and Distributors (P) Ltd.
2. Jackson SL. 2012. Research Methods and Statistics: A Critical Thinking Approach. Fourth Edition. Wadsworth Cengage Learning.
3. Mathukutty M Monippally, Academic Writing: A Guide for Management Students and Researchers, ISBN 9788132104414, Sage Publications, New Delhi, India.
4. Bell, J., & Waters, S. (2018). *Ebook: doing your research project: a guide for first-time researchers*. McGraw-hill education (UK).
5. Kumar, R. (2018). Research methodology: A step-by-step guide for beginners. *Research methodology*, 1-528.
6. Gall, M. D., Gall, J. P., & Borg, W. R. (2007). Educational research: an introduction (8. utg.). *AE Burvikovs, Red.) USA: Pearson*

WEB REFERENCES:

1. <https://egyankosh.ac.in/handle/123456789/35677>
2. <https://docstate.academy/courses/qualitative-analysis-and-review-writing/>
3. <https://shop.elsevier.com/books/writing-research/clare/978-0-443-07182-9>
4. [https://www.scribbr.com/dissertation/methodology/#:~:text=It%20involves%20studying%20the%20methods,surveys%2C%20and%20statistical%20tests\).](https://www.scribbr.com/dissertation/methodology/#:~:text=It%20involves%20studying%20the%20methods,surveys%2C%20and%20statistical%20tests).)
5. <https://www.indeed.com/career-advice/career-development/research-methodology>
6. <https://gradcoach.com/what-is-research-methodology/>
7. <https://ccsuniversity.ac.in/bridge-library/pdf/Research-Methodology-CR-Kothari.pdf>
8. <https://research.com/research/how-to-write-research-methodology>
9. <https://euacademic.org/BookUpload/9.pdf>
10. <https://www.slideshare.net/RonitRKharade/research-tools-and-techniques-245926961>

Course Code: CHRE-502**Course Title: Experiments in Analytical Chemistry****Credits: 4****Duration: 120 Hours****Maximum Marks: 100****Course Objectives:**

1. To enable students in understanding the knowledge of separation and characterization
2. To enable students to carry out, record and analyze the result of analytical experiments

Course Learning Outcomes:

On successful completion of the course, the student will be able to:

CLO1: Understand the quantitative approach towards various instruments

CLO2: Identify appropriate method to carry out quantitative analysis for desired samples

CLO3: Perform titrimetric and spectrophotometric analysis

CLO4: Evaluate statistical spectrophotometric data and interpret the absorption spectra's

MODULE I: Analysis of Pharmaceutical Tablets / Samples

1. Estimation of calcium from dietary supplements using Murexide indicator
2. Estimation of Ibuprofen / Paracetamol
3. Estimation of sulphadiazine / sulphonamide
4. Determination of neutralizing power of tablets of different brands and compare effectiveness
5. Determination of iron using Zimmermann-Reinhardt reagent by titrating against potassium permanganate
6. Estimation of iron from given pharmaceutical drug sample using thioglycolic acid

MODULE II: Ion Exchange Chromatography and Solvent Extraction Method

1. To determine the capacity of a cation exchange resin
2. To determine the capacity of an anion exchange resin
3. To determine the Fe ion as Fe-oxine complex using Butyl acetate/ CHCl_3 as extracting solvent.
4. To separate the acidic, basic and neutral compounds from the mixture by solvent extraction.

MODULE III: Electrochemical Method

1. pH-metric determination of hydrolysis constant of aniline hydrochloride
2. pH-metric determination of the acid-base dissociation constant and isoelectric point of amino acid
3. pH metric determination of dissociation constant of dibasic, oxalic acid
4. Potentiometric estimation of carbonate and bicarbonate from the mixture
5. Potentiometric determination of dissociation constant for Cu-ammonia complex
6. To determine the critical micelle concentration of the detergent using conductometer.

MODULE IV: Simple Chromatography

1. To separate alpha amino acids by paper chromatography
2. To separate the two organic compounds from the mixture by TLC
3. To separate the leaf pigments: chlorophyll 'a', chlorophyll 'b', carotene and xanthophylls by paper chromatography
4. To determine the R_f value of glycine by ascending paper chromatography
5. To separate sugars and amino acids by paper and thin layer chromatography
6. To separate the mixture of o- and p- nitro anilines by column chromatography
7. To study the presence of lactose in milk by descending paper chromatography

MODULE V: Spectrophotometric Method

1. To determine pka value of methyl red indicator at room temperature
2. To determine the indicator constant and isobestic point of an indicator
3. To determine the stoichiometry and stability constant of ferric salicylic acid complex by Job's method and mole ratio method
4. To determine the amount of each p-nitrophenol and m-nitrophenol from the mixture by spectrophotometric titration using standard NaOH solution at $\lambda_{\text{max}} = 280 \text{ nm}$
5. To record the UV absorption spectrum of acetone in n-hexane and identify the various transitions
6. To estimate the amount of aspirin and caffeine from APC tablet by UV-Visible spectrophotometry
7. To study the iodination of acetone by spectrophotometric method
8. To estimate the amount of arsenic in dried shrimp by UV-Visible spectrophotometry using molybdenum blue method.

MODULE VI: Interpretation Exercise

1. X-ray powder diffraction analysis of cubic compound:
 - a. Determination of Lattice constants and crystallite Size
 - b. Density
2. Interpretation of Mossbauer spectrum with reference to determination of: isomer shift; quadruple splitting; internal magnetic field; general comment
3. Interpretation of IR spectrum with reference to stretching vibration of: C=N; C=O; N-O; M-O
4. Interpretation of NMR spectrum with reference to calculation of chemical shifts and general comments
5. Interpretation of absorption spectra for:
 - a. Verification of the position of ligands in spectrochemical series

- b. Calculation of spectral splitting parameters
- c. Determination of geometry of a given compound (octahedral, tetrahedral, squareplanar)
6. Statistical reevaluation of spectrophotometric data

PRACTICAL BOOKS:

Supplementary:

1. Vogel's Textbook of Quantitative Chemical Analysis, 6th Edition
2. Comprehensive Experimental Chemistry, V. K. Ahluwalia; New Age Publications
3. Experimental Physical Chemistry, F. Daniels and J. Williams
4. Experimental Physical Chemistry, R. C. Das and B. Behera
5. Practical Physical Chemistry, B. Viswanathan, P. S. Raghavan
6. An Introduction to Practical Biochemistry, D. T. Plummer; 3rd Edition, Tata McGraw-Hill, New Delhi
7. Advanced Physical Chemistry, J. B. Yadav; 14th Edition, Goel Publishing House
8. Systematic Experimental Physical Chemistry, S. W. Rajbhoj, T. K. Chondhekar; Anjali Publication, Aurangabad.

VIDEO REFERENCES:

1. <https://www.youtube.com/watch?v=lha8dEBNFS4&t=251s>

Course Code: CHRE-503

Course Title: Experiments on analytical instrumentation

Credits: 4

Duration: 120 Hours

Maximum Marks: 100

Course Objectives:

1. Familiarize students with principles, components, and operation of spectroscopy, potentiometry, chromatography and thermal methods of analysis.
2. Teach students to prepare and handle samples for analysis, including proper techniques for sample collection, extraction and pre-treatment.
3. Give students opportunities for hands on experience with the instruments, ensuring proficiency in their use.

Course Learning Outcomes:

On successful completion of the course, the student will be able to:

CLO1: Demonstrate proficiency in operating and maintaining analytical instruments

CLO2: Analyze various types of chemical sample using proper techniques

CLO3: Plan experiments and draw conclusions from data

CLO4: Interpret data obtained from instruments and use appropriate software for data processing and presentation

MODULE I: IR Spectroscopy

1. Quantification of acetyl group from polymers using IR
2. Plasticizer from PVC using IR
3. Determination of ethanol in gasoline
4. Spectral analysis of different compounds (synthesized inorganic complexes and organic compounds)
5. Microscale analysis of patterning reactions via FTIR imaging

MODULE II: Potentiometry

1. Potentiometric determination of reducing sugars

2. Potentiometric titration using graphite sensor
3. Kinetics of bromination reaction: A potentiometric study
4. Non-aqueous titration containing mixture of aniline and ethanolamine

MODULE III: Gas Chromatography

1. To develop and validate the analytical method of any one drug using GC
2. Synthesis of high boiling organic compound by derivatization and analyses by GC
3. Separation of alcoholic mixtures
4. Determination of alcoholic content in: i. Beer ii. Wine iii. Local drinks
5. Gas chromatographic analysis for: i. automobile exhaust ii. Cigarette smoke
6. Analysis of preservatives from solid and liquid samples (extraction, sample preparation and analysis)
7. Internal normalization for the quantitative analysis of solvents using GC.
8. Determination of trace amounts of metals as their chelate complexes using GC.
9. Gas chromatographic analysis for a mixture of gases like O₂, N₂ and CO₂

MODULE IV: High Performance Liquid Chromatography

1. Determination of caffeine content in: i. Tea ii. Coffee iii. Soft drinks iv. Chocolates
2. Purity of the solvents using HPLC
3. Optimum flow rate for the determination of chloroform using Van Deemter equation
4. Quantitative analysis of a mixture of chloroform and carbon tetrachloride
5. Analysis of mixture of alcohols using HPLC
6. To study the quantitative assay of ampicillin injection powder by using HPLC
7. To analyze the mixture of two hydrocarbons (Toluene and Nitrobenzene) by HPLC
8. Analysis of Ibuprofen/Paracetamol (analgesics) in a commercial sample/tablet by HPLC
9. To develop and validate the analytical method of any one drug using HPLC
10. To determine the number of theoretical plates by HPLC using acetophenone as reference material
11. Quantitative analysis of aspirin, phenacetin and caffeine in a mixture by using HPLC.

MODULE V: TG/DTA/DSC

1. Determination of the purity of pharmaceuticals samples
2. Thermal decomposition of calcium oxalate monohydrate
3. Thermal decomposition of copper sulphate pentahydrate
4. Thermal decomposition of nickel oxalate dihydrate
5. Determination of calcium and magnesium in dolomite
6. Glass transition temperature of polymers (polymer to be used in preparation of membranesensor)
7. Determination of water of crystallization in coordination compounds/ inorganic salts Studies on thermal decomposition of Zinc NTA salt
8. DSC study on pharmaceutical product
9. Determination of calcium sulphate dihydrate in cement
10. Determining the purity of pharmaceutical drug: Phenacetin

MODULE VI: Atomic Absorption Spectroscopy

1. Analysis of Na, K and Ca in water samples
2. Analysis of metal ion from soil /ore
3. Analysis of metal ion from alloys: Fe and Cr from steel
4. Analysis of total metals in soil sample: Zn and Cu
5. Determination of metals in food products
6. Determination of K in fertilizers
7. Analysis of Lead and cadmium in toys

PRACTICAL BOOKS:

Supplementary:

1. Vogel, A. I., & Jeffery, G. H. (1989). Vogel's textbook of quantitative chemical analysis.
2. Kealey, D. (2013). Experiments in modern analytical chemistry. Springer.
3. Meloan, C. E. (1999). Chemical separations: Principles, techniques, and experiments (p. 155). Wiley.
4. Comprehensive Experimental Chemistry, V. K. Ahluwalia; New Age Publications

WEB REFERENCES:

1. Department of Polymer Science at the University of Southern Mississippi Web Site, the Macrogalleria; <http://www.psrc.usm.edu/macrog/pvc.htm>
2. Microscale analysis of patterning reactions via FTIR imaging: Application to intelligent hydrogel systems – ScienceDirect
3. Lab 14 (terrificscience.org)
4. 4.6 Determination of sodium, potassium, magnesium, and calcium in precipitation (nilu.no)

SEMESTER IV

Course Code: CHRE-504

Course Title: Synthesis of Inorganic Materials

Credit: 2

Duration: 30 Hours

Maximum Marks: 50

Course Objectives:

The course will enable the student to:

1. Define key terms and concepts related to reactions employed in synthesis, ceramic procedures, precursor methods, and various synthesis techniques.
2. Explain the principles and underlying mechanisms of various synthesis methods.
3. Describe the advantages and limitations of different synthesis techniques.
4. Apply the knowledge of synthesis methods to design and conduct experiments in the laboratory.

Course Learning Outcomes:

Upon successful completion of this course, the students will be able to:

CLO1: Recall and list the different precursor methods for material synthesis.

CLO2: Identify the principles and processes of combustion synthesis

CLO3: Explain the concept of intercalation chemistry and its significance in material synthesis

CLO4: Analyse the advantages and limitations of various synthesis methods in the context of material properties and applications.

MODULE I: Methods of Synthesis – I

15 Hours

Introduction, reactions employed in synthesis, ceramic procedures, precursor methods, combustion synthesis, Intercalation chemistry, sol-gel synthesis, ion exchange method, co-precipitation.

MODULE II: Methods of Synthesis – II

15 Hours

Electrochemical methods; nebulized spray pyrolysis; arc and skull methods; Reactions at high pressures; intergrowth structures; Metal borides, carbides, and nitrides; metal fluorides; metal silicides, phosphides, sulfides, and related materials.

REFERENCE BOOKS:

Mandatory:

1. Abbott, E. H., and Rao, C. N. R. (1995). *Chemical Approaches to the Synthesis of Inorganic Materials*.
2. Rao, C. N. R., and Biswas, K. (2015). *Essentials of inorganic materials synthesis*. John Wiley & Sons.

Supplementary:

1. Schubert, U. S., and Hüsing, N. (2019). *Synthesis of inorganic materials*. John Wiley & Sons.
2. Lalena, J. N., Cleary, D. A., Carpenter, E., and Dean, N. F. (2008). *Inorganic materials synthesis and fabrication*. John Wiley & Sons.
3. Van der Put, P. J. (1998). *The inorganic chemistry of materials: How to make things out of elements*. Springer Science & Business Media.
4. Sambandan, E. (2008). *Inorganic Materials Chemistry: General Concept and Research Topics in Universe*.

WEB REFERENCES

1. https://link.springer.com/chapter/10.1007/978-1-4899-0095-1_8
2. <https://pubs.acs.org/doi/10.1021/jacs.1c04888>
3. <https://www.nature.com/articles/s41597-022-01317-2>
4. <https://www.mdpi.com/1420-3049/27/7/2045>
5. <https://par.nsf.gov/servlets/purl/10040699>

Course Code: CHRE-505**Course Title: Catalysis****Credit: 2****Duration: 30 hours****Maximum Marks: 50****Course Objectives:**

The course will enable the student to

1. Define the general principles of catalysis.
2. Explain the thermodynamic considerations related to catalysis.
3. Identify various types of solid catalysts.
4. Compare and contrast monolayer and multilayer adsorption processes.
5. Apply knowledge of thermodynamics to assess the feasibility of catalytic reactions.
6. Analyse the kinetic mechanisms of catalytic reactions, including rate-determining steps and rate expressions.

Course Learning Outcomes:

On successful completion of the course, the student will be able to

CLO1: Explain the general principles of shape-selective catalysis and the various types of solid catalysts.

CLO2: Understand the thermodynamic considerations in catalytic reactions.

CLO3: Compare and contrast different types of adsorptions mechanisms.

CLO4: Analyse catalyst preparation and deactivation methods.

CLO5: Perform catalytic reactions for various chemical transformations using suitable catalysts.

MODULE I: Fundamentals in catalysis**15 Hours**

Catalysis - general principle, thermodynamic considerations, types of solid catalysts, catalyst deactivation, types of adsorptions - monolayer adsorption, monolayer adsorption on homogeneous and heterogeneous surface; multilayer adsorption- polyani's theory of adsorption: adsorption on porous solids, catalyst texture, surface area - volumetric method, gravimetric method, flow method;

pore size distribution- pore size from adsorption, mercury porosity meter, chemisorption - chemisorption of hydrogen, O₂, N₂ and CO, unsaturated hydrocarbons, chemisorption bond- covalent bond, ionic bond, quantum mechanical approach participation of d electrons.

MODULE II: Reaction kinetics and role of Catalyst

15 Hours

Reaction kinetics- the rate determining step, rate expressions, geometric factor in catalysis balandin's multiplet theory, electronic effect in catalysis by metals, band theory, pauling's valence bond method, electronic structure and catalysis. catalysis by semiconductors; boundary layer theory of chemisorption, catalysis by acidic solids, zeolites – structure, zeolite pores, synthesis, acidity of zeolites, shape selective catalysis, zeolite based processes, aluminophosphate molecular sieves, clays- intercalation of clays, pillared clays, catalysis with clays, mesoporous materials, preparation of catalysts precipitation method, impregnation method, role of support, loading of the support, microporous solids- mesoporous solids role of diffusion.

REFERENCE BOOK:

Mandatory:

1. D. K. Chakrabarty and B. Viswanathan, *Heterogeneous Catalysis*, New Age International Publishers, 2008.

Supplementary:

1. G. A. Somorjai, *Introduction to Surface Chemistry and Catalysis*, John Wiley, 2002
2. M. Thomas and W. J. Thomas, *Principles and Practice of Heterogeneous Catalysis*, VCH Publishers, 1996.
3. Bhatnagar, M. S. (2004). *A Textbook of Polymer Chemistry*. S. Chand Publishing.
4. Shelef, M., and Otto, K. (1971). *The theory of adsorption and catalysis*: By Alfred Clark, Academic Press, New York

WEB REFERENCES:

1. <https://www.britannica.com/science/catalysis/Classification-of-catalysts>
2. [https://chem.libretexts.org/Bookshelves/General_Chemistry/Map%3A_Chemistry_-_The_Central_Science_\(Brown_et_al.\)/14%3A_Chemical_Kinetics/14.07%3A_Catalysis](https://chem.libretexts.org/Bookshelves/General_Chemistry/Map%3A_Chemistry_-_The_Central_Science_(Brown_et_al.)/14%3A_Chemical_Kinetics/14.07%3A_Catalysis)
3. <https://www.sciencedirect.com/topics/engineering/catalyst-preparation>
4. [https://chem.libretexts.org/Bookshelves/General_Chemistry/Map%3A_Principles_of_Modern_Chemistry_\(Oxtoby_et_al.\)/Unit_5%3A_Rates_of_Chemical_and_Physical_Processes/18%3A_Chemical_Kinetics/18.7%3A_Kinetics_of_Catalysis](https://chem.libretexts.org/Bookshelves/General_Chemistry/Map%3A_Principles_of_Modern_Chemistry_(Oxtoby_et_al.)/Unit_5%3A_Rates_of_Chemical_and_Physical_Processes/18%3A_Chemical_Kinetics/18.7%3A_Kinetics_of_Catalysis)
5. <https://www.britannica.com/science/silicate-mineral>
6. <https://www.explainthatstuff.com/zeolites.html>

Course Code: CHRE-506

Course Title: Applied Organic Chemistry

Credits: 2

Duration: 30 Hours

Maximum Marks: 50

Course Objective:

The course will enable the student to

1. Recall and define key terms related to retrosynthesis, such as synthons, synthetic equivalents, and disconnection approach.
2. Comprehend the principles of retrosynthetic analysis, including how to perform one-group and two-group C-X disconnections for aromatic compounds.
3. Understand important strategies for amine and alkene synthesis.

4. Develop synthetic routes for complex molecules using retrosynthetic principles, including the selection of appropriate protecting groups and chiral reagents.

Course Learning Outcomes:

By the end of this course students will be able to, the student will be able to

CLO1: Recall the fundamental principles of retrosynthesis, including the concept of synthons and synthetic equivalents.

CLO2: Understand the disconnection approach in retrosynthetic analysis and its application in the synthesis of aromatic compounds, amines, and alkenes.

CLO3: Analyse protection and deprotection methods as well as chemo and regioselective protection techniques. for various functional groups,

CLO4: Apply important strategies of retrosynthesis for the synthesis of organic compounds and their interconversions.

MODULE I: Retrosynthetic Analysis and Protecting Group

15 hours

Basic Principles and Terminology of retrosynthesis: Introduction to synthons and synthetic equivalents, disconnection approach, synthesis of aromatic compounds- one group and two group C-X disconnections, Amine and alkene synthesis- important strategies of retrosynthesis, functional group interconversions, functional equivalents and reactivity-Umpolung reaction, Protection and deprotection of hydroxyl, carbonyl and amino groups, Chemo and regioselective protection and deprotection, common protecting groups used in Peptide synthesis.

MODULE II: Asymmetric Synthesis

15 hours

Introduction, enantiomeric and diastereomeric excess- determination, distereoselectivity and enantioselectivity in cyclic compounds, Cram's rule, Felkin Anh Model, Cram chelate model, stereoselective aldol reaction, asymmetric induction- use of chiral auxiliaries, Chiral reagents and catalysts, asymmetric hydrogenation, epoxidation and dihydroxylation.

REFERENCE BOOK:

Mandatory:

1. Organic Chemistry, Jonathan Clayden, Nick Greeves and Stuart Warren

Supplementary:

1. R.O.C Norman and J.M Coxon, Principles of organic synthesis, 3rd ed. Blackie Academic & Professional, 1993.
2. J. March, Advanced organic Chemistry: Reaction Mechanism and Structure, 5th ed, New York: John Wiley, 1999.
3. M.B. Smith, Organic Synthesis, McGraw Hill international Edn, 1994.
4. S. Warren, Organic Synthesis, The disconnection approach, John Wiley & Sons, 2004
5. P. Wyatt and S. Warren, Organic synthesis strategy and control, Wiley, 2008

WEB REFERENCES

1. <https://www.khanacademy.org/science/class-11-chemistry-india/xfb6cb8fc2bd00c8:in-in-organic-chemistry-some-basic-principles-and-techniques>
2. <https://themasterchemistry.com/fundamental-principles-of-organic-chemistry/>
3. <https://leah4sci.com/organic-chemistry-retrosynthesis/>
4. [https://chem.libretexts.org/Bookshelves/Organic_Chemistry/Basic_Principles_of_Organic_Chemistry_\(Roberts_and_Caserio\)/13%3A_Polyfunctional_Compounds_Alkadienes_and_Approaches_to_Organic_Synthesis/13.10%3A_Protecting_Groups_in_Organic_Synthesis](https://chem.libretexts.org/Bookshelves/Organic_Chemistry/Basic_Principles_of_Organic_Chemistry_(Roberts_and_Caserio)/13%3A_Polyfunctional_Compounds_Alkadienes_and_Approaches_to_Organic_Synthesis/13.10%3A_Protecting_Groups_in_Organic_Synthesis)
5. <https://www.sciencedirect.com/topics/biochemistry-genetics-and-molecular-biology/asymmetric-synthesis>
6. <https://www.britannica.com/science/asymmetric-synthesis>

Course Code: CHRE-507
Course Title: Nanomaterials
Credit: 2
Duration: 30
Maximum Marks: 50

Course Objectives:

The course will enable the student to

1. List and describe the four generations of Nanoproduct development.
2. Explain the concept of Phase transition in nanomaterials.
3. Describe the various manufacturing processes for integrating nanoparticles into nanoproducts.
4. Apply knowledge of magnetization processes in nanoparticles and their role in nanomaterial properties.
5. Demonstrate an understanding of the self-assembly of nanomaterials at macroscopic scales and fabrication techniques.
6. Analyse the various applications of nanoparticles in different fields.
7. Examine the nature of nanoparticles in the environment, including exposure, effects, and risk assessment.

Course Learning Outcome:

By the end of this course students will be able to

CLO1: Memorize the fundamental properties and four generations of nanoproduct development.

CLO2: Study the concept of nanocomposites and their applications.

CLO3: Apply knowledge of nanoparticle properties to predict their behaviour in various applications

CLO4: Analyse the phase transition of nanoparticles and the methods for making nanostructures using top-down techniques.

MODULE- I: Nanoscale Materials

15 Hours

Introduction, Properties; Fundamental importance of size and its influence; Nanoparticles in the Atmosphere and Space, Phase transition, Manufacturing Processes: four generations of Nanoproduct development; integrating nanoparticles into nanoproducts, Types of nanomaterials Titanium dioxide, Zero-valent iron, carbon nanostructures- carbon black, carbon nanotubes, carbon nano-horns, fullerenes; composites and nanocomposites

Magnetism in Nanoparticles-Magnetisation Processes in Nanoparticles, Self-Assembly of Nanomaterials at Macroscopic Scales- Fabrication of Nanomaterials ,2D and 3D Nanomaterial Structures. Making Nanostructures Using Top-Down Methods, Applications of nanoparticles.

MODULE II: Environmental Fate and Transport of Nanomaterials

15 Hours

Nature of nanoparticles in the environment-Exposure, Effects and Risk, Predicting the behavior of Nanomaterials, Treatment of Nanoparticles in wastewater- Treatment Processes, Factors that affect the toxicology of Nanomaterials- Exposure and effects, Nanoparticles use in Pollution control, Atmospheric Nanoparticles-Sources and sinks; Health effects; New Particle formation and growth in the atmosphere, Measurement of Aerosol nanoparticles.

REFERENCE BOOKS:

Mandatory:

Nanotechnology and the Environment, Kathleen Sellers, Christopher Mackay, Lynn L. Bergeson, Stephen R. Clough, Marilyn Hoyt, Julie Chen, Kim Henry, Jane Hamblen, First Indian Reprint, 2012

Supplementary:

1. Introduction to Nanoscience and Nanotechnology, Chris Binns, John Wiley & Sons, 2010

2. Nanomaterials and Nanochemistry, Catherine Bréchnignac, Philippe Houdy, Marcel Lahmani.
3. Nanoparticles in Medicine and Environment, Jan C.M. Marijnissen, Leon Gradoñ, European materials research society.

WEB REFERENCES

1. <https://www.emm-nano.org/what-is-nanoscience-nanotechnology/>
2. <https://pubs.acs.org/doi/10.1021/acsnano.5b01418>
3. <https://www.worldscientific.com/worldscibooks/10.1142/7364#t=aboutBook>
4. <https://www.nanowerk.com/nanotechnology-and-the-environment.php>
5. <https://www.opengrowth.com/resources/how-does-nanotechnology-impact-the-environment>

Course Code: CHAD-501

Course Title: Dissertation

Credit: 16

Duration: 480 Hours

Maximum marks: 400

The dissertation must comprise of original research and may be conducted either at the Institute or with approval, in an outside institution or company e. g., the student's employers. The guiding teacher may serve some laboratory hours for industry work.

The dissertation work is to be submitted for: evaluation and Viva Voice examination at the end of Semester IV.

Written test must be conducted regarding the basic principles of techniques or instruments used with respect to the area of dissertation topic.

Students may be assessed based on designing the question bank by students on dissertation topic.

Course Code: CHAI-501

Course Title: Internship

Credit: 16

Duration: 192 Hours

Maximum marks: 400

MODULE A: Internship at Industry; Two weeks per Semester (Semester III and IV) **144 Hours**

MODULE B: Write up of the Internship work per Semester (Semester III and IV) **16 Hours**

MODULE C: Students to design four modules based on their experience at industry **32 Hours**