PARVATIBAI CHOWGULE COLLEGE OF ARTS AND SCIENCE
(AUTONOMOUS)
DEPARTMENT OF CHEMISTRY
ACADEMIC YEAR: 2025-2026

COURSE STRUCTURE TO BE IMPLEMENTED FROM ACADEMIC YEAR: 2025-2026 ONWARDS

SEMESTER	MAJOR CORE	MINOR/ VOCATIONAL	DOUBLE MAJOR	MULTIDISCIPLINARY COURSE (MDC)	VALUE ADDED COURSES (VAC)	ABILITY ENHANCEMENT COURSE (AEC)	SKILL ENHANCEMENT COURSE (SEC)
I	**UG-CHE-101** General Chemistry-I	**UG-CHE-101** General Chemistry-I	-	**UG-CHE-MDC1** Basics in Chemistry **UG -CHE-MDC2** Essentials of Chemistry	**UG-CHE-VAC1** Environmental monitoring **UG-CHE-VAC2** Ethics in science	-	**UG-CHE-SEC1** Skill Development in Chemistry **UG-CHE-SEC2** Basic Laboratory Methods and Safety in Chemistry
II	**UG-CHE-102** General Chemistry-II	**UG-CHE-102** General Chemistry-II	-	**UG-CHE-MDC1** Basics in Chemistry **UG-CHE-MDC2** Essentials of Chemistry	**UG-CHE-VAC1** Environmental monitoring **UG-CHE-VAC2** Ethics in science	-	**UG-CHE-SEC3** Chemistry of Water and Soil
III	**UG-CHE-201** Concepts in Chemistry-I	**UG-CHE-207** Concepts in Chemistry -III	-	**UG-CHE-MDC5** Fundamentals of Chemistry	-	-	**UG-CHE-SEC4** Basics of Analytical Chemistry
	UG-CHE-202 Concepts in Chemistry-II			-	-	-	-
IV	**UG-CHE-203** Selected Topics in Physical Chemistry	**UG-CHE - VOC1** Spectroscopic Techniques	**UG-CHE-203** Selected Topics in Physical Chemistry	-	-	-	-
	UG-CHE-204 Selected Topics in Organic Chemistry	-	**UG-CHE-205** Selected Topics in Inorganic Chemistry	-	-	-	-
	UG-CHE-205 Selected Topics in Inorganic Chemistry	-	-	-	-	-	-

	UG-CHE-206 Introduction to Pharmaceutical Chemistry	-		-	-	-	-
V	**UG-CHE-301** Advanced Physical Chemistry -I	**UG-CHE - VOC2** Analytical techniques	**UG-CHE-301** Advanced Physical Chemistry -I	-	-	-	-
	UG-CHE-302 Advanced Organic Chemistry -I	-	**UG-CHE-302** Advanced Organic Chemistry -I	-	-	-	-
	UG-CHE-303 Advanced Inorganic Chemistry -I	-	-	-	-	-	-
VI	**UG-CHE-304** Advanced Physical Chemistry -II	**UG-CHE - VOC3** Industrial Process	**UG-CHE-305** Advanced Organic Chemistry -II	-	-	-	-
	UG-CHE-305 Advanced Organic Chemistry -II	-	**UG-CHE-306** Advanced Inorganic Chemistry -II	-	-	-	-
	UG-CHE-306 Advanced Inorganic Chemistry -II **UG-CHE-PRJ** Project **UG-CHE-307** Environmental and sustainable chemistry	-	**UG-CHE-PRJ** Project **UG-CHE-307** Environmental and sustainable chemistry	-	-	-	-

PARVATIBAI CHOWGULE COLLEGE OF ARTS AND SCIENCE (AUTONOMOUS)
DEPARTMENT OF CHEMISTRY ACADEMIC YEAR: 2026-2027

REVISED DRAFT SYLLABI
SYLLABI TO BE REVISED TO IMPLEMENT FROM ACADEMIC YEAR: 2026-2027

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 help to get better understanding about the basics of Chemical kinetics.
3. To be able 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:
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: Develop practical skills in Physical, Organic and Inorganic Chemistry.

SECTION-I (PHYSICAL CHEMISTRY)

MODULE I: Mathematical Concepts in Chemistry **07 Hours**

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.

MODULE II: Chemical Kinetics **08 Hours**

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).

SECTION-II (ORGANIC CHEMISTRY)

MODULE III: IUPAC Nomenclature of Organic Compounds **02 Hours**

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.

MODULE IV: Fundamentals of Organic Compounds **08 Hours**

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.

MODULE V: Study of alkanes and cycloalkanes **05 Hours**

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.

SECTION-III (INORGANIC CHEMISTRY)

MODULE VI: Atomic Structure and the Periodic Table **05 Hours**

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.

MODULE VII: Covalent Bonding **10 Hours**

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^- 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. To determine the amount of Ca^{+2} ion in the given solution 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 $Na_2C_2O_4$ 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**

REFERENCES

Mandatory Reading:

PHYSICAL CHEMISTRY TEXT BOOK:

1. Atkins, P., Paula, J. D. Atkins' Physical Chemistry, Oxford University Press.

ORGANIC CHEMISTRY TEXT BOOK:

1. Morrison, R. T., Boyd, R. N. and Bhattacharjee, S. K., Organic Chemistry, Pearson India.

INORGANIC CHEMISTRY TEXT BOOK:

1. Atkins, P., Overton, T., Rourke, J., Weller, M., Armstrong, F., Shriver and Atkins' Inorganic Chemistry, Oxford University Press.

Supplementary Reading:

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. 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.
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., Advanced Inorganic Chemistry, Wiley Publications.
10. Puri, B. R., Sharma, L. R., Kalia, K. C. Principles of Inorganic Chemistry, Vishal Publishing Co.
11. House croft, 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_14auLect ureSlides_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
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/

MULTI DISIPLINARY COURSES
THEORY
Course Code: UG-CHE-MDC1
Course Title: Basics in Chemistry
Credits: 2
Duration: 30 Hours
Maximum Marks: 50

Course Objectives:

1. To make students understand about the basic theoretical concepts in chemistry.
2. To provide the knowledge about the different types of pollution, its harmful effects and green chemistry.
3. To provide basic practical knowledge by performing experiments in laboratory.

Course Learning Outcomes:

On successful completion of the course, the student will be able to:
CLO1: Explain the basic concepts in chemistry.
CLO2: Discuss different types of pollution, its related harmful effects, and the importance of green chemistry.
CLO3: Develop practical skills by performing basic chemistry experiments in the laboratory.

MODULE I: Introduction to Chemistry **15 Hours**

Introduction and importance of chemistry, classification into 4 major branches: Organic, Inorganic, Physical and Analytical; basic concepts of atoms, elements, molecules, compounds, reactants, products, reagents, chemical bonds, and ions; Physical: States of matter: solids, liquids, and gases; Organic: Introduction to organic compounds, properties, examples, and their applications in everyday life. Purification techniques of solids: recrystallization and sublimation; Inorganic: structure of atom; acids and bases; metals, non-metals, and noble gases: Analytical: Preparation of solutions: normality, molarity, ppm.

MODULE II: Pollution and Green Chemistry **15 Hours**

Types of pollution: Air, Water, Noise: Sources, harmful effects, hazards associated with flora and fauna, measures to control, upcoming methods for air/water pollution treatment Acid rain: causes and harmful effect with an example of effect on Taj mahal, Corrosion Rusting of iron, its causes and prevention, Impact

of Toxic chemicals in environment, Pollutants and their statutory limits; 12 principles of green chemistry with one example, Global warming, Greenhouse gases, Greenhouse effect, Hydrochemistry: Reaction of water with atmospheric gases, Renewable and non-renewable sources of energy (examples) and its conservation.

PRACTICALS
Course Code: UG-CHE-MDC1
Course Title: Basics in Chemistry
Credit: 1
Duration: 30 Hours
Maximum Marks: 25

LIST OF EXPERIMENTS

1.	Purification techniques of solid: Recrystallization.	**02 Hours**
2.	Purification techniques of solid: Sublimation.	**02 Hours**
3.	Preparation of solutions in terms of normality.	**02 Hours**
4.	Preparations of solution in terms of molarity.	**02 Hours**
5.	Preparations of solution in terms of ppm.	**02 Hours**
6.	Standardization of solution: Acid and base.	**04 Hours**
7.	Determination of melting point of solids (any two).	**02 Hours**
8.	Determination of mixed melting point of solids.	**02 Hours**
9.	Determination of boiling point of liquids (any two).	**02 Hours**
10.	Identification of physical and chemical properties of the given compounds.	**04 Hours**
11.	Identification of acids from the given samples using saturated $NaHCO_3$ solution.	**02 Hours**
12.	Identification of bases from the given samples using NaOH solution.	**02 Hours**
13.	Identification of chemical type of the given organic compound.	**02 Hours**

REFERENCES
Mandatory Reading:

1. Gurdeep, R. Advanced Physical Chemistry, 27th Edition; Goel Publishing House, Meerut
2. Shriver, D. F. et. al. Inorganic Chemistry, 5th Edition, Oxford University Press

SUPPLEMENTARY READING:

1. Ahluwalia, V. K.; Green Chemistry: Environmentally Benign Reactions, Ane Books India, New Delhi.
2. Cooper, M. M.; Cooperative chemistry laboratory manual, International Edition, McGraw-Hill Company.
3. Furniss, B. et. al. Vogel's Textbook of Practical Organic Chemistry, Pearson Education
4. Iqbal, S. A. et. al. Chemistry of Air and Air Pollution Discovery Publishing House, New Delhi
5. Matlack, A. S. et. al.; Introduction to Green Chemistry, CRC Press, New York
6. Puri, B. R. et. al. Principles of Physical Chemistry
7. Tyagi, O. D. et. al. A Text Book of Environmental Chemistry, Anmol Publications, New Delhi
8. Skoog, D. A., et. al. Fundamentals of Analytical Chemistry, 8th Edition
9. Morrison, R. T. et. al. Organic Chemistry Pearsons Publications, Noida India.

WEB REFERENCES:

1. https://ncert.nic.in/ncerts/l/kech105.pdf
2. https://www.ugc.gov.in/oldpdf/modelcurriculum/Chapter5.pdf
3. https://www.asdlib.org/onlineArticles/ecourseware/Manahan/GreenChem-2.pdf
4. https://faculty.ksu.edu.sa/sites/default/files/2_preparation_of_solutions 0.pdf

THEORY

Course Code: UG-CHE-MDC2
Course Title: Essentials of Chemistry
Credits: 2
Duration: 30 Hours
Maximum Marks: 50

Course Objectives:
1. To make students understand the basic theory concepts in organic chemistry.
2. To write the formula of simple inorganic compounds and their nomenclature.
3. To understand the different types of solids and their structures.
4. To provide basic practical knowledge by performing experiments in the laboratory.

Course Learning Outcomes:
On successful completion of the course, the student will be able to:
CLO1: Explain the basic concepts in organic chemistry.
CLO2: Identify the nomenclature of inorganic compounds; explain different types of solids and their structure.
CLO3: Develop practical skills by performing basic chemistry experiments in the laboratory.

MODULE I: Basics in Organic Chemistry **15 Hours**
Organic compounds shape, structure, hybridization of carbon; structure and stability of carbocation, carbanion, and free radicals; electrophile, nucleophile; homolytic and heterolytic cleavage; isomerism, keto-enol tautomerism; substitution reactions, elimination reactions, aromaticity, resonance, resonating structures.
Structure, nomenclature, classification, properties, and applications of organic compounds with different functional groups: amines, nitro compounds, ethers, alcohols, aldehydes, ketones, carboxylic acids, esters, benzene and substituted benzene compounds (any two).

MODULE II: Basics in Inorganic Chemistry **15 Hours**
Inorganic Nomenclature: Writing symbols of elements and formulae of inorganic species, Inorganic nomenclature, Names of compounds in general, Names of ions, radicals, and polyanions, Names of acids, salts, and salt-like compounds. Names of addition compounds.
Structure of solids: crystalline and amorphous solids, size and shape of crystals, Basic crystal systems, structure of ionic crystals examples: diamond, NaCl and CsCl.

PRACTICALS
Course Code: UG-CHE-MDC2
Course Title: Essentials of Chemistry
Credit: 1
Duration: 30 Hours
Maximum Marks: 25

LIST OF EXPERIMENTS
1. Qualitative analysis of only solid organic compounds: Acid, phenol, bases, amides, anilides, hydrocarbons, carbohydrates (any five). **10 Hours**
2. Qualitative analysis of inorganic salts (any four). **08 Hours**
3. Standardisation of NaOH using potassium hydrogen phthalate. **02 Hours**
4. Standardisation of $KMnO_4$ using oxalic acid. **02 Hours**
5. To prepare 100 ppm Manganese solution using $KMnO_4$ and carry out the further dilutions like 5, 10 ppm in 50 mL standard volumetric flasks. **02 Hours**
6. Standardisation of HCl against Na_2CO_3. **02 Hours**
7. Preparation of ZnO. **02 Hours**

8. Preparation of Ni-DMG complex. **02 Hours**

REFERENCES

Mandatory Reading:

1. Morrison, R. T., Boyd, R. N. and Bhattacharjee, S. K., Organic Chemistry, Pearson India.
2. Atkins P. W., Overton T. L., Rourke J. P., Weller M. T. and Armstrong F. A., Shriver and Atkins Inorganic Chemistry, Oxford University Press.

SUPPLIMENTARY READING:

1. Bruice, P. Y., Organic Chemistry; Pearson India.
2. Carey, F. C. and Giuliano, R. M., Organic Chemistry; Tata McGraw-Hill India.
3. March, J., Advanced Organic Chemistry Reaction, Mechanism and Structure, 4th Edition, Wiley Publications.
4. Greenwood, N. N., Earnshaw, A., Chemistry of Elements, Pergamon, Oxford.
5. Huheey, J. E., Keiter, E. A., Keiter, R. L., Medhi, O. K. Inorganic Chemistry: Principles of Structure and Reactivity, Pearson Edu.
6. Lee J. D., Concise Inorganic Chemistry; Wiley-India.
7. Cotton F. A. and Wilkinson G., Basic Inorganic Chemistry; Wiley Eastern Ltd.

PRACTICAL BOOKS:

1. Furniss, B., Brian, S., Vogel's Textbook of Practical Organic Chemistry, Pearson Education.
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. https://byjus.com/jee/hybridization-of-carbon/
2. http://www.chem.ualberta.ca/~vederas/Chem_164/handouts/pdf/sub_elim_rxn.pdf
3. https://www.vedantu.com/chemistry/hybridization
4. https://www.toppr.com/guides/chemistry/chemical-bonding-and-molecular-structure/molecular-orbital-theory/
5. https://www.visionlearning.com/en/library/Chemistry/1/Chemical-Bonding/55
6. https://unacademy.com/content/neet-ug/study-material/chemistry/types-of-bonding/

VALUE ADDED COURSE THEORY
Course Code: UG-CHE-VAC1
Course Title: Environmental monitoring
Credits: 2
Duration: 30 hours
Maximum Marks: 50

Course Objectives:

1. To understand the sampling techniques and the various parameters tested to monitor the quality of air and water.
2. To gain knowledge about soil sample preparation and soil analysis.

/Course Learning Outcomes:

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

CLO1: Analyze the nature and types of air and water pollutants, describe the sampling techniques and explain the parameters tested for air and water quality.

CLO2: Compare the techniques employed for soil sample preparation and explain the different tests conducted for soil analysis.

MODULE I: Air and Water Analysis **15 Hours**

Sampling of air pollutants: Absorption in liquids, Adsorption on solids - cold trapping adsorption and collection of particulates. Relative humidity of atmosphere, Analysis of pollutants in air: SO_2, H_2S, CO, CO_2, and NO_x.

Nature and types of water pollutants, Sampling of water: sampling and sample preservation; Water analysis: Physico-Chemical Tests-Temperature, Transparency, Turbidity, pH, Conductivity, Total solids, total suspended solids, Acidity, alkalinity, chloride, fluoride, sulphate, total hardness, Determination of organic loadings, determination of toxic metal ions, Chemical oxygen demand, Biochemical oxygen demand and dissolved oxygen.

MODULE II: Soil Analysis **15 Hours**

Soil sample preparation, Soil analysis: Bulk density, specific gravity, moisture content, water holding capacity, pH, conductivity, alkalinity and detection of chloride, sulphate, nitrate, total phosphorus, sodium, potassium, calcium, magnesium, iron, and organic matter.

REFERENCES

Mandatory Reading:

1. De, A. K., Environmental Chemistry, Wiley Eastern Ltd. House, New Delhi.
2. Trivedi P. R. et.al, Environmental Water and Soil Analysis, 1st Edition, Akashdeep Publishing house, New Delhi
3. Tyagi, O. D. et.al, A Text Book of Environmental Chemistry, Anmol Publications, New Delhi

Supplementary Reading:

1. Katyal Jimmy et.al., Environmental Pollution", Anmol Publications, New Delhi.
2. Schroede, E. D., Water and Waste Water Treatment, McGraw Hill.
3. Vanloon G. W. et.al, Environmental Chemistry, Oxford University Press

WEB REFERENCES:

1. https://www.sciencedirect.com/topics/earth-and-planetary-sciences/pollutant-analysis
2. https://web.iitd.ac.in/~arunku/files/CEL212_Y14/Lab7part2_Air_Lab_Manual.pdf
3. https://www.sciencedirect.com/science/article/abs/pii/S2214158820300350ttps://www.sciencedirect.com/science/article/abs/pii/S2214158820300350
4. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC7126548/
5. https://eos.com/blog/soil-testing/

VALUE ADDED COURSE

THEORY

Course Code: UG-CHE-VAC2
Course Title: Ethics in Science
Credits: 2
Duration: 30 hours
Maximum Marks: 50

Course Objectives:

1. To acquire the knowledge of ethics in Science and professionalism and learn various ethical theories.
2. To understand the diverse ethical issues in Science and ethical problem solving methods.

Course Learning Outcomes:

CLO1: Explain ethics, professionalism and ethical theories in Chemistry.
CLO2: Analyse diverse ethical issues in Science and their ethical problem solving methods.

MODULE I: Ethical Theory and Professionalism and Ethics in Science **15 Hours** 1: Introduction, common morality, Utilitarian theories, Deontological theories, Virtue theories, Communitarian theories, Prima facie and actual norms.

UNIT 2: Concept of profession, moral idea for science, development of professions, internal code of practice, epistemology and ethics, science and society, pure and applied research, shared fate and user-inspired research, trust in science, teaching and learning scientific ethics.

MODULE II: Unique Ethical Issues in Science and Ethical Problem Solving **15 Hours**

UNIT 1: Moral communities, ethics and chemical synthesis, ethics in the laboratory, Chemical weapons and other dangerous substances, environmental pollution, codes of ethics.
UNIT 2: Ethical problem solving: Definition, data collection, data analysis, resolution. Case Studies: Any five case studies.

REFERENCES
Mandatory Reading:
1. Kovac, J., The Ethical Chemist: Professionalism and Ethics in Science

WEB REFERENCES:
1. https://www.chemistryworld.com/features/ethics-in-chemistry/3008982.article 2. https://pubs.acs.org/doi/pdf/10.1021/bk-2021-1401.ch001
3. https://chemistry-europe.onlinelibrary.wiley.com/doi/10.1002/chem.201605259
4. https://www.nature.com/articles/s41557-021-00848-2
5. https://www.bing.com/search?q=ethical+issues+in+chemistry&FORM=QSRE2

SKILL ENHANCEMENT COURSE THEORY
Course Code: UG-CHE-SEC1
Course Title: Skill Development in Chemistry
Credits: 2
Duration: 30 Hours
Maximum Marks: 50

Course Objectives:
1. To understand the chemistry of fats, oils and the process involved in preparing soaps, detergents and disinfecting agents and provide necessary skills for the preparation.
2. To study the composition and chemical parameters of commonly consumed beverages like soft drinks and packed fruit juices, the process involved in their preservation and their long-term effects on human health.
3. To study the various food additives like food colours, taste enhancers, preservatives, etc. and their effects on food and health. Food adulteration of commonly used kitchen ingredients like wheat, rice, dal, milk, butter, etc. and the tests involved to detect the adulterants will be studied.

Course Learning Outcomes:
On successful completion of the course the students will be able to:
CLO1: Determine the saponification value, iodine value and acid values of oils and Analyze the chemistry of cleaning agents.
CLO2: Identify the adulterants in food items and understand the chemistry of soft drinks.
CLO3: Apply the knowledge for testing foods items for adulterants, determine pH of samples and apply the skills for the preparation of white phenyl and liquid soap.

MODULE I: Fats, Oils and Cleaning Agents **15 Hours**
Introduction to fats and oils: Chemical nature, physical and chemical properties.

Types: Natural fats, saturated fats, unsaturated fats different types of edible and industrial oils of vegetable origin, common fatty acids, and glycerides.
Quality parameters of oil: Acid value, Saponification value, Iodine value, peroxide value, moisture content, Reichert- Meissl (RM) value and smoke point.
Hydrogenation of oil, Rancidity of oil, good and bad effects on health.
Soaps: Chemical composition, Structure of molecule and its preparation, properties of soaps, method of preparation. Detergents: Chemical composition, natural and synthetic detergents, alkyl and aryl sulphonates, properties of detergents and method of preparation. Micelle formation, Kraft's temperature, critical micellar concentration, mechanism of cleansing action of soap and difference between soaps and detergents. Floor cleaners- preparation, storage, and disposal of white phenyl.

MODULE III: Beverages, Food Additives and Adulterants **15 Hours**

Soft drinks, soda, fruit juices and alcoholic beverages (types and content of alcohol). Composition of soft drinks, and its excessive use leading to urinary bladder stones. Preservation in tetra pack. Nitrogen preservation and packing of fruit juices. Food additives: Artificial sweeteners-saccharin, cyclomate, asparatame; food Flavours-esters, aldehydes and heterocyclic compounds. Food colours: Restricted use, spurious colours. Emulsifying agents, preservatives and leavening agents- Baking powder, Yeast. Taste enhancers-MSG, vinegar.Food Adulteration: Contamination of wheat, rice, dal, milk, butter, etc. with clay, sand, stone, water and toxic chemicals. Food poisons: natural poisons (alkaloids, nephrotoxins), pesticides (DDT, BHC, Follidol), Heavy metal (Hg, Pb, Cd) contamination of sea food.

PRACTICALS
Course Code: UG-CHE-SEC1
Course Title: Skill Development in Chemistry
Credit: 1
Duration: 30 Hours
Maximum Marks: 25

LIST OF EXPERIMENTS

1. Preparation of household cleaners:
   a. Floor deodorant b. Dish wash liquid c. Liquid soap d. Detergent powder e. Soap bar (any 3). **6 Hours**
2. To determine the Iodine number of:
   a. Sunflower oil b. Coconut oil c. Olive oil d. Vanaspati ghee e. Palm oil (any 2). **4 Hours**
3. To determination the saponification value of oils: a. Palm oil b. Castor oil c. Coconut oil (any 2). **6 Hours**
4. To determine the pH and acidity using pH meter (3 samples each).
   a. soft drinks b. fruit juices c. Energy drinks (any 2 to be performed). **8 Hours**
5. Test for presence of adulterants in food items (turmeric powder, chilli powder, vanaspati ghee, milk, coffee, pulses, tea leaves, sugar, pepper, edible oils, jaggery, honey, etc) **6 Hours**

REFERENCES

Mandatory Reading:

1. Battershall, J. P. *Food Adulteration and its detection*, ebook.
2. Belitz, H. D. etal., *Food Chemistry*. 4th Edition, Springer.
3. Branen, A. L. etal., *Food Additives*. 2nd Edition, Marcel Dekker, Inc.,
4. Fennema, O. R., *Food Chemistry*, Marcel Decker Inc., New York.
5. Madan, R. L., *Chemistry for Degree Students: T. Y. B. Sc. Students*, 2nd Edition, S. Chand Publications.

WEB REFERENCES:

1. https://www.wikihow.com/Formulate-White-Phenyle
2. https://www.youtube.com/watch?v=33NysscBs1k
3. https://www.wisegeek.com/what-are-the-most-common-hand-sanitizer-ingredients.htm
4. https://www.sciencedirect.com/topics/food-science/food-adulteration
5. https://fssai.gov.in/
6. https://www.who.int/news-room/fact-sheets/detail/food-additives

SKILL ENHANCEMENT COURSE

Course Title: Basic Laboratory Methods and Safety in Chemistry
Course Code: UG-CHE-SEC2
Credits: 2
Duration: 30 Hours
Maximum Marks: 50

Course Objectives:
1. To develop experimental skills in different purification techniques and basic laboratory methods.
2. To acquire knowledge about laboratory safety.

Course Learning Outcomes:
On successful completion of the course the students will be able to:
CLO1: Explain the concepts of diverse purification techniques and laboratory methods.
CLO2: Summarize the importance of laboratory safety.
CLO3: Acquire laboratory skills by performing various purification techniques.

MODULE I: Purification techniques and basic laboratory methods 15 Hours
Recrystallization: principle, procedure, choice of solvent, advantages, disadvantages. Sublimation: principle, procedure, advantages, and disadvantages. Distillation: principle, procedure, types, advantages and disadvantages. Physical constants: Importance of melting point and boiling point, advantage of mixed melting point, cleaning and drying methods for laboratory apparatus. Solvent extraction technique: principle, procedure and importance in separation of organic compounds. Various methods used for heating and cooling, filtration methods for separation of compounds, and methods for drying of compounds, their advantages and disadvantages.

MODULE II: Laboratory Safety 15 Hours
Risks in the laboratory, importance of laboratory safety, safety symbols of chemicals, safety symbols of equipment/area, SDS, MSDS, CAS RN, safety gadgets-PPE, fume hoods, emergency equipment's, general laboratory safety rules, do's and dont's in laboratory, Laboratory waste: characterization of laboratory waste, handling, collection and storage, segregation of chemical, glass and other waste and its proper disposal, special attention to Hazardous Waste Minimization, laboratory emergency: spills and fires, precautionary steps and emergency measures, laboratory accidents (case studies with key lessons).

PRACTICALS
Course Title: Basic Laboratory Methods and Safety in Chemistry
Course Code: UG-CHE-SEC2
Credits: 1
Duration: 30 Hours
Maximum Marks: 25

LIST OF EXPERIMENTS

1. Purification of solids by Recrystallization including determination of a suitable solvent and recording melting point (any two solids) **04 Hours**
2. Purification of solids by Sublimation and recording its melting point (any two solids) **04 Hours**
3. Purification of solvent by Distillation and recording its boiling point (any two liquids) **04 Hours**
4. Separation of a mixture of volatile and non-volatile solvents by Distillation (any two mixture) **04 Hours**
5. Separation of a mixture of organic compounds using solvent extraction technique **08 Hours**
   a) Acid and Phenol b) Phenol and Neutral c) Base and Neutral d) Acid-Phenol-Neutral
6. Determination of physical constants: Melting point and Boiling point (1 solid and 1 liquid) **02 Hours**
7. Determination of mixed melting point of benzoic acid and β-naphthol **04 Hours**

REFERENCES

Mandatory Reading:

Vogel, A. I.; Tatchell, A. R.; Furnis, B. S.; Hannaford, A. J. Smith, P. W. G., *Textbook of Practical Organic Chemistry*, 5th Edition, Prentice Hall.

SUPPLIMENTORY READING:

1. MANN, F. G.; SAUNDERS, B. C., *Practical Organic Chemistry*, 2nd Edition, Longman Inc., New York.
2. GATTERMANN, L., *The Practical Methods of Organic Chemistry*, 2nd Edition, Macmillan and Co., Ltd.

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1. https://people.chem.umass.edu/mcdaniel/chem269/experiments/recrystallization/Recrystallization.pdf
2. https://acikders.ankara.edu.tr/pluginfile.php/75185/mod_resource/content/0/Distillation.pdf
3. https://soe.unipune.ac.in/studymaterial/ashwiniWadegaonkarSelf/BSC%20821%20Ch%201.pdf
4. https://www.ncbs.res.in/sitefiles/labsafety.pdf

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 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 have a 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.
6. To Compare and understand the properties of elements within the s-block and p-block in the periodic table in relationship with the other elements.

Course Learning Outcomes:
On successful completion of the course, the student will be able to:
CLO1: Analyze and apply the different properties of liquids, the gas laws and PV Isotherms
CLO2: Apply the theoretical knowledge to synthesize alkenes, alkynes and delineate the concept of Stereochemistry.
CLO3: Predict available oxidation states for s- and p-block elements.
CLO4: Develop practical skills in Physical, Organic and Inorganic Chemistry.

SECTION- I (PHYSICAL CHEMISTRY)

MODULE I: Liquid State and Applications 07 Hours
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).

MODULE II: The Gaseous State 08 Hours
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 CH_4 and CO_2, 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)

SECTION- II (ORGANIC CHEMISTRY)

MODULE III: Study of Alkenes and Alkynes 08 Hours
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.

MODULE IV: Stereochemistry **07 Hours**

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; Can-Ingold-Prelog sequence rules: R/S configuration (for upto two chiral carbons) and E/Z nomenclature (for up to two C=C systems).

SECTION- III (INORGANIC CHEMISTRY)

MODULE V: Chemistry of s-block elements **05 Hours**

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

MODULE VI: Chemistry of p-block Elements **10 Hours**

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 prepare 0.001 M EDTA solution and separately estimate the amount of Zn^{2+} ion from $ZnCO_3$, Mg^{2+} ion from MgO. **02 Hours**
2. Volumetric estimation of Fe^{2+} using internal indicator by potassium dichromate method. **02 Hours**
3. To determine the alkali content in antacid tablet using standard HCl solution. **02 Hours**
4. Volumetric estimation of calcium from anhydrous Calcium Chloride. **02 Hours**
5. To determine the Total Dissolved Solids (TDS) in water samples **02 Hours**

REFERENCES

Mandatory Reading:

PHYSICAL CHEMISTRY TEXT BOOK:

1. Atkins, P., Paula, J. D. Atkins' Physical Chemistry, Oxford University Press.

ORGANIC CHEMISTRY TEXT BOOK:

1. Morrison, R. T., Boyd, R. N. and Bhattacharjee, S. K., Organic Chemistry, Pearson India.

INORGANIC CHEMISTRY TEXT BOOKS:

1. Lee, J. D., Concise Inorganic Chemistry, ELBS Publications.
2. Atkins, P., Overton, T., Rourke, J., Weller, M., Armstrong, F., Shriver, an Atkins' Inorganic Chemistry, Oxford University Press.

Supplementary Reading:

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., Pathania M. S., Principles of Physical Chemistry; Vishal Publishing.
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., Advanced Inorganic Chemistry, Wiley Publications. Puri, B. R., Sharma, L. R., Kalia, K. C., Principles of Inorganic Chemistry, Vishal Publishing Co.
9. Sharpe and Emilus, Inorganic Chemistry.
10. 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:

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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/eooptic/linkfiles/The%20Elements.pdf
5. Mechanism and Structure in Organic Chemistry, E. S. Gould et al.
6. Stereochemistry of Carbon Compounds, E. L. Eliel, Tata MacGraw Hill
7. https://www.sciencedirect.com/topics/chemistry/stereochemistry
8. https://www.sciencedirect.com/topics/chemistry/detailed-reaction-mechanisms
9. http://web.chem.ucla.edu/~harding/notes/notes_14D_additionpibonds.pdf
10. http://www.chem.ucalgary.ca/courses/350/Carey5th/Ch05/ch5-4.html
11. https://www.slideshare.net/kumar_vic/solid-state-chemistry-17237117
12. https://chem.libretexts.org/Bookshelves/Physical_and_Theoretical_Chemistry_Textbook_Maps/Supplemental_Modules_(Physical_and_Theoretical_Chemistry)/Physical_Properties_of_Matter/States_

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 explain the chemistry of water.
2. To discuss the chemistry of soil.
3. To provide the basic practical knowledge by performing water and soil related experiments in the laboratory.

Course Learning Outcomes:
On successful completion of the course, the student will be able to:
CLO1: Explain the chemistry of water.
CLO2: Summarize the chemistry of soil.
CLO3: Develop practical skills by performing performing water and soil related experiments in the 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

LIST OF EXPERIMENTS

1. To detect the presence of chloride, sulphate, nitrate, and phosphate ions in different water samples. **02 Hours**
2. To detect the presence of chloride, sulphate, nitrate, and phosphate ions in different soil samples. **02 Hours**
3. To detect the presence of ammonium, lead, magnesium, calcium and potassium ions in different water and soil samples. **02 Hours**
4. To determine the amount of carbonate and bicarbonate in the given water sample. **02 Hours**
5. To determine the pH of different water and soil samples using pH paper and pH meter. **02 Hours**
6. To determine the amount of Calcium in the given soil sample by Titrimetry. **02 Hours**
7. To determine the salinity of different water samples. **02 Hours**
8. To estimate residual chlorine in water by Iodometric method. **02 Hours**
9. To determine the total dissolved solids of given water sample. **02 Hours**
10. To determine the moisture content in different soil samples. **02 Hours**
11. To determine the bulk density of the given soil samples. **02 Hours**
12. To determine the specific gravity of the given soil samples. **02 Hours**
13. To determine the amount of Magnesium in the given soil sample by Titrimetry. **02 Hours**
14. To determine the chloride content in the given soil sample. **02 Hours**
15. To determine the amount of carbonate and bicarbonate in the given soil sample. **02 Hours**

REFERENCES

Mandatory Reading:

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. 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.

WEB REFERENCES:

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2. 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/152396498 219QuadrantIE-TEXT.pdf

SEMESTER III

CORE COURSE

THEORY
Course Code: UG - CHE-201
Course Title: Concepts in Chemistry-I
Credits: 3
Duration: 45 Hours
Maximum Marks: 75

Course Objectives:

1. To have knowledge of the main areas of Physical Chemistry, to develop critical thinking abilities and be able to work in chemical or related fields.
2. To attain practical skills in some classical and instrumental techniques.
3. To gain knowledge about the chemistry of aromatic compounds.
4. To write the mechanisms involved in electrophilic aromatic substitution reactions.
5. To learn the chemistry of alcohols, diols, ethers and alkyl halides.
6. To learn the chemistry of 3d transition metals and compare them with their 4d and 5d analogues.
7. To have knowledge of ionic solids in terms of their structure, bonding and defects in crystals.

Course Learning Outcomes:
On successful completion of the course, the student will be able to:
CLO1: Illustrate the first law of thermodynamics, Hess's law, interpret the Gibbs phase rule and pressure temperature diagrams in unary and binary systems.
CLO2: Utilize the concept of aromaticity and apply the theoretical knowledge to write the synthesis of aromatic compounds, alcohols, ethers and alkyl halides.
CLO3: Explain the chemistry of transition elements, describe the structure and bonding in ionic solids and illustrate the types of defects in ionic solids.
CLO4: Develop practical skills in Physical, Organic and Inorganic Chemistry

SECTION- I (PHYSICAL CHEMISTRY)

MODULE I: Thermodynamics **10 Hours**

Thermodynamic terms: system, surrounding, types of systems, intensive and extensive properties, State and path functions and their differentials, Thermodynamic process, Concept of work and heat, First law of thermodynamics: Definition and statements of internal energy and enthalpy, Heat capacities at constant volume and pressure and their relationships, Joule Thomson effect, Joule Thomson coefficient and inversion temperature, Calculation of w, q, dU, dH, for the expansion of ideal gases under isothermal and adiabatic conditions for reversible processes; Thermochemistry: Standard state, standard enthalpy of formation, Hess's law of heat summation and its applications, Heat of reaction at constant pressure and at constant volume, Enthalpy of neutralisation, bond dissociation energy and its calculation from thermodynamic data, Temperature dependence of enthalpy, Kirchoff's equation (Numerical expected).

MODULE II: Phase Equilibria **05 Hours**

Statement, meaning of terms: phase, components, degrees of freedom, Gibbs phase rule, derivation of Gibbs phase rule, Phase equilibria of one component system: water system, sulphur

system, Phase equilibria of two component system, simple eutectic system, Pb/Ag system, Nernst distribution law, deviations from Nernst distribution law, applications of the law.

SECTION- II (ORGANIC CHEMISTRY)

MODULE III: Arenes and Aromaticity 07 Hours

The aryl group, structure of benzene: Molecular formula and Kekule structure, stability and carbon- carbon bond lengths of benzene, resonance structure, molecular orbital picture, Huckel's rule, 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 of activating and deactivating groups (ortho, para and meta effects) and ortho/para ratio, side chain reactions of alkyl benzenes, Birch reduction with mechanism (benzene) and regioselectivity (anisole, benzoic acid).

MODULE IV: Study of Alcohols, Diols, Ethers and Alkyl Halides 08 Hours

Alcohols: Classification, structure and bonding, physical properties, methods of preparation-catalytic hydrogenation, metal hydride reduction, Grignard reaction (using formaldehyde, other aldehydes, ketones, esters, nitriles and epoxides), reactions of alcohols- oxidation reactions using chromic acid, $KMnO_4$, PCC and PDC (structures and preparation of PCC and PDC), conversion of alcohols to ethers by dehydration, Fischer Esterification.

Diols: Classification, methods of preparation, reactions of vicinal diols-Pinacol Pinacolone rearrangement (with mechanism) and periodic oxidative cleavage.

Ethers: Physical properties of ethers; Preparation of ethers: Williamson ether synthesis, alkoxymercuration-demercuration; Reaction of ethers with acids (HX)

Alkyl halides: Classification, methods of preparation: using alcohols and $SOCl_2$, PCl_3, halogenation of alkanes, mechanism for chlorination of methane, relative reactivity and selectivity with respect to chlorination and bromination of propane; nucleophilic substitution reactions of alkyl halides, S_N^1 and S_N^2 mechanisms with energy profile diagrams.

SECTION- III (INORGANIC CHEMISTRY)

MODULE IV: Chemistry of transition elements 07 hours

Chemistry of elements of the first transition series: properties, their binary compounds, oxidation states and their stability, coordination number and geometry, comparative study with 4d and 5d analogues with respect to the ionic radii, magnetic behaviour, oxidation states and spectral properties.

MODULE V: Ionic Solids: Structure and Bonding 08 hours

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 centres, extended defects, non-stoichiometric defects, conductivity in ionic solids.

PRACTICALS

Course Code: UG CHE-201

Course Title: Concepts in Chemistry -I

Credit: 1

Duration: 30 Hours
Maximum Marks: 25

LIST OF EXPERIMENTS:
PHYSICAL CHEMISTRY

1. To determine the partition coefficient of I_2 between $C_2H_4Cl_2$ and H_2O. **04 Hours**
2. To investigate the molecular condition of benzoic acid in a mixture of water and toluene. **04 Hours**
3. To determine the heat of neutralization of strong acid with strong base. **02 Hours**

ORGANIC CHEMISTRY

1. Purification techniques for organic compounds (Liquids) and determination of physical constant.
   Distillation: a. Separation of acetone and toluene
   b. Separation of ethyl acetate and nitrobenzene **04 Hours**
2. Organic Synthesis: **06 Hours**
   a. *p*-Bromo acetanilide from acetanilide
   b. Oxime from cyclohexanone
   c. 2,4-DNP hydrazone derivative of benzaldehyde

INORGANIC CHEMISTRY

Semi-micro qualitative analysis: To analyse inorganic mixtures containing four ions only (two cations and two anions). **10 Hours**

Cations: Pb^{2+}, Cu^{2+}, Cd^{2+}, Sn^{2+}, Fe^{2+}, Fe^{3+}, Al^{3+}, Cr^{3+}, Zn^{2+}, Mn^{2+}, Ni^{2+}, Co^{2+}, Ba^{2+}, Sr^{2+}, Ca^{2+}, Mg^{2+}, K^{+}, NH_4^{+}.

Anions: Cl^{-}, Br^{-}, I^{-}, NO_2^{-}, NO_3^{-}, SO^{2-}, $^3CO^{2-}$, SO_4^{2-}, PO_4^{3-}

Note: Minimum five inorganic compound mixtures to be analysed covering different groups of cations.

REFERENCES
Mandatory Reading
PHYSICAL CHEMISTRY TEXT BOOK:

Atkins, P., Paula, J. D., *Atkin's Physical Chemistry*, Oxford University Press.

ORGANIC CHEMISTRY TEXT BOOK:

Morrison, R. T., Boyd, R. N. and Bhattacharjee, S. K., Organic Chemistry, Pearson India.

INORGANIC CHEMISTRY TEXT BOOKS:

1. Lee, J. D., *Concise Inorganic Chemistry*, ELBS Publications.
2. Atkins, P., Overton, T., Rourke, J., Weller, M., Armstrong, F., *Shriver and Atkins' Inorganic Chemistry*, Oxford University Press.

Supplementary Reading:

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. Bruice, P. Y., *Organic Chemistry*, Pearson India.
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6. Finar, I. L., *Organic Chemistry*, Pearson India
7. Greenwood, N. N., Earnshaw, A., *Chemistry of Elements*, Pergamon, Oxford.
8. Cotton, F. A. and Wilkinson, G., *Advanced Inorganic Chemistry*, Wiley Publications.

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4. Svehla, G. and Sivasankar, B., Vogel's Qualitative Inorganic Analysis, Pearson
5. Bassett J., Denney R. C., Jeffrey G. H., Mendham J., Vogel's Text Book of Quantitative Inorganic Analysis.

THEORY
Course Code: UG CHE 202
Course Title: Concepts in Chemistry -II
Credits: 3
Duration: 45 Hours

Maximum Marks: 75

Course Objectives:

1. To have a working knowledge of the main areas of Physical Chemistry, develop critical thinking abilities and be able to work in chemical or related fields.
2. To get better understanding about the basics of Physical Chemistry.
3. To learn important classes of organic compound i.e., carbonyl compounds.
4. To obtain a comprehensive and detail understanding of the properties and compounds of the f-block elements.
5. To learn about coordination compounds, their nomenclature and the types of isomerism in coordination compounds.

Course Learning Outcomes:

On successful completion of the course, the student will be able to:
CLO1: Apply symmetry rules used in X-ray diffraction studies to various examples, and employ the theoretical concept to study solutions and the properties of liquids
CLO2: Analyze the mechanisms and stereochemical outcomes of key organic reactions, including addition, substitution, and elimination processes and apply the theoretical knowledge to write the reactions and synthesis of carbonyl compounds.
CLO3: Write the nomenclature of coordination compounds, predict the isomers of coordination complexes and explain the chemistry of f-block elements,
CLO4: Develop practical skills in Physical, Organic and Inorganic Chemistry.

SECTION- I (PHYSICAL CHEMISTRY)

MODULE I: The Solid State **07 Hours**

Introduction: difference between crystalline and amorphous solids; laws of crystallography: law of constancy of interfacial angles, law of symmetry and law of rationality of indices, Miller and Wei indices; Elements of symmetry and symmetry operations, introduction to point groups, lattice and unit cells; X ray diffraction by crystals and Bragg's equation. (Numerical expected).

MODULE II: Solutions and Colligative Properties **07 Hours**

Liquid-liquid - ideal solutions, Raoult's law. Ideally dilute solutions, Henry's law. Non ideal solutions, activity and activity coefficient. Colligative properties: Elevation in boiling point, depression in freezing point, relative lowering of vapour pressure, osmotic pressure (Thermodynamic derivations expected). Abnormal molecular mass, Van't Hoff factor. Applications in calculating the molar masses of solutes in solution (Numerical expected).

SECTION- II (ORGANIC CHEMISTRY)

MODULE III: Mechanism and Stereochemistry of Addition, Substitution and Elimination Reactions **07 hours**

Mechanism and stereochemistry of i) Addition of halogens acids (HX) and halogen (X2) to open chain alkenes. Markownikoff's and anti-Markownikoff's addition. ii) S_N1, S_N2, S_Ni, substitutions and iii) E1, E2 and E1cb elimination reactions.

MODULE IV: Aldehydes and Ketones **08 Hours** Physical properties of aldehydes and ketones; Geometry and polarity of the carbonyl group; Preparation of aldehydes and ketones: Reduction of acid chlorides (aldehydes), Reaction of acid chloride with organocopper compounds (ketones), ozonolysis of alkenes; Reactions of aldehydes and ketones: General mechanism of nucleophilic addition at carbonyl group, reaction with amine derivatives (imine formation with mechanism), addition of carbanions (Aldol condensation with mechanism); Cannizaro reaction (with mechanism); Wittig reaction (with mechanism); Baeyer Villiger oxidation (with mechanism).

SECTION- III (INORGANIC CHEMISTRY)

MODULE VI: Chemistry of f-block elements **07 Hours**

Electronic structure, oxidation states and ionic radii; physical and chemical properties; occurrence and isolation of lanthanides from monazite ore; Lanthanide compounds; General properties and chemistry of actinides; Chemistry of extraction of Thorium and Uranium from its ore; Compounds

of Th and U; comparison between lanthanides and actinides.

MODULE VII: Introduction to Coordination Compounds **08 Hours**

Werner's coordination theory; effective atomic number concept; nomenclature of coordination compounds; constitution and geometry; Isomerism and chirality in coordination compounds; chelates and macro cyclic effect.

PRACTICALS
Course Code: UG CHE-202
Course Title: Concepts in Chemistry -II
Credit: 1
Duration: 30 Hours
Maximum Marks: 25

LIST OF EXPERIMENTS:

PHYSICAL CHEMISTRY

1. To determine the amount of weak acid (CH_3COOH) present in the given solution by conductometric titration using standard NaOH solution. **03 Hours**
2. To study the effect of surfactant on the surface tension of Toluene. **03 Hours**
3. To study the effect of different solutes on the boiling point of liquid. **02 Hours**
4. To study the solubility of benzoic acid at room and below room temperature by volumetric method. **02 Hours**

ORGANIC PRACTICALS

Qualitative Analysis (any five liquids): **10 Hours**

Haloalkane and haloarene: Chloroform, carbon tetrachloride, chlorobenzene, bromobenzene
Nitro Compounds: Nitrobenzene
Alcohols: Methanol, ethanol, 2-propanol, cyclohexanol
Carbonyl compounds (Neutral compounds): Benzaldehyde, acetone;
Esters: Methyl acetate, ethyl acetate, ethyl benzoate, methyl salicylate
Bases: Aniline, *N*-methylaniline

INORGANIC CHEMISTRY

1. Preparation of Hexamine nickel (II) chloride complex **02 Hours**
2. Estimation of Nickel in hexamine nickel (II) chloride by EDTA method **02 Hours**
3. Preparation of Tetraamine copper (II) sulphate monohydrate **02 Hours**
4. Gravimetric estimation of Fe as Fe_2O_3 **02 Hours**
5. Gravimetric estimation of Ni as Ni-DMG **02 Hours**

REFERENCES
Mandatory Reading:
PHYSICAL CHEMISTRY TEXT BOOK:

Atkins, P., Paula, J. D., *Atkin's Physical Chemistry*, Oxford University Press.

ORGANIC CHEMISTRY TEXT BOOK:

Morrison, R. T., Boyd, R. N. and Bhattacharjee, S. K., *Organic Chemistry,* Pearson India.

INORGANIC CHEMISTRY TEXT BOOKS:

1. Lee, J. D., *Concise Inorganic Chemistry*, ELBS Publications.
2. Atkins, P., Overton, T., Rourke, J., Weller, M., Armstrong, F. *Shriver and Atkins' Inorganic Chemistry*, Oxford University Press.

Supplementary Reading:

1. Bahl, A., Bahl, B. S. and Tuli, G. D., *Essentials of Physical Chemistry*, S. Chand and Company Ltd., New Delhi.Puri B. R., Sharma L. R. and Pathania M. S., *Principles of Physical Chemistry*, Vishal Publishing Co.
2. Raj G., *Advanced Physical Chemistry*, Goel Publishing House, Meerut.
3. Bruice, P. Y., *Organic Chemistry*, Pearson India.
4. Carey, F. C. and Giuliano, R. M., *Organic Chemistry*, Tata McGraw-Hill India.
5. Finar, I. L., *Organic Chemistry*, Pearson India.
6. Greenwood, N. N., Earnshaw, A., *Chemistry of Elements,* Pergamon, Oxford.
7. Huheey, J. E., Keiter, E. A., Keiter, R. L., Medhi, O. K., *Inorganic Chemistry: Principles of Structure and Reactivity*, Pearson.
8. Cotton, F. A. and Wilkinson, G., *Advanced Inorganic Chemistry*, Wiley Publications.
9. Puri, B. R., Sharma, L. R., Kalia, K. C., *Principles of Inorganic Chemistry*, Vishal Publishing Co.
10. Housecroft, C. E. and Sharpe, A. G., *Inorganic Chemistry*, Prentice Hall.

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3. https://www.khanacademy.org/science/organic-chemistry/alkenes-alkynes
4. https://www.khanacademy.org/science/organic-chemistry/substitution-elimination- reactions
5. https://www.khanacademy.org/science/organic-chemistry/aromatic-compounds
6. https://www.khanacademy.org/science/organic-chemistry/alcohols-ethers-epoxides- sulfides
7. https://nptel.ac.in/content/storage2/courses/104101005/downloads/LectureNotes/chapter% 2013.pdf
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11. https://www.quora.com/What-is-fajans-rule-in-chemistry
12. https://chem.libretexts.org/Bookshelves/Inorganic_Chemistry/Supplemental_Modules_(Inorg ani c_Chemistry)/Crystal_Lattices/Thermodynamics_of_Lattices/Lattice_Energy%3A_ The_Born- Haber_cycle
13. https://www.chem.fsu.edu/chemlab/chm1046course/solids.html

PRACTICAL BOOKS:

1. Khosla B. D., Garg V. C., Gulati A., Senior Practical Physical Chemistry, S. Chand and Co., New Delhi
2. Svehla, G. and Sivasankar, B., Vogel's Qualitative Inorganic Analysis, Pearson

3. Bassett J., Denney R. C., Jeffrey G. H., Mendham J., Vogel's Text Book of Quantitative Inorganic Analysis
4. Furniss, B., Brian, S., Vogel's Textbook of Practical Organic Chemistry, Pearson education.

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 explain the chemistry of alcohols, diols and aromatic compounds and learn the mechanisms involved in electrophilic aromatic substitution reactions.
4. To understand the acid and base concepts with respect to aqueous and non-aqueous solvent systems.
5. To learn about ionic solids in terms of their structure, bonding and defects in crystals.
6. To develop experimental skills required in Physical, Organic and Inorganic Chemistry Laboratory.

Course Learning Outcomes:
On successful completion of the course, the student will be able to:
CLO1: Predict the mechanistic behaviour of catalytic reactions and evaluate the conditions under which a catalysed reaction changes rate dependence.
CLO2: Explain the chemistry of alcohols and diols, understand the concept of aromaticity and learn the mechanisms involved in electrophilic aromatic substitution reactions.
CLO3: Apply the concepts of acids, bases and non-aqueous solvents to chemical reactions and describe the structure, bonding and defects in ionic solids.
CLO4: Develop experimental skills in Physical, Organic and Inorganic Chemistry.

SECTION-I (PHYSICAL CHEMISTRY)

MODULE I: Catalysis **15 Hours**

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.

SECTION-II (ORGANIC CHEMISTRY)

MODULE II: Study of Alcohols and Diols **07 Hours**

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.

MODULE III: Arenes and Aromaticity **08 Hours**

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.

SECTION-III (INORGANIC CHEMISTRY)

MODULE IV: Acids, Bases, and Non-Aqueous Solvents **07 Hours**

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.

MODULE V: Ionic Solids: Structure and Bonding **08 Hours**

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. 0**2 Hours**
2. To synthesize ZnO from $ZnCO_3$ by decomposition method and determine the amount of zinc in ZnO by complexometric method. **02 Hours**
3. To calculate band gap of any three catalysts using their UV-DRS data. **02 Hours**
4. To determine the energy of activation of the autocatalytic reaction between $KMnO_4$ and oxalic acid. **02 Hours**
5. To calculate the Scherrer particle size of any three catalysts using their X-ray diffractograms spectra. **02 Hours**

ORGANIC CHEMISTRY:

1. Purification of Pet ether using Distillation technique and determination of boiling point. 0**2 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. **02 Hours**
2. Estimation of Nickel in hexamine nickel (II) chloride by EDTA method. **02 Hours**
3. Preparation of Tetraamine copper (II) sulphate monohydrate. **02 Hours**
4. Estimation of Copper (II) from tetraamine copper (II) sulphate by iodometry. **02 Hours**
5. Gravimetric estimation of Fe as Fe_2O_3. **02 Hours**

REFERENCES

Mandatory Reading:

PHYSICAL CHEMISTRY TEXT BOOK:

1. Raj G., Advanced Physical Chemistry, Goel Publishing House

ORGANIC CHEMISTRY TEXT BOOK:

1. Morrison, R. T., Boyd, R. N. and Bhattacharjee, S. K., Organic Chemistry, Pearson India.

INORGANIC CHEMISTRY TEXT BOOK:

1. Lee, J. D., Concise Inorganic Chemistry, ELBS Publications.

Supplementary Reading:

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. Puri, B. R., Sharma, L. R., Kalia, K. C., *Principles of Inorganic Chemistry*, Vishal Publishing.
5. Atkins, P., Overton, T., Rourke, J., Weller, M., Armstrong, F. *Shriver and Atkins' Inorganic Chemistry*, Oxford University Press.

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.

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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/

THEORY

Course Code: UG-CHE-MDC5

Course Title: Fundamentals of Chemistry
Credits: 2
Duration: 30 Hours
Maximum Marks: 50

Course Objectives:

1. To learn chemistry of matter.
2. To learn basic chemistry of atoms.
3. To understand various chemical formulas and equations used in chemistry.
4. To understand the states of matter in chemistry.
5. To explain acid-base reactions in chemistry.
6. To get a deeper understanding of the theory with practical knowledge through laboratory experiments.

Course Learning Outcomes:

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

CLO1: Classify matter.
CLO2: Explain basic chemistry of atoms.
CLO3: Apply the chemical formulas and equations used in chemistry.
CLO4: State Gas Laws and other related concepts of states of matter in chemistry.
CLO5: Explain acid-base reactions in chemistry.
CLO6: Develop practical skills through laboratory experiments.

MODULE I: Matter **07 Hours**

Extensive and intensive properties, physical and chemical properties, solids, liquids and gases, density and its uses, calculation using density of an unknown liquid, classification of matter, physical and chemical changes, measurement and notation, units and dimensions in chemistry, introduction to scientific notation, converting units, uncertainty in measurement, significant figures (numerical expected).

MODULE II: Atom **04 Hours**

Atoms, elements and the nucleus, atom and atomic mass, (numerical expected).

MODULE III: Chemical Formulae and Equations **08 Hours**

Chemical formulae and their arithmetic, empirical and molecular formulae, formula and mass composition, calculating mass percent, molecular and empirical formula from mass percent, chemical nomenclature, stoichiometry and limiting reagents, chemical equations and calculations, calculating molar mass and number of moles, balancing chemical reactions, calculating amounts of reactants and products (numerical expected).

MODULE IV: States of Matter **07 Hours**

Gases and Gas Laws, observable properties of gases, basic gas laws, ideal gas equation, Charles law, Boyle's law and Avogadro's law, partial pressure, kinetic molecular theory (only postulates), Phase Changes, states of matter, liquid state, introduction to surface tension and viscosity, solid state, introduction to crystal systems

MODULE V: Acid-base reactions **04 Hours**

Acids and bases, aqueous solutions, pH, acid-base neutralization reaction (numerical expected).

PRACTICALS
Course Code: UG-CHE-MDC5
Course Title: Fundamentals of Chemistry
Credit: 1
Duration: 30 Hours
Maximum Marks: 25
LIST OF EXPERIMENT

1.	Standardization of HCl using Na_2CO_3	**02 Hours**
2.	Standardization of NaOH using potassium hydrogen phthalate	**02 Hours**
3.	Standardization of NaOH using succinic acid	**02 Hours**
4.	Measurement of pH using pH meter (any 2 buffer solutions)	**02 Hours**
5.	Sublimation of any 2 solids	**02 Hours**
6.	Melting point of a solid	**02 Hours**
7.	Boiling point of a liquid	**02 Hours**
8.	Measurement of density	**02 Hours**
9.	Measurement of surface tension	**02 Hours**
10.	Measurement of viscosity	**02 Hours**
11.	Theoretical calculation of molarity, normality, molality and ppm.	**02 Hours**
12.	Dilution of solution from higher concentration to lower concentrations.	**02 Hours**
13.	Standardization of $KMnO_4$ with oxalic acid.	**02 Hours**
14.	Standardization of $Na_2S_2O_3$ with K_2Cr_2O7.	**02 Hours**
15.	Preparation of solutions based on theoretical calculations.	**02 Hours**

REFERENCES
Mandatory Reading:
Atkins, P., Paula, J. D., *Atkin's Physical Chemistry*, Oxford University Press.

SUPLLEMENTARY READING:
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.

PRACTICAL BOOK:
Rajbhog S. W. and Chondekar T. K., Systematic Experimental Physical Chemistry

WEB REFERENCES
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2. https://www.geeksforgeeks.org/mole-concept/
3. https://chem.libretexts.org/Bookshelves/General_Chemistry/Book%3A_General_Chemistry%3A_
Principles_Patterns_and_Applications_(Averill)/04%3A_Reactions_in_Aqueous_Solution/4.07%

3A_Acid_Base_Reactions

4. https://physics.info/viscosity/
5. https://www.thoughtco.com/overview-of-ph-measurements-608886

SKILL ENHANCEMENT COURSE THEORY

Course Code: UG-CHE-SEC4
Course Title: Basics of Analytical Chemistry
Credits: 2
Duration: 30 Hours
Maximum Marks: 50

Course Objectives:

1. To learn principles of Analytical Chemistry and its applications in various processes.
2. To apply the principles of Analytical Chemistry to chemical analysis.
3. To get a deeper understanding of the theory with practical knowledge.

Course Learning Outcomes:

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

CLO1: Describe the role of Analytical Chemistry in sciences

CLO2: Interpret titration curves

CLO3: Formulate methods for separation of compounds

CLO4: Perform qualitative and quantitative analysis

MODULE I: Introduction to Analytical Chemistry and some basic concepts 05 Hours

Analytical Chemistry and its role in sciences, some important units of measurement, solutions and their concentrations, stoichiometric calculations (Numerical expected)

MODULE II: Titrimetric methods of analysis 10 Hours

Some general aspects of volumetric titrimetry, standard solutions, volumetric calculations; titration curves in titrimetric methods, Theory and applications of neutralization titrations: solutions and indicators for acid/base titrations, titration curves for strong acids and strong bases, buffer solutions, titration curves for weak acids, titration curves for weak bases, composition of buffer solutions as a function of pH, reagents for neutralization titrations, applications of neutralization titrations; Complex formation titrations, redox titrations.

MODULE III: Separation techniques 15 Hours

Solvent extraction: Factors affecting extraction, principle, apparatus and applications; Paper chromatography: Principle, technique and applications; Thin layer chromatography: Principle, technique and applications; Ion exchange chromatography: Introduction, types of ion exchangers, properties of resins, factors affecting separation of ions, ion exchange capacity, applications.

Course Code: UG-CHE-SEC4
Course Title: Basics of Analytical Chemistry
Credit: 1
Duration: 30 Hours
Maximum Marks: 25

LIST OF EXPERIMENTS:

1. Preparation of standard solution based on molarity and normality.	**02 Hours**
2. Standardisation of strong acid with strong base.	**02 Hours**
3. Standardisation of strong acid with weak base.	**02 Hours**
4. Standardisation of weak acid with strong base.	**02 Hours**
5. Standardisation of weak acid with weak base.	**02 Hours**
6. Complexometric titrations. (any 2)	**04 Hours**
7. Redox titration.	**02 Hours**
8. Separation using solvent extraction (any 2)	**04 Hours**
9. Separation and identification using paper chromatography	**02 Hours**
10. Separation and identification using thin layer chromatography	**02 Hours**
11. Quantitative estimation using ion exchange chromatography	**02 Hours**
12. Separation and quantitative estimation using ion exchange chromatography	**04 Hours**

REFERENCES

Mandatory Reading:

Skoog, D. A., West, D. M., Holler F. J. and Crouch, S. R., Fundamentals of Analytical Chemistry, 8th Edition, Saunders College Publishing.

Supplementary Reading:

1. Willard, H. H., Merritt, L. L., Dean, J. A., Settle, F. A., Instrumental Methods of Analysis, CBS Publishing, New Delhi, 7th Edition.
2. Bassett J., Denney R. C., Jeffrey G. H., Mendham J., Vogel's Text Book of Quantitative Inorganic Analysis.
3. Christian, G. D., Analytical Chemistry, John Wiley.

PRACTICAL BOOK:

Popat P. R., *Practical Book of Analytical Chemistry (First Edition)* Notion Press

WEB REFRENCES

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2. https://microbenotes.com/paper-chromatography/
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5. https://www.britannica.com/science/thin-layer-chromatography

SEMESTER IV

THEORY

Course Code: UG-CHE-203

Course Title: Selected Topics in Physical Chemistry

Credits: 3
Duration: 45 Hours
Maximum Marks: 75

Course Objectives:

1. To learn principles of Physical Chemistry and its applications in various processes.
2. To be able to apply the principles of Physical Chemistry to industrial processes.
3. To get a deeper understanding of the theory with practical knowledge.

Course Learning Outcomes:

On successful completion of the course, the student will be able to:
CLO1: State Second and Third law of Thermodynamics
CLO2: Formulate conditions for maximum yield in industrial processes
CLO3: Explain theory of strong and weak electrolytes.
CLO4: Analyze photochemical processes
CLO5: Evaluate properties of colloids
CLO6: Perform instrumental and non-instrumental analysis

MODULE I: Thermodynamics **10 Hours**

Second law of thermodynamics: Different statements of the law; Carnot cycle and its efficiency, Carnot theorem; Thermodynamic scale of temperature; Concept of entropy: entropy as a state function, entropy as a function of V and T, entropy as a function of P and T, entropy change in physical processes, entropy as a criterion of spontaneity and equilibrium; Entropy changes for ideal gases. Third law of thermodynamics: Nernst heat theorem, statement and concept of residual entropy, evaluation of absolute entropy from heat capacity data; Gibbs and Helmholtz functions; A and G as criteria for thermodynamic equilibrium and spontaneity, their advantages over entropy change; Variation of G and A with P, V and T (Numerical expected).

MODULE II: Chemical Equilibrium **08 Hours**

Reversible reactions, equilibrium constant, Equilibrium constant and free energy; Thermodynamic derivation of law of mass action; Reaction isotherm and reaction isochore - Clapeyron equation and Clausius - Clapeyron equation; Le Chatelier's principle and its applications to some industrial processes (Numerical expected).

MODULE III: Electrochemistry **10 Hours**

Electrical transport-conduction in metals and in electrolyte solutions, weak and strong electrolytes; conductance, specific conductance and equivalent conductance and measurements; variation of specific and equivalent conductance with dilution; Arrhenius theory of electrolyte dissociation and its limitations; Ostwald's dilution law, its uses and l imitations; Migration of ions and Kohlrausch's law; Debye-Huckel-Onsager's equation for electrolytes; Transport number, determination of transport number by Hittorf's method, Applications of conductance measurements: degree of dissociation, dissociation constant of acids; Solubility and solubility product of a sparingly soluble salts; Conductometric titrations (Example: Strong acid and strong base) (Numerical expected).

MODULE IV: Photochemistry **07 Hours**

Interaction of radiation with matter, difference between thermal and photochemical processes, Laws of photochemistry: Grothus–Drapper law, Stark–Einstein law, Jablonski diagram depicting various processes occurring in the excited state, qualitative description of fluorescence, phosphorescence, non-radiative processes (internal conversion, intersystem crossing), quantum yield, photosensitized reactions. (Numerical expected).

MODULE V: Colloid Chemistry **10 Hours**

Colloidal state; colloidal solution; classification of colloids; lyophobic and lyophilic colloids; true solution, colloidal solution, and suspension; preparation of sols; purification of sols; stability of colloids; protective action; Hardy- Schulze Law; gold number; general properties; electrical properties; electrical double layers; kinetics of coagulation; inhibition; general applications of colloids on size of colloidal particles; Emulsions- definition, types, preparation; gels- definition; classification, preparation and properties; applications of colloids, emulsions, and gels.

PRACTICALS
Course Code: UG-CHE-203
Course Title: Selected Topics in Physical Chemistry
Credit: 1
Duration: 30 Hours
Maximum Marks: 25

LIST OF EXPERIMENTS:

1. To determine the cell constant of a conductivity cell. **02 Hours**
2. To verify Ostwald's dilution law by determining the equivalent conductance of a weak mono basic acid at different concentrations. **02 Hours**
3. To determine the equivalent conductance of a strong electrolyte at several concentrations and hence verify Onsager's equation. **02 Hours**
4. To determine solubility product of sparingly soluble salt by conductometric method **02 Hours**
5. To determine hydrolysis constant of sodium acetate by conductometric method. **02 Hours**
6. To estimate the amount of dibasic acid present in given solution against standard NaOH solution by conductometric method. **02 Hours**
7. To determine hydrolysis constant of ammonium chloride by conductometric method. **02 Hours**
8. To estimate the concentration of NH_4Cl salt by titration against NaOH by conductometric method. **02 Hours**
9. To estimate the concentration of KCl salt by titration against $AgNO_3$ by conductometric method. **02 Hours**
10. To estimate the concentration of Fe^{3+} salt by titration against $K_2Cr_2O_7$ by conductometric method. **02 Hours**
11. To study the solubility of benzoic acid in water at different temperatures and to calculate the heat of solution. **02 Hours**
12. To determine the energy of activation for acid catalysed hydrolysis of methyl acetate. **04 Hours**
13. To estimate the amount of monobasic (HCl) and dibasic acid (Oxalic acid) present in the

mixture solution against NaOH by conductometric method. **02 Hours**

14. To estimate the amount of H_2SO_4, CH_3COOH and $CuSO_4$ present in the mixture against NaOH by conductometric method. **02 Hours**

REFERENCES

Mandatory Reading:

Atkins, P., Paula, J. D., *Atkin's Physical Chemistry*, Oxford University Press.

Supplementary Reading:

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.

WEB REFERENCES

1. https://www.britannica.com/science/second-law-of-thermodynamics
2. https://chem.libretexts.org/Bookshelves/Physical_and_Theoretical_Chemistry_Textbook_Maps/Supplemental_Modules_(Physical_and_Theoretical_Chemistry)/Equilibria/Le_Chateliers_Principle/The_Haber_Process
3. https://www.nobelprize.org/uploads/2018/06/arrhenius-lecture.pdf
4. https://www.edinst.com/blog/jablonski-diagram-2/
5. https://openstax.org/books/chemistry-2e/pages/11-4-colligative-properties
6. https://www.toppr.com/guides/chemistry/surface-chemistry/colloids/

CORE COURSE

THEORY

Course Title: Selected Topics in Organic Chemistry
Course Code: UG-CHE-204
Credits: 3
Duration: 45 hours
Maximum Marks: 75

Course Objectives:

1. To make students understand about the chemistry of carboxylic acids and its derivatives.
2. To deliver knowledge about the chemistry of carbohydrates.
3. To provide knowledge about chemistry of amines, diazonium salts and nitro compounds.
4. To discuss the chemistry of cyanides and isocyanides.
5. To discuss the chemistry of thiols and thioethers.
6. To provide basic practical knowledge by performing experiments in the laboratory.

Course Learning Outcomes:

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

CLO1: Apply the chemistry of carboxylic acids and its derivatives.

CLO2: Explain the chemistry of carbohydrates.

CLO3: Apply the chemistry of amines, diazonium salts and nitro compounds.

CLO4: Understand the chemistry of cyanides and isocyanides.

CLO5: Understand the chemistry of thiols and thioethers.

CLO6: Develop practical skills by performing organic chemistry experiments in the laboratory.

MODULE I: Carboxylic Acids and its Derivatives 14 Hours

Carboxylic acids: Structure and nomenclature of aliphatic and aromatic carboxylic acids, dicarboxylic acids, physical properties, industrial source, Preparation of acids: Oxidation of primary alcohols and alkyl benzenes, hydrolysis of nitriles with mechanism; Reaction of acids: Salt formation, conversion to different functional groups (esters, amides, acid chlorides and anhydrides), Hell-Volhard-Zelinsky reaction, ring substitution in aromatic acids, reduction of acids.

Derivatives of Carboxylic acids: General physical properties of carboxylic acid derivatives: acid anhydrides, esters, amides and acid halides; nucleophilic acyl substitution (role of carbonyl group of carboxylic acid derivatives), alkyl vs. acyl nucleophilic substitution. Preparations of acid anhydrides, esters, amides and acid halides. Reactions of acid chlorides: Conversion to acids (hydrolysis), conversion to amides (ammonolysis), conversion to esters (Alcoholysis), formation of ketones (Friedel Craft's acylation), reduction to aldehydes (Rosenmund reduction). Reactions of acid anhydrides: conversion into acids (hydrolysis), conversion into amides (ammonolysis) and formation of ketones (Friedel Craft's acylation). Reactions of esters: Conversion to acids (acidic and alkaline hydrolysis along with mechanism), conversion to amides (ammonolysis), conversion to esters (Trans-esterification), reaction with Grignard reagents, reduction to aldehydes and alcohols. Reactions of amides: Hydrolysis, conversion into imides, Hofmann degradation of amides, conversion to amine having same number of carbon atoms, conversion to nitriles. Interconversion reactions of acid anhydrides, esters, amides and acid halides, comparative study of nucleophilicity of acyl derivatives.

MODULE II: Carbohydrates 06 Hours

Classification and nomenclature. Monosaccharides: General reactions. Configuration of monosaccharides with reference to glucose. d(+)/l(-) and D/L systems of nomenclature. Interconversion of glucose to fructose and glucose to mannose. Cyclic structure of D(+)-Glucose. Mechanism of mutarotation. Formation of glycosides, ethers and esters. Structure of sucrose and inversion of cane sugar.

MODULE III: Amines, diazonium salts and nitro compounds 15 Hours

Amines: Structure, classification, nomenclature, physical properties and industrial source of amines. Preparation of alkyl and aryl amines by reduction of nitro compounds, nitriles and amides, reductive amination of carbonyl compounds, salts of amines, alkylation, conversion into amides, ring substitution in aromatic amines, Hinsberg test reactions, Hoffman elimination, reaction with nitrous acid, Gabriel phthalimide reaction and Hofmann rearrangement. Basicity of amines, effect of substituents on basicity of amines.

Diazonium salts: Structure, preparation using aromatic amines, Sandmeyer reaction, conversion to phenol and arene; reduction reaction.

Nitro compounds: Preparation of nitroalkanes and nitroarenes, chemical reactions of nitroalkanes. Mechanisms of nucleophilic substitution in nitroarenes and their reductions in acidic, neutral and alkaline media. Picric acid: preparation and properties.

MODULE IV: Cyanides and Isocyanides 05 Hours

Alkyl cyanides: structure, nomenclature, methods of preparation, physical and chemical

properties. Alkyl isocyanides: structure, nomenclature, methods of preparation, physical properties and chemical properties. Distinguishing points between Cyanides and Isocyanides.

MODULE V: Thiols and Thioethers **05 Hours**

Thiols: structure, nomenclature, methods of preparation, physical and chemical properties. Thioethers: structure, nomenclature, methods of preparation, physical and chemical properties. Mustard gas.

PRACTICAL

Course Title: Selected Topics in Organic Chemistry

Course Code: UG-CHE-204

Credits: 1

Duration: 30 hours

Maximum Marks: 25

LIST OF EXPERIMENTS

1. Qualitative analysis of organic compounds: (any two) **04 Hours**

Solids (examples: Benzoic acid, Nitro-benzaldehyde, Benzophenone) Liquids (Acetone, ethyl acetate, benzaldehyde)

2. Identification of type and separation of mixture of organic compounds:
   a) Solid-solid (Soluble-insoluble, insoluble-insoluble) (any three) **06 Hours**
   b) Solid-liquid (Solid and low boiling liquid) (any two) **04 Hours**
   c) Liquid-liquid) (High boiling and low boiling liquid) (any two) **04 Hours**
3. Organic preparations:
   a) Iodoform: Preparation of Iodoform from acetone **02 Hours**
   b) Esterification: Preparation of ethyl benzoate from benzoic acid and ethanol **02 Hours**
   c) Hydrolysis: Preparation of benzoic acid and ethanol from ethyl benzoate **02 Hours**
   d) Aldol condensation reaction: Preparation of chalcone from benzaldehyde and acetophenone **02 Hours**
4. Organic estimations:
   a) Estimation of Glucose by Titrimetry**.** **02 Hours**
   b) Estimation of Amide by Titrimetry. **02 Hours**

REFERENCES:

TEXT BOOK:

Morrison, R. T., Boyd, R. N. and Bhattacharjee, S. K., *Organic Chemistry*, Pearson India.

REFERENCE BOOKS:

1. Bruice,, P. Y., *Organic Chemistry*, Pearson India.
2. Carey, F. C. and Giuliano, R. M., *Organic Chemistry*, Tata McGraw-Hill India.
3. Finar, I. L., *Organic Chemistry*, Pearson India.

PRACTICAL BOOK:

Furniss, B. Brian, S., *Vogel's Textbook of Practical Organic Chemistry*, Pearson education.

WEB REFERENCES:

1. https://ncert.nic.in/textbook/pdf/lech203.pdf

2. https://www.angelo.edu/faculty/kboudrea/index_2353/Chapter_05_2SPP.pdf
3. https://www2.unbc.ca/sites/default/files/sections/todd-whitcombe/chapter_21_acid_derivatives.pdf
4. https://ncert.nic.in/textbook/pdf/lech204.pdf
5. https://www.lkouniv.ac.in/site/writereaddata/siteContent/202003291608409191arun_sethi_Diazon ium_compounds.pdf

THEORY

Course Code: UG - CHE-205
Course Title: Selected Topics in Inorganic Chemistry
Credits: 3
Duration: 45 Hours
Maximum Marks: 75

Course Objectives:
1. To understand the acid and base concepts with respect to aqueous and non-aqueous solvent systems.
2. To understand the magnetic behavior of metal complexes and determine its magnetic properties.
3. To acquire knowledge about metal-ligand bonding in metal complexes with reference to VBT and CFT and calculate the CFSE for octahedral complexes.
4. To understand the thermodynamic and kinetic aspects of metal complexes with respect to ligand substitution reactions.
5. To develop practical skills in the separation of metal ions and analyze them using titrimetry or gravimetry and using spectrophotometer for studying metal complexes.

Course Learning Outcomes:
On successful completion of the course, the student will be able to:
CLO1: Explain and integrate the concepts of acids and bases and non-aqueous solvents wherever applicable in chemistry.
CLO2: Compare the VBT and CFT theories and apply them to explain the structure, bonding and magnetic properties of metal complexes and calculate their crystal field stabilization energy (CFSE).
CLO3: Compare the types of magnetic behavior and explain the magnetic properties of metal complexes and calculate their magnetic moments.
CLO4: Explain the mechanism of ligand substitution reactions in metal complexes and differentiate between thermodynamic stability and kinetic stability and apply it to transition metal complexes.
CLO5: Separate and estimate the amount of metal ions in solution and determine the stability and instability constant of complexes using spectrophotometry.

MODULE I: Acids, Bases and Non-Aqueous Solvents 08 hours
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 SO_2.

MODULE II: Metal-Ligand Bonding in Transition Metal Complexes 15 hours

Principles and limitations of Valence bond theory, Crystal field theory (CFT) splitting of d orbitals in octahedral, tetrahedral and square planar complexes. Crystal Field Stabilization Energy (CFSE), Measurement of 10 Dq for octahedral complexes, Factors affecting 10 Dq, spectrochemical series, Effect of crystal field splitting on properties of octahedral complexes: Magnetic, Spectral.

MODULE III: Magnetic Properties of Metal Complexes 07 hours

Types of magnetic behaviour, magnetic susceptibility, effect of temperature on magnetic properties, Curie temperature, Neel temperature, Curie-Weiss law, methods of determining magnetic susceptibility, Guoy's balance, spin only formula, calculation of magnetic moment of transition metal ions, application of magnetic moment data for 3d-metal complexes.

MODULE IV: Thermodynamic and Kinetic Aspects of Metal Complexes 15 hours

Thermodynamic and kinetic stability of metal complexes, equilibrium constants, formation constants, labile and inert complexes, factors affecting the stability, Ligand substitution reactions in tetrahedral and octahedral complexes, Factors affecting the rate of substitution reactions. Electron transfer reactions- inner sphere mechanism and outer sphere mechanism. Trans effect with respect to square planar complexes.

PRACTICALS

Course Code: UG CHE-205

Course Title: Selected Topics in Inorganic Chemistry

Credit: 1

Duration: 30 Hours

Maximum Marks: 25

LIST OF EXPERIMENTS:

1. Separation and determination of transition metal ions: Separation of Mg^{2+} and Zn^{2+} by ion exchange and its estimation. **4 Hours**
2. Estimation of metal ions in a mixed metal ion solution (Co^{+2} and Fe^{+2}) by employing gravimetric and volumetric methods. **4 Hours**
3. To estimate the amount of barium as $BaSO_4$ gravimetrically in a solution of Barium chloride containing ferric chloride and free HCl. **4 Hours**
4. Determination of stability constant of Fe(III)- salicylic acid complex spectrophotometrically (Job's Method). **2 Hours**
5. Determination of stability constant of Fe(II)-1,10-phenanthroline complex spectrophotometrically. **2 Hours**
6. Determination of instability constant for the reaction between Cu^{2+} and NH_3 **2 Hours**
7. Determination of instability constant for the reaction between Cu^{2+} and ethylenediamine
   i. **2 Hours**
8. Preparation of trisethylenediamine nickel(II) complex. **2 Hours**
9. Preparation of potassium trioxalato ferrate(III) complex. **2 Hours**
10. Preparation of zinc oxalate complex. **2 Hours**
11. Estimation of oxalate from the zinc oxalate complex. **2 Hours**
12. Preparation of tris(thiourea) copper(I) sulphate. **2 Hours**

REFERENCES:

Mandatory Reading:

1. Lee, J. D., *Concise Inorganic Chemistry,* ELBS Publications.
2. Atkins, P., Overton, T., Rourke, J., Weller, M., Armstrong, F., Shriver and Atkins' Inorganic Chemistry, Oxford University Press.

Supplementary Reading:

1. Greenwood, N. N., Earnshaw, A., *Chemistry of Elements,* Pergamon, Oxford.
2. Cotton F. A and Wilkinson G., Basic Inorganic Chemistry, Wiley Eastern Ltd.
3. Huheey J. E, Keiter E. A, Keiter R. L, Medhi O. K, Inorganic Chemistry: Principles of Structure and Reactivity, Pearson Edu.

WEB REFERENCES:

1. https://www.rsc.org/images/EiC%20v1i2%20The%20Theory%20of%20Acids%20and%20Bases_ tcm18-230799.pdf
2. https://chem.libretexts.org/Bookshelves/Inorganic_Chemistry/Map%3A_Inorganic_Chemistry_(H ousecroft)/09%3A_Non-aqueous_Media/9.04%3A_Acid-Base_Behaviour_in_Non-Aqueous_Solvents
3. https://unacademy.com/content/nda/study-material/chemistry/theories-based-on-the-concept-of- acids-and-bases/
4. https://unacademy.com/content/cbse-class-12/study-material/chemistry/magnetic-properties-of-coordination-compounds/#:~:text=The%20coordination%20compound%20complexes%20show,are%20in%20t he%20d%20orbitals.
5. http://home.iitk.ac.in/~madhavr/CHM102/Lec5.pdf
6. https://chemistnotes.com/inorganic/crystal-field-splitting-of-d-orbitals-octahedral-and-tetrahedral- complexes/
7. https://chemistrywithwiley.com/crystal-field-splitting/
8. https://unacademy.com/content/jee/study-material/chemistry/stability-of-complexes/#:~:text=Charge%20on%20the%20metal%20ion,stability%20to%20the%20coordinati on%20compound.
9. https://utkaluniversity.ac.in/wp-content/uploads/2022/03/Stability_Const_NDas.pdf

PRACTICAL BOOKS:

1. Mendham J., Barnes J. D., Denney R. C., Thomas M. J., Sivasankar B., Vogel's Text book of Quantitative Chemical Analysis, Pearson.
2. Svehla, G. and Sivasankar, B., Vogel's Qualitative Inorganic Analysis, Pearson
3. Bassett J., Denney R. C., Jeffrey G. H., Mendham J., Vogel's Text Book of Quantitative Inorganic Analysis

Course Code: UG-CHE-206
Course Title: Introduction to Pharmaceutical Chemistry
Credits: 3
Duration: 45 Hours
Maximum Marks: 75

Course Objectives:

1. To study the Chemistry and data treatment involved in pharmaceutical industries.

2. To give blend of chemical and pharmaceutical principles necessary for understanding structure–activity relationships and molecular mechanisms of drug action.
3. To gain knowledge about the classes of drugs and synthesis of some selected drugs.

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

CLO1: Outline the significance of terminologies and regulation in pharmaceutical chemistry and discuss the safety in Pharmaceutical laboratories.

CLO2: Handle and treat the statistical data of analysis.
CLO3: Analyze the medicinal chemistry in plants.
CLO4: Apply theoretical knowledge for the synthesis of some pharmaceutical drugs and its analysis.

MODULE I: Introduction and Drug Design Strategies **15 Hours**

Importance of Chemistry in Pharma, definition of terminologies: Pharmacology: Pharmacokinetics, Pharmacodynamics; Pharmacognosy, Dosage forms and Routes of administration, Advantages, and disadvantages. Pharmacopoeia. Risks in a pharmaceutical Laboratory, Personal Protective Equipment (PPE), General preparation for Emergencies, Laboratory Emergencies: Spills and Fires.
Drug designing; General pathways of drug metabolism: Oxidative reactions, reductive reactions, hydrolytic reactions, Phase II or conjugation reactions.

MODULE II: Statistical Data Treatment **15 Hours**

Errors: absolute error, relative error, constant and proportionate errors; determinate errors, classification of determinate errors, indeterminate error, minimization of errors.
Significant figures and rounding off, replicate analysis, reliability of analytical data, mean, mode, median & range, precision and accuracy, methods of expressing precision and accuracy: deviation, mean deviation, relative mean deviation, and standard deviation, Gaussian distribution curve and its characteristics, Histogram and Frequency polygon; Measures of central tendency and dispersion, Confidence limit; Test of significance: Students t, F test; Rejection of the results: 2.5d & 4d rule and Q test; Linear least squares and Method of averages (Numerical are expected)

MODULE III: Introduction to Medicinal Chemistry of Plants and Different Classes of Drugs

15 Hours

Historical background to medicinal chemistry of plants; type of plants; active ingredient structure, IUPAC names and their medicinal properties: Capsicum, Garlic, turmeric.
Anti-Infective Agents (definition): Antifungal agents (definition): Haloprogin and Flucytosine (structures and uses); Antibacterial agents (definition): Ciprofloxacin and Furazolidone (structures and uses); Anti protozoal agents (definition): Metronidazole (structure and uses); Antihelmintics (definition): Thiabendazole (structure and uses); Synthesis of Flucytosine.
Cardiovascular agents (definition): Antianginal Agents and Vasodilators (definition): Nitroglycerin, Nifedipine (structures and uses); Antiarrhythmic Drugs (definition): Quinidine sulfate (structure and uses); Antihypertensive Agents (definition): Prazosin (structure and uses); Synthesis of Nifedipine by Hantsch synthesis.
Central nervous system stimulant and depressants: Central sympathomimetic agents (psychomotor stimulants) (definition): Pentylenetetrazole (structure and uses); Antidepressants (definition): Desipramine Hydrochloride and Clomipramine Hydrochloride (structures and uses); Anxiolytic

(definition): Paroxetine (structure and uses); Sedative and hypnotic agents (definition): Propofol, Methaquolone (structures and uses); Synthesis of clomipramine.

PRACTICALS
Course Code: UG- CHE-206
Course Title: Introduction to Pharmaceutical Chemistry
Credit: 1
Duration: 30 hours
Maximum Marks: 25

LIST OF EXPERIMENTS

1.	Synthesis of Aspirin.	**02 Hours**
2.	Synthesis of Benzocaine.	**04 Hours**
3.	Synthesis of Paracetamol.	**02 Hours**
4.	Synthesis of Acetaminophen.	**02 Hours**
5.	Synthesis of benzophenone oxime.	**02 Hours**
6.	Synthesis of phenytoin.	**02 Hours**
7.	Synthesis of benzimidazole.	**02 Hours**
8.	Estimation of acetyl salicylic acid in the given aspirin tablet by potentiometry.	**04 Hours**
9.	Estimation of alkali content in antacid tablet.	**02 Hours**
10.	UV Absorbance Standard Curve of Salicylic Acid.	**02 Hours**
11.	Assay of the following drugs by titrametry: Ibuprofen, aspirin.	**04 Hours**
12.	Quantitative estimation of ascorbic acid in given tablet.	**02 Hours**

REFERENCES
Mandatory Reading:

1. Beale J. Jr., Block J., Wilson and Gisvold's Textbook of Organic Medicinal and Pharmaceutical Chemistry, 12th Edition, Baltimore: Lippincott Williams and Wilkins.
2. Skoog D. A., Leary J. J., Principles of Instrumental Analysis, Philadelphia: Saunders College Publishing.

SUPPLEMENTARY READING:

1. Indian Pharmacopoeia Commission, Indian Pharmacopoeia 2007.
2. Prichard Elizabeth, B. V., Quality Assurance in Analytical Chemistry. John Wiley and Sons.
3. Beckett A.H., StenlakeJ.B., Practical Pharmaceutical Chemistry, London: The Athlone Press.
4. Christian, G. D.; Analytical Chemistry, 6th Edition, New Jersey: John-Wiley and Sons, Inc.
5. Prabhu D.V, Raghuraman K., Basic Principles of Analytical Chemistry, Shet Publishers.
6. Lednicer D., Mitscher L., The Organic Chemistry of Drug Synthesis, New Jersey: John- Wiley and Sons, Inc.
7. Gennaro, A. R., Remington: The Science and Practice of Pharmacy, London: Mack Publishing Company.
8. Sharma, B. K., Instrumental Methods of Chemical Analysis, Meerut: Goel Publishing House.
9. Higuchi T., E. B.-H., Pharmaceutical Analysis. New York: Interscience Publishers.

WEB REFERENCES:

1. http://www.chemistryexplained.com/Ny-Pi/Pharmaceutical-Chemistry.html
2. https://www.pharmatutor.org/articles/significance-of-pharmaceutical-regulatory-bodies-a-review
3. https://www.pharmatutor.org/articles/pharmaceutical-regulatory-agencies-and- organizations-around-world-scope-challenges-in-drug-development
4. https://luxury.rehabs.com/drug-abuse/classifications/
5. https://www.europeanpharmaceuticalreview.com/article/868/pharmaceutical-analysis-in-quality- control/
6. https://www.nhp.gov.in/introduction-and-importance-of-medicinal-plants-and-herbs_mtl
7. https://www.pharmatutor.org/articles/chromatography-introduction
8. https://www.labmanager.com/lab-health-and-safety/2017/12/science-laboratory-safety- rules-guidelines#.XiUvXcgzaM8
9. http://www.lawplainandsimple.com/legal-guides/article/health-and-safety-in-the-pharmaceutical- industry

VOCATIONAL COURSES
THEORY
Course Code: UG-CHE-VOC1
Course Title: Spectroscopic Techniques
Credits: 3
Duration: 45 Hours
Maximum Marks: 75

Course Objectives:

1. To understand the dual nature of light and the interaction of electromagnetic radiation with matter.
2. To learn the components of spectroscopic instruments and their function.
3. To acquire knowledge of UV-Vis spectroscopy and Atomic Spectroscopy and their applications.
4. To solve numerical problems based on EMR theory and Beer-Lamberts law.
5. To operate and carry out analysis on a UV-visible spectrophotometer.

Course Learning Outcomes:

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

CLO1: Elucidate the dual nature of light, the interaction of electromagnetic radiation with matter and the basic components of spectroscopic instruments.
CLO2: Explain the principles, instrumentation and applications of UV-Visible spectroscopy.
CLO3: Describe the principles, instrumentation and applications of AES, AAS, ICP and Fluorimetry.
CLO4: Solve numerical problems based on EMR theory and Beer-lamberts law.
CLO5: Perform qualitative and quantitative analysis using UV-visible spectrophotometer.

MODULE I: General Introduction **15 Hours**

Overview of spectroscopy; meaning of electromagnetic radiation; interaction of electromagnetic radiation with matter; wave properties of electromagnetic radiation; particle properties of

electromagnetic radiation; the electromagnetic spectrum; regions of spectrum; atomic and molecular spectra; representation of spectra; photons as a signal source; basic components of spectroscopic instruments; sources of energy; sources of electromagnetic radiation; sources of thermal energy; chemical sources of energy; wavelength selection; wavelength selection using filters; wavelength selection using monochromators; interferometers; detectors; photon transducers; thermal transducers; signal processors; solvents for spectrometry; quantitative calculations; spectrometric errors in measurements.

MODULE II: UV-Visible Spectroscopy **15 hours**

UV-Visible spectroscopy: Beer-Lambert's Law; validity and limitations of Beer-Lambert's law; Deviations from Beer-Lambert's Law; electronic transitions in a molecule; chromophores and auxochromes; Bathochromic, hypsochromic, hyperchromic and hypochromic shifts; solvent effect; effect of temperature. Instrumentation: spectrophotometers; single and double beam instruments. Applications of UV and visible spectroscopy- identification of structural groups, cis-trans isomerism, chemical kinetics, qualitative and quantitative analysis; limitations of UV and visible spectroscopy, quantitative analysis, study of co-ordination compound; photometric titrations. (Numerical problems based on Beer-Lambert's law to be solved)

MODULE III: Atomic Spectroscopy **15 hours**

Atomic Spectroscopy: origins of atomic spectra, production of atoms and ions; Atomic Emission Spectrometry (AES): Introduction, principle, instrumentation, applications, advantages and limitations of flame photometry. atomisation methods and sample introduction methods used in atomic spectroscopy. Atomic Absorption Spectrometry (AAS): Introduction, principle, instrumentation, applications, internal standard and standard addition calibration method, limitations; Fluorimetry: Introduction, principles, instrumentation and applications. Inductively coupled plasma spectroscopy: principle, instrumentation and applications.

PRACTICALS
Course Code: UG-CHE-VOC1
Course Title: Spectroscopic Techniques
Credit: 1
Duration: 30 Hours
Maximum Marks: 25

LIST OF EXPERIMENTS:

1. To test the validity of Beer-Lambert Law using spectrophotometer and determine the unknown concentration of a solution. **2 Hours**
2. To calibrate the UV- Visible spectrophotometer for control of absorbance and limit of stray light. **2 Hours**
3. To determine Mn^{2+} ion concentration by periodate method using spectrophotometer. **2 Hours**
4. To determine Fe^{3+} ion concentration by salicylic acid method using spectrophotometer. **2 Hours**
5. To estimate the amount of nitrite in water sample by spectrophotometric method. **2 Hours**
6. To determine the amount of K_2CrO_4 present in given sample by using UV-Visible

spectrophotometer. **2 Hours**

7. To estimate the amount of paracetamol in tablet by spectrophotometric method. **2 Hours**
8. To estimate the amount of aspirin in the given tablet by spectrophotometric method. **2 Hours**
9. To verify the law of additivity of absorbance ($KMnO_4$ and $K_2Cr_2O_7$) at λ_{max} of $K_2Cr_2O_7$ and determine molar absorptivity. **2 Hours**
10. To determine the phosphate concentration in a soft drink by spectrophotometric method. **2 Hours**
11. To determine spectrophotometrically, the stoichiometry of a complex formed between iron and 1,10- phenanthroline by continuous variation method. **2 Hours**
12. To determine spectrophotometrically, the stoichiometry of a complex formed between iron and 1,10- phenanthroline by mole ratio method. **2 Hours**
13. To determine the dissociation constant of methyl red indicator by spectrophotometric method. **2 Hours**
14. To determine the amount of Cr (VI) in the given solution as dichromate by least square method spectrophotometrically. **2 Hours**
15. To determine the amount of nitrobenzene from the organic sample by spectrophotometric method. **2 Hours**

REFRENCES

Mandatory Reading:

1. Skoog, D. A., West, D. M., Holler F. J., Crouch, S. R., Fundamentals of Analytical Chemistry, 8th Edition.
2. Christian, G. D., Analytical Chemistry, John Wiley, 5th Edition.

Supplementary Reading:

1. Holler, F. J., Skoog, D. A., Crouch, S. R., Principles of Instrumental Analysis, 6th Edition, Thomson Books.
2. Willard, H. H., Merritt, L. L., Dean, J. A., Settle, F. A., Instrumental Methods of Analysis, CBS Publishing, New Delhi, 7th Edition.
3. Ewing, G. W., Instrumental Methods of Chemical Analysis, 5th Edition, Mc-Graw Hill International Edition.
4. Bassett J., Denney R. C., Jeffrey G. H., Mendham J., Vogel's Text Book of Quantitative Inorganic Analysis, 4th Edition, ELBS and Longman.

PRACTICAL BOOK:

Yadav, J. B., Advanced Practical Physical Chemistry, 14th Edition, Goel Publishing House.

WEB REFERENCES:

1. https://www2.chemistry.msu.edu/faculty/reusch/VirtTxtJml/Spectrpy/UV- Vis/spectrum.htm
2. https://chemdictionary.org/beer-lambert-law/
3. https://www.indiastudychannel.com/resources/146681-Principle-working-and-applications- of-UV- spectroscopy.aspx
4. https://www.slideshare.net/manishpharma/application-of-uv-spectroscopy

SEMESTER V

CORE COURSE
THEORY
Course Code: UG-CHE-301
Course Title: Advanced Physical 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 help to get a better understanding about the basics of Spectroscopy and Electrochemistry.
3. To develop a better knowledge of nuclear reactors.
4. To be able to carry out experiments with required skills.

Course Learning Outcomes:

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

CLO1: Comprehend the interactions of electromagnetic radiation with the matter in Microwave, IR and Raman spectroscopy and predict their applications.

CLO2: Construct electrochemical cells, its theory and apply the same in determining various chemical parameters.

CLO3: Elucidate the nuclear decay process, its measurement ,applications of radioisotopes and delineate the working of nuclear reactors.

CLO4: Apply the chemical concepts, carry out instrumental experiments and work efficiently in the laboratory.

MODULE I: Molecular Spectroscopy **15 Hours**

Introduction: definition of spectrum. Electromagnetic radiation, quantization of different forms of energies in molecules: translational, rotational and electronic, Born Oppenheimer approximation, factors affecting line width and intensity, Introduction to dipole moment, of bond, bond moment, Mossotti-Clausius equation (derivation expected).

Microwave spectroscopy: Rotational spectrum of diatomic molecule as a rigid rotator (derivation expected), moment of inertia, energy levels, selection rules, determination of internuclear distance, applications of Microwave spectroscopy. Numerical problems expected.

Infrared spectroscopy:Hooke's law, energy levels and transitions: Simple harmonic oscillator, anharmonic oscillator (derivations expected), Calculation of force constant, Stretching and bending vibrations, modes of vibration of linear triatomic and non-linear Triatomic molecule and changes in dipole moment, applications of IR spectroscopy.

Vibration –rotation spectroscopy: Diatomic vibrating rotator, P, Q, R branches.

Raman spectroscopy:Rayleigh and Raman scattering, Stokes and Antistokes lines. Quantum theory of Raman Effect, Mutual exclusion principle, Differences between Raman and IR spectroscopy, applications of Raman spectroscopy. Numerical problems expected.

MODULE II: Electrochemistry **15 Hours**

Introduction: Construction of an electrochemical cell, representation of electrochemical cell and calculation of $E_{cell}$and different types of electrochemical cells.

Emf of a cell and its measurements: concentration cells-electrode amalgam and gas electrodes reversible to cations and anions(derivations expected); electrolyte- metal/metal ion and gas electrodes with and without transport reversible to cations and anions(derivations expected), liquid junction potential and its measurement (derivations expected).
Applications of concentration cells: determination of ionic product of water, transport number of ions, solubility and solubility product, definition of pH, pOH, pK**a**, and pK**b**, determination of pH using glass electrodes by potentiometric method, buffer solution, Henderson- Hasselbalch equation for acidic and basic buffer (derivation NOT expected). Numerical problems expected.

MODULE III: Nuclear Chemistry **15 Hours**

Introduction : Composition of the nucleus, nuclear binding forces and energy, nuclear stability, nucleon –nucleon forces and their equality, characteristics and theory of nuclear forces, nuclear models- liquid drop model and shell model.
Natural Radioactivity: nuclear reactions and its representation, kinetics of radioactive decay, half-life and average life of radioelements (derivations expected).
Measurement of radioactivity:Ionisation chamber, proportional counter, GM counter, Scintillation counter.
Artificial radioactivity: Nuclear fission chain reaction and conditions for its control.
Nuclear reactors: classification of reactors, types of nuclear reactors – Production reactor, power reactor and breeder reactor, reprocessing of spent fuels.
Radioisotopes and their applications: radiolabelled reactions, radiocarbon dating, medicinal and agricultural field, hazards and biological effects of nuclear radiation. Numerical problems expected.

PRACTICALS
Course Title: Advanced Physical Chemistry I
Course Code: UG-CHE-301
Marks: 25
Credits: 1
Duration: 30 hours

List of experiments

1. To determine the percent composition of acid mixture (strong acid and weak acid) by titrating against strong base by conductometry. **03 Hours**
2. To determine the strength of a mixture containing weak acid (CH_3COOH) and salt of strong acid and weak base (NH_4Cl) by titrating against strong base by conductometry. **03 Hours**
3. To verify Ostwald's dilution law using acetic acid by conductometry. **02 Hours**
4. To determine the percent composition and amount of halide ions from their mixture (any two halides)by potentiometry using standard 0.1N $AgNO_3$ **04 Hours**
5. To determine the solubility and solubility product of silver halide by potentiometry. **03 Hours**
6. To determine the formal redox potential of Fe^{2+}/Fe^{3+} system using standard 0.1N $K_2Cr_2O_7$by potentiometry. **03 Hours**
7. To determine the dissociation of weak monobasic acid (CH_3COOH) by titrating against standard 0.1N NaOHby pH metry. **02 Hours**
8. To determine the strength of Strong acid and weak acid in a mixture of two by pH metry. **04 Hours**
9. To study the acid hydrolysis of ethyl acetate at two different temperatures and calculate the energy of activation. **04 Hours**
10. Interpretation of different IR spectra **02 Hours**

REFERENCES

Mandatory Reading:

1. Atkins P, et.al.(2006) *Physical Chemistry*. Oxford University Press, New Delhi.
2. BahlB.S.,et.al. (2010) *Essentials of Physical Chemistry*. S. Chand & Co., New Delhi
3. Laxmeshwar N.B, et.al.(2018) *Concepts of Physical Chemistry*. New Age International.

Supplementary Reading:

1. Arnikar H. J.(2004) *Essentials of Nuclear Chemistry* Wiley-Eastern Ltd., New Delhi.
2. Castellan G.W.(2002) *Physical Chemistry*. Narosa Publishing House, New Delhi.
3. KunduK.,et.al.(2003) *Physical Chemistry*. S. Chand & Co., Ltd., New Delhi.
4. Puri B.R., et.al. (2008). *Principles of Physical Chemistry*. Vishal Publishing Company, Jalandhar.
5. Raj G.(2000) *Advanced Physical Chemistry*. Goel Publishing House, Meerut.

PRACTICAL REFERENCES:

1. Das, R. C., & Raj, B. (2006). *Experimental physical chemistry*.New Age International.
2. Dogra, S. K., &Kaur, R. (2012). *Practical chemistry*. S. Chand Publishing.
3. Glasstone, S., & Lewis, D. (1960). *An introduction to physical chemistry*. Macmillan.
4. Laidler, K. J., &Meiser, J. H. (1999). *Laboratory manual of physical chemistry*.HarperCollins.
6. Mundra, J. N., & Jain, S. R. (2005). *Practical physical chemistry*.PragatiPrakashan.
7. Yadav, J. B. (2012). *Physical chemistry: A laboratory manual*. New Age International.

WEB REFERENCES:

1. https://eis.hu.edu.jo/ACUploads/10224/Brett%20Ch.,%20Brett%20A.%20Electrochemistry..%20principles,%20methods,%20and%20applications%20(Oxford,%201994)(T)(444s).pdf
2. NDE Education Resources - Detection & Measurement
3. MIT OCW - Experimental Chemistry Background

CORE COURSE

THEORY

Course Title: Advanced Organic Chemistry-I

Course Code: UG-CHE-302

Credits: 3

Duration: 45 hours

Maximum Marks: 75

Course Objectives:

1. To understand the chemistry of enolates.
2. To provide knowledge about different name reactions and their mechanisms.
3. To understand the principle and applications of UV-Visible and IR spectroscopy.
4. To develop students' hands-on skills in chemical synthesis, reinforcing their understanding of reaction mechanisms and compound formation.

Course Learning Outcomes:

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

CLO1: Apply the chemistry of enolates in organic synthesis.

CLO2: Describe mechanisms of various name reactions and rearrangements and apply these

mechanisms towards the formation of complex molecules.

CLO3: Explain the principles of UV-visible and IR spectroscopy and apply the same.

CLO4: Synthesize different organic molecules, calculate UV maxima of given organic molecules using Woodward-Fieser rules and interpret the given IR spectra.

MODULE I: Chemistry of Enolates and Related Name Reactions 15 Hours

Chemistry of Enolates: Definition of enolate ion, acidity of an α-hydrogen in carbonyl compounds, p*k*a values, generation of enolate ion, role of bases in enolate ion formation, keto-enoltautomerism(ketones, β-diketones, β-keto esters), alkylating the α-carbon of compounds with reference to ketones (symmetrical and unsymmetrical), ethylacetoacetate and malonic ester. Malonic ester synthesis of carboxylic acids, ethylacetoacetate synthesis of ketones.Alkylation of α-carbon via enamine synthesis.

Name reactions involving enolate ions: Reactions, mechanisms and applications of Claisen-Schmidt condensation, Claisen condensation, Dieckmann condensation, Perkin condensation, Knoevenagel condensation, Doebner modification, Stobbe condensation, Benzoin condensation, Michael addition.

MODULE II: Selected Name Reactions in Organic Chemistry 15 Hours

Name reactions involving electrophilic aromatic substitutions**:** Reactions, mechanisms and applications ofVilsmeier-Haack reaction, Gattermann-Koch reaction, Reimer-Tiemann reaction and Kolbe-Schmitt reaction.

Rearrangement reactions: Reactions, mechanisms and applications of Beckmann rearrangement, Curtius rearrangement, Hofmann rearrangement, Wagner-Meerwin rearrangement, Benzilic acid rearrangement, Claisen rearrangement, Favorskii rearrangement

MODULE III: UV-Visible Spectroscopy and IR-Spectroscopy 15 Hours

UV-Visible Spectroscopy: Introduction to spectroscopy, Beer-Lambert's law (statement, expression and terms involved), types of electronic transitions in a molecule, intensity of absorption. Concept of chromophores and auxochromes with examples, λmax, baochromic and hypsochromic shifts, hypochromic and hyperchromic effects. Effect of conjugation on colour with resgpect to benzene, nitrobenzene, *p*-nitroaniline and β-Carotene. Application of Woodward-Fieser rules for calculation of λmax for the following systems: Conjugated (alicyclic, homoannular and heteroannular, extended conjugated systems), α,β-unsaturated compounds (aldehydes, ketones, acids, esters) and aromatic compounds (aldehydes, ketones, carboxylic acids, esters). Problems on calculation of λmax using Woodward-Fieser rules for the above systems.Applications of UV-Visible spectroscopy.

IR Spectroscopy: Principle of IR Spectroscopy (Hooke's law), types of molecular (Stretching and bending), intensity and position of IR bands, measurement of IR spectrum, functional group region, finger print region. Applications of IR Spectroscopy in establishing the identity of an unknown molecule, functional group analysis, detection of purity of sample, to study progress of chemical reactions, effect of H-bonding, conjugation, resonance and ring size on IR absorptions. Interpretation of IR spectra of organic compounds and problems based on IR spectroscopy.

PRACTICALS

Course Title: Advanced Organic Chemistry-I

Course Code: UG-CHE-302

Credits: 1

Duration: 30 hours

Maximum Marks: 25

List of experiments:

Organic Spotting

1. Binary organic mixture separation, purification of individual compounds and qualitative analysis of both the separated compounds. **08 Hours**
   Solid-solid (any two)

Organic Preparations

1. Preparation of dibenzalacetone **02 Hours**
2. Preparation of benzoin using benzaldehyde and thiamine hydrochloride **02 Hours**
3. Oxidation of benzoin to benzyl **02 Hours**
4. Preparation of 2,4-DNP hydrazone of acetophenone **02 Hours**
5. Nitration of nitrobenzene **02 Hours**
6. Nitration of acetanilide **02 Hours**
7. Benzil to benzilic acid **02 Hours**
8. Synthesis of tetrahydroquinazolines from 2-aminobenzyl amine andbenzaldehyde via hand grinding **02 Hours**
9. Acetanilide from acetophenoneoxime **02 Hours**

UV-Visible and IR Spectroscopy

1. Calculation of UV maxima for given organic structures (dienes,α,β-unsaturated compounds and aromatic compounds) **02 Hours**
2. Interpretation of the given IR spectra **02 Hours**

REFERENCES

Mandatory Reading:

1. Morrison, R. T., Boyd, R. N., &Bhattacharjee, S. K. (2010). *Organic chemistry* (7th ed.). Pearson.
2. Bruice, P. Y. (2014). *Organic chemistry* (7th ed.). Pearson Education Inc.

Supplementary Reading:

1. Carey, F., &Giuliana, R. M. (2012). *Organic chemistry* (8th ed.). McGraw Hill.
2. Finar, I. L. *Organic chemistry*. Pearson India.
3. March, J. (2007). *Advanced organic chemistry* (4th ed.). John Wiley.
4. Ahluwalia, V. K., &Parashar, R. K. (2011). *Organic reaction mechanisms* (4th ed.). Narosa Publishing House.
5. Kalsi, P. S. (2004). *Spectroscopy of organic compounds* (6th ed.). New Age International Publishers.
6. Kemp, W. (1991). *Organic spectroscopy* (3rd ed.). Palgrave Macmillan.
7. Pavia, D. L., Lampman, G. M.,&Kriz, G. S. (2001). *Introduction to spectroscopy* (3rd ed.). Thomson Learning.
8. Silverstein, R. M., & Webster, F. (2006). *Spectrometric identification of organic compounds* (5th ed.). John Wiley & Sons.
9. Sharma, Y. R. (2017). *Elementary organic spectroscopy: Principles and chemical applications* (5th ed.). S. Chand and Company Ltd.

PRACTICAL REFERENCES:

1. Ahluwalia, V. K., &Aggarwal, R. (2001). *Comprehensive practical organic chemistry: Preparation and quantitative analysis*. Universities Press.
2. Mann, F. G., & Saunders, B. C. (2009). *Practical organic chemistry* (4th ed.). Pearson Education.
3. Furniss, B. S., Hannaford, A. J., Smith, P. W. G., &Tatchell, A. R. (1989). *Vogel's textbook of practical organic chemistry* (5th ed.). Pearson Education.

4. Shriner, R. L., Hermann, C. K. F., Morrill, T. C., & Curtin, D. Y. (2004). *The systematic identification of organic compounds* (8th ed.). John Wiley & Sons.

WEB REFERENCES:

1. https://chem.libretexts.org
2. Infrared (IR) Spectroscopy- Definition, Principle, Parts, Uses (microbenotes.com)
3. UV-Vis Spectroscopy: Principle, Strengths and Limitations and Applications | Technology Networks

CORE COURSE
THEORY
Course Title: Advanced Inorganic Chemistry I
Course Code: UG-CHE-303
Semester: V
Credits: 3
Marks: 75
Duration: 45 hours

Course Objectives:

1. To have knowledge of the electronic spectra of metal complexes and its interpretation.
2. To understand and learn the synthesis, structure, bonding and properties of organometallic compounds.
3. To understand the chemistry of solid-state compounds with respect to their reactions and properties.
4. To develop skills in the synthesis of inorganic compounds and their chemical analysis by different methods.

Course Learning Outcomes:

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

CLO1: Interpret the electronic transitions in metal complexes and explain the electronic properties using Orgel diagram.
CLO2: Identify, classify and explain the structure and bonding in metal carbonyls and apply the EAN concept to any organometallic system and predict its stability based on electron count.
CLO3: Explain the reactions and properties of solid-state compounds.
CLO4: Synthesize inorganic compounds and carry out their analysis by using different chemical methods.

MODULE I: Electronic Spectra of Transition Metal Complexes: 15 Hours

Introduction, types of electronic transitions: The d-d transitions (d1/d9, d3/d7 and d2/d8), charge transfer transitions and ligand-ligand transitions, selection rules (Laporte orbital and spin), Electronic spectra of complexes, spectroscopic terms, energies of the terms, Orgel diagrams applications (ligand field strength, colour of complexes, *cis*-, *trans*- isomerism and geometry of complexes).

MODULE II: Introduction to Organometallic Chemistry and Metal Carbonyls 15 Hours

Definition, classification of organometallic compounds, Nomenclature, ligands, concept of hapticity of organic ligands, 18 electron rule, EAN concept, electron counhting and oxidation states in complexes, classification of metal carbonyls; mononuclear metal carbonyls: Preparation,

properties, structure and bonding of $Ni(CO)_4$, $Fe(CO)_5$, $Cr(CO)_6$ using VBT; polynuclear metal carbonyls: Preparation, properties structure and bonding of $Co_2(CO)_8$, $Mn_2(CO)_{10}$, $Fe_2(CO)_9$ and $Fe_3(CO)_{12}$. π-acceptor behaviour of CO (MO diagram of CO), synergic effect and use of IR data to explain structure and bonding in metal carbonyls.

MODULE III: Solid State chemistry **15 Hours**

Reactions of solids: tarnish reactions, decomposition reaction, solid-solid reactions, addition reactions, double decomposition reaction, electron transfer reaction, solid- gas reactions; sintering; phase transformations in solids-structural change in phase transformation, Martensite transformation, temperature and pressure induced transformations, order-disorder transitions.

Theories of metallic bonding (free electron theory and band theory); Properties of solids: Electrical conductivity, insulators, semiconductor and conductors; Band structure of metals, insulators and semiconductors, photo conductivity and ionic conductivity; Types of semiconductors; intrinsic and extrinsic semiconductors. Applications of semiconductors. Solid Solutions; types of solid solutions, solid solution mechanisms.

PRACTICALS

Course Title: Advanced Inorganic Chemistry I
Course Code: UG-CHE-303
Semester: V
Credits: 1
Marks: 25
Duration: 30 Hours

List of experiments:

1. Preparation of $[Ni(NH_3)_6]Cl_2$ and estimate the amount of Ni from the complex volumetrically. **04 Hours**
2. Preparation of $K_2[Cr(SCN)_6].4H_2O$ complex. **02 Hours**
3. Preparation of $K_3[Al(C_2O_4)_3]$. H_2O complex and estimation of the amount of Al volumetrically. **04 Hours**
4. Preparation of zinc oxalate and estimation of zinc from the complex. **04 Hours**
5. To estimate the amount of barium as $BaSO_4$ in a solution containing ferric chloride and free HCl. **04 Hours**
6. To determine the strength of the given $AgNO_3$ solution by Mohr's method. **02 Hours**
7. To estimate the amount of nitrite in the given solution of sodium nitrite using $KMnO_4$ volumetrically. **02 Hours**
8. Preparation of Potassium trioxalato chromate, $K_3[Cr(C_2O_4)_3]$. $3H_2O$ and estimate the amount of oxalate in the complex volumetrically. **04 Hours**
9. To estimate the amount of Iron (II) by dichromate method from the given solution of ferric alum. **02 Hours**
10. To estimate the amount of copper from the given gum metal iodometricaly **02 Hours**

REFERENCES

Mandatory Reading:

1. Atkins, P., Overton, T., Rourke, J., Weller, M., Armstrong, F., & Hagerman, M.,(2010), Shriver and Atkins' Inorganic Chemistry,5th Edition, Oxford University Press.
2. West, A. R., (2017), Solid State Chemistry and its Applications, 2nd Edition, Wiley Publications.

Supplementary Reading:

1. Cotton, F. A., & Wilkinson, G., (2007), Basic Inorganic Chemistry, 3rd edition, Wiley Eastern Ltd.
2. Huheey, J. E., Keiter, E. A., Keiter, R. L., Medhi, O. K., (2006), Inorganic Chemistry: Principles of Structure and Reactivity, 4th Edition, Pearson Education, India.
3. Lee, J. D., (2008), Concise Inorganic Chemistry, 5th edition, Wiley-India
4. Keer H. V., (2017), Principles of the Solid State Chemistry, 2nd Edition, New Age International.

PRACTICAL BOOKS:

1. Marr, G., &Rockett, B. W. (1972). *Practical inorganic chemistry* (3rd ed.). Van Nostrand Reinhold.
2. Jeffery, G. H., Bassett, J., Mendham, J., & Denney, R. C. (1989). *Vogel's textbook of quantitative chemical analysis* (5th ed.). Longman Scientific & Technical.
3. Svehla, G. (1996). *Vogel's qualitative inorganic analysis* (7th ed.). Pearson Education.
4. Pass, G., & Sutcliffe, H. (1979). *Practical inorganic chemistry: Preparations, reactions, and instrumental methods* (2nd ed.).
5. Chapman and Hallhluwalia, V. K., &Aggarwal, R. (2001). *Comprehensive practical organic and inorganic chemistry*. University Press.

WEB REFERENCES:

1. http://cdn.intechopen.com/pdfs/38537/InTechElectronic_absorption_spectra_of_3d_transition_metal_complexes.pdf
2. https://employees.csbsju.edu/cschaller/Principles%20Chem/New_Folder/TMligands.htm3.
3. https://link.springer.com/chapter/10.1007/978-3-662-25191-1_8
4. https://chem.libretexts.org
5. https://www.sciencedirect.com/topics/materials-science/metal-organic-framework

VOCATIONAL COURSE
THEORY
Course Code: UG-CHE-VOC2
Course Title: Analytical Techniques
Credits: 3
Duration: 45 Hours
Maximum Marks: 75

Course Objectives:

1. To understand principles of some important analytical techniques.
2. To apply analytical techniques for qualitative and quantitative analysis.
3. To perform qualitative and quantitative analysis.

Course Learning Outcomes:
On successful completion of the course, the student will be able to:
CLO1: Explain sampling techniques and thermoanalytical techniques.
CLO2: Apply radioanalytical techniques and electroanalytical techniques for quantitative analysis.
CLO3: Apply nuclear magnetic resonance Spectroscopy and coulometric method of analysis for chemical analysis.
CLO4: Perform qualitative and quantitative analysis.

MODULE I: Sampling Techniques and Thermoanalytical Techniques 15 Hours

UNIT I: Sampling Techniques

Terms encountered in sampling: Sample, the population or the universe, sampling unit, increment, the gross sample, the sub sample, Analysis sample, bulk ratio, size to weight ratio, random sampling, systematic sampling, multistage sampling, sequential sampling; sampling of gases, liquids and solids; Preservation, storage and preparation of sample solution.

UNIT II: Thermoanalytical Techniques

Introduction, Thermogravimetric analysis (TG), Derivative thermogravimetric analysis (DTG), Differential thermal analysis (DTA), Differential scanning calorimetry (DSC), Simple thermometric titrations, Thermometric titration applications, Direct enthalpimetric titrations, Thermal methods in quantitative analysis,

MODULE II: Radioanalytical Techniques and Electroanalytical Techniques 15 Hours

UNIT I: Radioanalytical Techniques

Isotope dilution analysis - principle and applications; neutron activation analysis - principle and applications.

UNIT II: Electroanalytical Techniques

Conductometric Titrations: Introduction, Principles, procedure, types, advantages and limitations of conductometric titrations

Potentiometric Titrations: Introduction, indicator and reference electrodes, Principle, procedure, types, advantages of potentiometric titrations

Polarography: Introduction, Principles of polarography; Residual, limiting, migration and diffusion current, equation of polarographic wave; Ilkovic equation; diffusion current, half wave potential and their measurement, oxygen interference, dropping mercury electrode, polarographic cells, polarographic instrumentation and polarographic quantitative analysis.

MODULE III:Nuclear Magnetic Resonance Spectroscopy and Coulometric Methods of Analysis 15 Hours

Unit I: Nuclear Magnetic Resonance Spectroscopy

Introduction, Principles, Instrumentation, Environmental effects on NMR, chemical shift, Spin-spin splitting, Applications of NMR spectroscopy, ^{13}C, ^{19}F and ^{31}P NMR, FT-NMR

Unit II: Coulometric Methods of Analysis

Introduction, Principles of electrolysis, Electrolysis at constant potential, Electrolysis at constant current, Coulometric methods of analysis, Applications of coulometry, Coulometric titrations, Applications of coulometric titrations, Stripping voltammetry, Conventional stripping analysis, Electrogravimetry

PRACTICALS

Course Code: UG-CHE-VOC2

Course Title: Analytical Techniques

Credit: 1

Duration: 30 Hours

Maximum Marks: 25

List of experiments:

1. To determine the amount of HCl in the given solution using a quinhydrone electrode by potentiometric method. **02 Hours**
2. To determine the amount of CH_3COOH in the given solution by potentiometric method. **02 Hours**
3. To determine the amount of oxalic acid in the given solution using a quinhydrone electrode by potentiometric method. **02 Hours**

4. To estimate the amount of dibasic acid (oxalic acid) present in the given solution against standard NaOH solution by conductometric method. **02 Hours**
5. To estimate the amount of monobasic (HCl) and dibasic acid (oxalic acid) present in a mixture solution by titration against NaOH by conductometric method. **02 Hours**
6. To estimate the amount of H_2SO_4, CH_3COOH and $CuSO_4$ present in the mixture by titration against NaOH by conductometric method. **04 Hours**
7. To determine the amount of ferrous ions present in the given solution using $KMnO_4$ by potentiometric method. **04 Hours**
8. To determine the amount of iron present in the given solution using $K_2Cr_2O_7$ by potentiometric method. **04 Hours**
9. To estimate the amount of individual halide present in a halide mixture solution by titration against silver nitrate by potentiometric method. **04 Hours**
10. To analyse the TG/DTA pattern of zinc oxalate dihydrate. **02 Hours**
11. To analyse the TGA/DTG pattern of copper sulphatepentahydrate. **02 Hours**

REFERENCES

Mandatory Reading:

1. Khopkar, S. M. (2020). *Basic Concepts [1]of Analytical Chemistry* (4th Edition). New Age International Publishers
2. Christian, G. D. (2003). *Analytical Chemistry* (6th Edition). John Wiley & Sons.
3. Skoog, D. A., West, D. M., Holler, F. J., & Crouch, H. R. (2000). *Analytical Chemistry: An Introduction* (7th Edition). Saunders College Publishing.

Supplementary Reading:

1. Skoog, D. A., West, D. M., Holler, F. J., & Crouch, H. R. (2014). *Fundamentals of Analytical Chemistry* (9th Edition). Cengage Learning.

PRACTICAL BOOK:

1. Khosla, B. D., Garg, V. C., &Gulati, A. (2018). *Senior Practical Physical Chemistry* (18th Edition). R. Chand and Co.

WEB REFERENCES:

1. https://chem.libretexts.org/Bookshelves/Analytical_Chemistry/Analytical_Chemistry_2.1_(Harvey)/07%3A_Obtaining_and_Preparing_Samples_for_Analysis
2. https://onlinelibrary.wiley.com/doi/10.1002/9783527828692.ch1?msockid=2972e3e7fc526b7a2915f235fde06aec
3. https://link.springer.com/chapter/10.1007/978-1-349-16236-9_8
4. https://chem.libretexts.org/Bookshelves/Physical_and_Theoretical_Chemistry_Textbook_Maps/Supplemental_Modules_(Physical_and_Theoretical_Chemistry)/Spectroscopy/Magnetic_Resonance_Spectroscopies/Nuclear_Magnetic_Resonance/Nuclear_Magnetic_Resonance_II

SEMESTER VI

CORE COURSE
THEORY
Course Code: UG-CHE-304
Course Title: Advanced Physical Chemistry-II
Credits: 3
Duration: 45 Hours
Maximum Marks: 75

Course Objectives:
1. To predict the mechanism of catalytic reactions.
2. To realize the need of Quantum Mechanics and its applications.
3. To calculate the surface area of solids.
4. To synthesize and characterize catalysts.

Course Learning Outcomes:
On successful completion of the course, the student will be able to:
CLO1: Predict the mechanistic behavior of catalytic reactions.
CLO2: Apply quantum mechanics to chemical systems.
CLO3: Interpret various types of adsorption isotherms and estimate surface area of a solid
CLO4: Synthesize and characterize catalysts.

MODULE I: Quantum Mechanics **15 Hours**

Black body radiation, Plank's radiation law, photoelectric effect, Bohr's model of hydrogen atom (no derivation) and its defects, Compton Effect, de Broglie hypothesis, Heisenberg's uncertainty principle, sinusoidal wave equation, Hamiltonian operator, Schrödinger wave equation and its importance, physical interpretation of the wave function, postulates of quantum mechanics, particle in one dimensional box; Schrödinger wave equation for H-atom, separation into three equations (without derivation), quantum numbers, hydrogen like wave function, radial wave functions, angular wave functions.

MODULE II: Quantum Chemistry and Adsorption **15 Hours**

UNIT I: Quantum Chemistry

Molecular orbital theory, Formation of M.O from A.O, construction of M.O's by LCAO-H 2+ ion, calculation of energy levels from wave functions, physical picture of bonding and antibonding wave functions, concept of σ, σ*, π, π* orbitals and their characteristics, Hybrid orbitals sp, sp^2 , sp^3 ; Calculation of coefficients of A. O's used in the hybrid orbitals sp, sp^2 , sp^3 ; introduction to valence bond model of H_2; comparison of M. O. and V. B. models.

UNIT II: Adsorption

Introduction, differences between adsorption, absorption and sorption; characteristics of adsorption, sorption and occlusion; adsorption of gases on solids; Physisorption and chemisorption; Adsorption isotherms; types of adsorption isotherms: Freundlich adsorption isotherm, Langmuir adsorption isotherm; adsorption isobars; the BET equation (derivation not needed); determination of surface area: Harkin and Jura method, Benton and White method, the BET method, Point B method, from electrical potential of adsorbed layer, using rate of dissolution, from heat of wetting; importance of surface area; heat of adsorption and its measurement; Adsorption from solution; Gibbs adsorption equation (derivation not needed); desorption by porous solids; adsorption in meso pores and micro pores.

MODULE III: Catalysis And Catalysts **15 Hours**

Introduction, Criteria for catalysis, Types of catalysts, Theory of homogenously catalysed reactions; Langmuir-Hinshelwood theory of heterogeneous catalysis; Mechanistic behaviour and kinetics of heterogeneously catalysed reactions; Effect of temperature on heterogeneously catalysed reactions; Classification of catalysis, Enzyme catalysis; Characteristics of enzyme catalysis; Factors affecting rate of enzyme catalysed reactions; Mechanism and kinetics of enzyme catalysed reactions; Michaelis-Menten kinetics of enzyme catalysed reactions, Methods of calculation of rate of enzyme catalysed reactions, Acid-base catalysis, Types of acid-base catalysis, Mechanism and kinetics of acid-base catalysis; catalytic coefficients; Hammett and Bronsted equation (derivation not needed); Acidity function. Concept of activity and selectivity in catalysis. Some important classes of catalysts and their applications, Methods for characterization of catalysts, Scheme for catalyst development and design (only flow chart).

PRACTICALS

Course Code: UG-CHE-304

Course Title: Advanced Physical Chemistry-II

Credit: 1

Duration: 30 Hours

Maximum Marks: 25

List of experiments:

1. To study the adsorption of acetic acid on charcoal and to verify Freundlich adsorption isotherm. **04 Hours**
2. To study the adsorption of oxalic acid on charcoal and to verify Langmuir adsorption isotherm. **04 Hours**
3. To study acid catalysed inversion of cane sugar by polarimetry. **02 Hours**
4. To determine the interfacial tension between two immiscible liquids at room temperature using a stalagmometer. **02 Hours**
5. To determine the indicator constant of a given indicator by colorimetric measurement. **02 Hours**
6. To synthesize ZnO by decomposition method and determine its adsorption capacity using acetic acid. **04 Hours**
7. To synthesize CuO by decomposition method and determine its adsorption capacity using acetic acid. **04 Hours**
8. To determine the Hammett constant of a substituted benzoic acid by pH measurement. **04 Hours**
9. To study the adsorption of iodine from alcoholic solution using charcoal. **02 Hours**
10. To determine the energy of activation for the autocatalytic reaction between $KMnO_4$ and oxalic acid. **02 Hours**
11. To study the kinetics of autocatalytic reaction between $KMnO_4$ and oxalic acid. **02 Hours**

REFERENCE

Mandatory Reading:

1. Atkins, P., Paula, J. D., & Keeler J. (2018). *Atkins' Physical Chemistry* (11th Edition). Oxford University Press.
2. McQuarrie, D. A. (2008). *Quantum Chemistry* (2nd Edition). University Science Books.
3. Rothenberg, G. (2008). *Catalysis: Concepts and Green Applications* (1st Edition). Wiley-VCH.

Supplementary Reading:

1. McQuarrie, D. A., & Simon J. D. (2023). *Physical Chemistry: A Molecular Approach*. University Science Books.

PRACTICAL BOOK:

1. Khosla B. D., Garg V. C., &Gulati A. (2018). *Senior Practical Physical Chemistry* (18th Edition), R. Chand and Co.

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1. http://www.savitapall.com/atomic_structure/notes/Unit_09-10/4-The%20Wave%20Mechanical%20Model%20of%20the%20Atom.pdf
2. https://phys.libretexts.org/Bookshelves/Quantum_Mechanics/Quantum_Mechanics_(Fowler)/09%3A_Perturbation_Theory/9.01%3A_Time-Independent_Perturbation_Theory
3. https://www.researchgate.net/publication/354849653_Adsorption_Phenomena_Definition_Mechanisms_and_Adsorption_Types_Short_Review
4. https://static.horiba.com/fileadmin/Horiba/Products/Scientific/Particle_Characterization/Webinars/Slides/BET_Theory_Explained.pdf

CORE COURSE
THEORY
Course Title: Advanced Organic Chemistry-II
Course Code: UG-CHE-305
Credits: 3
Duration: 45 hours
Maximum Marks: 75

Course Objectives:

1. To discuss the chemistry of selected five and six membered heterocyclic compounds.
2. To explain Proton and Carbon-13 Nuclear Magnetic Resonance Spectroscopy and to solve problems based on its data.
3. To develop understanding with regards to Mass spectroscopy and elucidate the structures of organic compounds based on UV, IR, ^{1}H NMR, ^{13}C NMR and Mass spectral data.
4. To provide basic practical knowledge by performing experiments in the laboratory and to solve problems based on UV, IR, ^{1}H NMR, ^{13}C NMR and Mass spectroscopic techniques.

Course Learning Outcomes:

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

CLO1: Explain the chemistry of selected five and six membered heterocyclic compounds.

CLO2: Explain and apply the knowledge of Proton and Carbon-13 Nuclear Magnetic Resonance Spectroscopy to elucidate the structures of organic compounds.

CLO3: Discuss and apply the knowledge of Mass spectroscopy to determine the structures of organic compounds along with UV, IR, ^{1}H NMR and ^{13}C NMR spectral data.

CLO4: Develop practical skills by performing organic chemistry experiments in the laboratory in addition to determining the structures of organic compounds based on UV, IR, ^{1}H NMR, ^{13}C NMR and Mass spectral data.

MODULE I: Chemistry of five and six membered aromatic heterocycles 15 Hours

Heterocyclic chemistry: Introduction, classification and nomenclature.

Five membered aromatic heterocycles (Pyrrole, Furan and Thiophene): Structure and reactivity of pyrrole, furan and thiophene; Electrophilic substitution reactions of pyrrole, furan and thiophene:

General mechanism, mechanism of nitration, sulphonation, halogenation, acylation, formylation and reaction using acids (HCl, H_2SO_4 and HNO_3). Nucleophilic substitution reactions of five membered aromatic heterocycles.Any two methods of preparation of furan, pyrrole and thiophene. Six membered aromatic heterocycle (Pyridine): Structure and reactivity of pyridine; Electrophilic substitution reactions of pyridine: General mechanism, mechanism of nitration, sulphonation and halogenation. Electrophilic addition at nitrogen: Protonation using acids (HX), *N*-alkylation using alkyl halide and *N*-acylation using acid halide. Nuceophilic substitution reactions of pyridine: General mechanism with examples, Chichibabin reaction. Any two methods of preparation of pyridine.Structural similarities and differences between pyrrole and pyridine; comparison of basicity ofpyrrole, pyridine and piperidine.

MODULE II: Nuclear Magnetic Resonance Spectroscopy 15 Hours

Proton Nuclear Magnetic Resonance(^{1}H NMR) Spectroscopy: Introduction to NMR Spectroscopy, types of protons: equivalent, non-equivalent, homotopic, enantiotopic and diastereotopic protons, NMR Spectrometer (block diagram), nuclear shielding and deshielding, chemical shift and molecular structure, spin-spin splitting and coupling constants, intensity of peaks, interpretation of ^{1}H NMR spectra of simple organic molecules. Structure elucidation of organic compounds using ^{1}H NMR spectral data is expected.

Carbon-13 Nuclear Magnetic Resonance (^{13}C NMR) Spectroscopy: Number of signals, splitting of signals, proton coupled and decoupled spectra, off resonance decoupled spectra. ^{13}C NMR chemical shifts, identification of hybridization of carbons and nature of functionalization. Structure elucidation of organic compounds using ^{13}C NMR spectral data is expected.

MODULE III: Mass Spectrometry and spectral problems 15 Hours

Mass Spectrometry: Instrumentation, definitions of parent or molecular ion peak and base peak. Ionization of a molecule on Electron Impact; the mass spectrum. Fragmentation of alkanes, cycloalkanes, alkenes, aromatic hydrocarbons, alkyl halides, aryl halides, alcohols, aldehydes, ketones: α-cleavage and Mc-Lafferty rearrangement. Isotope effect with respect to alkyl halides. Structure elucidation of organic compounds using UV, IR, ^{1}H NMR, ^{13}C NMR and Mass spectral data (combined problems).

PRACTICALS
Course Title: Advanced Organic Chemistry-II
Course Code: UG-CHE-305
Credits: 1
Duration: 30 hours
Maximum Marks: 25

List of experiments:

1. Binary organic mixture separation, purification of individual compounds and qualitative analysis of both the separated compounds. Solid-Liquid (any 1); Liquid-Liquid (any 1). **08 Hours**
2. Synthesis of 2,3-diphenylquinoxaline heterocyclic compound. **02 Hours**
3. Synthesis of 3,4-dihydropyrimidin-2(1*H*)-one *via* Biginelli reaction. **04 Hours**
4. To elucidate the structure of organic compounds using a given set of ^{1}H NMR data. **02 Hours**
5. To elucidate the structure of organic compounds using the given ^{1}H NMR spectra. **02 Hours**
6. To assign the chemical shift values to the peaks of given ^{1}H NMR spectra of the selected organic compounds. **02 Hours**
7. To elucidate the structure of organic compounds using a given set of ^{13}C NMR data. **02 Hours**

8. To identify the compounds based on the given Mass spectra. List: Alkane, alkene, alcohol, ether, amine, carboxylic acid, ester and amides. **02 Hours**
9. To write the fragmentation pattern for the given mass spectra of organic compounds. **02 Hours**
10. To elucidate the structure of organic compounds based on the given spectroscopic information of UV, IR, ^{1}H NMR, ^{13}C NMR and Mass spectroscopic techniques. **02 Hours**
11. To elucidate the structure of organic compounds based on UV, IR, ^{1}H NMR, ^{13}C NMR and Mass spectroscopic data. **02 Hours**

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Mandatory Reading:

1. Morrison, R. T.; Boyd, R. N.; Bhattacharjee, S. K. (2010).*Organic Chemistry* (7th Edition). Pearson Publications, India.
2. Joule, J. A.; Mills, K. (2010).*Heterocyclic Chemistry* (5th Edition).John Wiley & Sons, Ltd. publication, UK.
3. Silverstein, R. M.;Webster, F. X.; Kiemle, D. J. (2005). *Spectrometric Identification of Organic Compounds* (7th Edition). John Wiley & Sons, Ltd. publication, USA.

Supplementary Reading:

1. Bruice, P. Y. (2020).*Organic Chemistry* (8th Edition). Pearson Publications, India.
2. Carey, F. A.; Giuliano, R. M. (2016).*Organic Chemistry* (10th Edition). McGrawHill Education, India.
3. Finar, I. L. (2002).*Organic Chemistry* (6th Edition). Volume 1, Pearson Publications, India.
4. Gilchrist, T. (2005).*Heterocyclic Chemistry* (3rd Edition). Pearson Publications, India.
5. Kalsi, P. S. (2016).*Spectroscopy of Organic compounds* (7th Edition). New Age International Private Ltd.,India.

PRACTICAL BOOKS:

1. Furniss, B. S.; Hannaford, A. J.; Smith, P. W. G.;Tatchell, A. R. (2003). *Vogel's Textbook of Practical Organic Chemistry* (5th Edition). Pearson Publications, India.
2. Pavia, D. L.;Lampman, G. M.;Kriz, G. S. (2001). *Introduction to Spectroscopy* (3rd Edition). Thomson Learning, USA.

WEB REFERENCES:

1. https://www.dalalinstitute.com/wp-content/uploads/sites/2/Books/A-Textbook-of-Organic-Chemistry-Volume-1/ATOOCV1-11-1-Mechanistic-and-Stereochemical-Aspects-of-Addition-Reactions-Involving-Electrophiles-Nucleophiles-and-Free-Radicals.pdf
2. https://www.lndcollege.co.in/syllabus/co_po/Carbohydrates%20-Classification,%20Structure%20and%20function.pdf
3. https://faculty.ksu.edu.sa/sites/default/files/CH-2-1%20Pyrrole%2C%20Furan%20and%20Thiophene_0.pdf
4. https://www.bhu.ac.in/Content/Syllabus/Syllabus_3006312720200506092720.pdf
5. https://www.vanderbilt.edu/AnS/Chemistry/Rizzo/chem220a/Ch13slides.pdf
6. https://www1.udel.edu/chem/kohclasses/docs/13CNMRfor322.pdf

CORE COURSE

THEORY

Course Title: Advanced Inorganic Chemistry-II

Course Code: UG-CHE-306

Semester: VI
Credits: 03
Marks: 75
Duration: 45 hours

Course objectives:

1. To have a comprehensive knowledge of the chemistry of inorganic materials.
2. To understand the synthesis, properties, characterisation techniques and application of technologically important materials.
3. To comprehend the role of metal ions that are involved in different processes like oxygen transport, electron-transfer reactions, etc. in biological systems.
4. To develop skills in material synthesis and their characterization methods.

Course Learning Outcomes:

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

CLO1: Explain the chemistry of inorganic materials and illustrate their preparation, structure, bonding and applications.

CLO2: Compare the properties and synthesis techniques of nanoparticles and explain the characterization methods employed to analyse the properties.

CLO3: Evaluate the significance of biologically important compounds and elucidate the role of metal ions that are involved in different biological processes.

CLO4: Synthesize inorganic materials and carry out its analysis using different techniques.

MODULE I: Materials Chemistry **15 hours**

Inorganic Polymers: Definition, properties, classification (condensation, addition and coordination), preparation, structure and bonding, applications of dimers and polymers containing Boron (borazine), phosphorous (phosphazenes), silicon (silicones), sulfur (S_4N_4, thiazylhalides).
Silicates: Type, structure and applications; Zeolites: Types, structure and applications.
Metal-organic frameworks (MOF's): structure, ligands, applications.
Molecular materials: Fullerides and liquid crystals.

MODULE II: Nanomaterials **15 hours**

Terminology and history, classification of nanomaterials, properties of nanomaterials- mechanical, optical, magnetic, electronic, catalytic and surface area; synthetic approach with at least one example of each type; Chemical methods (precursor method, sol-gel, hydrothermal, and co-precipitation); Top down and bottom up approach; Physical methods (mechanical methods, chemical vapor deposition, laser ablation); biological methods (using plant extract)
Characterization Methods: X-Ray diffraction techniques, electron microscopic techniques (SEM and TEM), magnetic measurement, UV-Visible spectroscopy, Infrared and Raman spectroscopy.

MODULE III: Biological Inorganic Chemistry **15 hours**

Essential and trace elements in biological processes; distribution of elements in biosphere; bio-availability and bio-stability; Biologically important compounds: sugars (carbohydrates), fatty acids (lipids), nucleotides (nucleic acids) and amino acids (proteins); Biological importance of water. Mechanism of ion transport across membranes; sodium-potassium pump.
Heme proteins: hemoglobin, myoglobin and cytochrome c; non-heme proteins: hemerythrin and hemocyanin, Iron transport proteins: Siderophores, transferrin and ferritin. Iron-Sulphur clusters.

PRACTICALS

Course Title: Advanced Inorganic Chemistry-II
Course Code: UG-CHE-306
Semester: VI
Credit: 01
Marks: 25
Duration:30 hours

List of experiments:

1. Preparation of bis(dimethylglyoxime)cobalt(II) complex **02 Hours**
2. Preparation of Tris(acetylacetonato)iron(III). **02 Hours**
3. Preparation of acetylacetonatomanganese(III) complex. **02 Hours**
4. Preparation of isomers, cis and trans dichloro(ethylenediamine)cobalt(III) chloride. **04 Hours**
5. To prepare mixed metal oxide of Zn and Fe using co-precipitation technique **02 Hours**
6. To carry out the chemical analysis of the mixed metal oxide, $ZnFe_2O_4$. **04 Hours**
7. Synthesis of ZnO nanoparticles by chemical method. **02 Hours**
8. To determine the particle size of metal oxides using SEM/TEM data. **02 Hours**
9. To study the X-ray diffraction pattern of given sample (Phase and particle size). **02 Hours**
10. To calculate the lattice parameter of any three-metal oxides using their XRD data. **02 Hours**
11. Estimation of Cu from Copper Chloride volumetrically. **02 Hours**
12. Separation and determination of transition metal ions: Separation of Mg^{2+} and Zn^{2+} by ion exchange and its estimation. **04 Hours**

REFERENCE BOOKS:

Mandatory Reading:

1. Atkins, P., Overton, T., Rourke, J., Weller, M., Armstrong, F., & Hagerman, M.,(2010), *Shriver and Atkins' Inorganic Chemistry*,5th Edition, Oxford University Press.
2. West, A. R., (2017), *Solid State Chemistry and its Applications*, 2nd Edition, Wiley Publications.

Supplementary Reading:

1. Cotton, F. A., & Wilkinson, G., (2007), *Basic Inorganic Chemistry*, 3rd edition, Wiley Eastern Ltd.
2. Lee, J. D., (2008), *Concise Inorganic Chemistry*, 5th edition, Wiley-India.
3. Fausto da Silva, J. J. R., & Williams, (1991), R. J. P., *The Biological Chemistry of the Elements*, Clarendon Press.
4. Poole, C. P., & Owens, F. J., (2003), *Introduction to Nanotechnology*, 1st Edition, John-Wiley and Sons.
5. Rao, M. B., & Reddy, K. K., (2015), *Introduction to Nanotechnology*, 1st Edition, Campus books International.

PRACTICAL BOOKS:

1. Jeffery, G. H., Basett, J., Mendham, J., Denney, R. C., (1989), *Vogel's Text Book of Quantitative Chemical Analysis*, 5th Edition, Longman Scientific and Technical.
2. Brauer, G., (1963), *Handbook of Preparative Inorganic Chemistry*, Volume 1 and 2, 2nd Edition, Academic Press.
3. Elias, A. J., (2008), *General Chemistry Experiments*, Universities Press

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3. https://www.sciencedirect.com/science/article/abs/pii/B9780128139349000013
4. https://www.sciencedirect.com/topics/materials-science/metal-organic-framework
5. https://www.sciencedirect.com/topics/chemistry/bioinorganic-chemistry#:~:text=A%20Overview,active%20site%20of%20the%20enzyme.

CORE COURSE
THEORY
Course Code: UG-CHE-307
Course Title: Environmental and Sustainable Chemistry
Credits: 3
Duration: 45 Hours
Maximum Marks: 75

Course Objectives:
1. Will understand the effects of pollution on our environment
2. Will be aware of solid waste management challenges.
3. Will be introduced to sustainable chemistry.
4. Will develop skills to apply concepts in analysis of water and soil.

Course Learning Outcomes:
On successful completion of the course, the student will be able to:
CLO1: Delineate how air pollutants are transported and accumulated in the environment and its toxicity.
CLO2: Articulate the knowledge relevant to key parameters responsible towards water and soil pollution; and its analysis.
CLO3: Evaluate solid waste management and explicate the technique involved in the treatment of drinking water and wastewater.
CLO4: Develop skills to analyze and adopt methods deployed in analysis of soil and water pollution and carry out valorisation experiments towards sustainability.

MODULE I: Chemistry of Atmosphere and air pollution **15 Hours**
Atmosphere: Composition, Structure, properties vertical temperature performance, lapse rate and temperature inversion. Reactions in the atmosphere: i) formation in the atmosphere ii) reaction of hydroxyl radical with trace gases and as sources of hydro peroxy radical and hydrogen peroxide.
Ozone Chemistry: Major atmospheric species involved in ozone formation and destruction, some major chemical reactions in the troposphere associated with ozone. Stratospheric ozone: pollutants, destroying stratospheric ozone layer. Species destroying layer: i) catalytic NO, ii) photodissociation of CFCs, and iii) combined chain reaction.
Air pollution: Introduction, classification of air pollutants, sources, effects of air pollutants on living and nonliving things with respect to NOx, Carbon and Sulphur, Photochemical smog, acid rain, greenhouse effect and its consequences on the environment, air quality index, air pollution problems in India; method to control the air pollution; instrumental analysis of air pollutants: a) SO_2, b) H_2S, c) CO d) CO_2 (excess) and e)NOx

MODULE II: Water and Soil pollution **15 Hours**
Water pollution : Introduction, types, sources and classification of water pollutants; Chemical, physical and biological characteristics of water pollution, effects of water pollutants on life and environment; method to control water pollution; toxic elements in water; chemical analysis of dissolved oxygen (DO), Chemical oxygen demand (COD), Biochemical oxygen demand (BOD)

and Total organic carbon (TOC).Importance of buffer and buffer index in waste water treatment.
Soil Pollution and instrumental techniques: Composition of soil, classification of pollutants and their characteristics, sources, organic and inorganic components in soil; Nitrogen and NPK in soil, wastes and pollutants in soil, biochemical effect of pesticides, sources of pesticides residue in the soil; pesticides degradation by natural forces, effect of pesticide residue on life, chemical analysis of Soil/Sediment analysis: a)Bulk density, b)Specific gravity, c) Moisture content d) Water holding capacity e) Conductivity f)Alkalinity, and g) detection of sulphate, calcium and iron.

MODULE III: Treatment of water and solid waste management 15 Hours

Techniques of water treatment: a) Treatment of water for municipal purpose: Important processes involved in purification of water. b) Treatment of water for Industries: Removal of hardness of water by Clark's method and use of ion exchange resins.
Fundamentals of solid waste management: Origin and Classification of solid waste : domestic waste, commercial waste, industrial waste, market waste, agricultural waste, biomedical waste, institutional waste, hazardous waste and e waste, sources of solid waste, physical and chemical characteristics of municipal solid waste, impacts of solid waste on environment, collection, storage and transportation of solid waste, health aspects involved in handling solid waste, Solid waste management methods relating: i) Utilisation, ii) Recovery, iii) Reuse iv) Recycling of wastes residues, v) Recycling avoidance of solid waste, concept of composting, pyrolysis, incineration and sanitary landfills.

PRACTICALS
Course Title: Environmental and Sustainable Chemistry
Course Code: UG-CHE-307
Maximum Marks: 25
Credits: 1
Duration: 30 hours

List of Experiments

1. To estimate sodium in water samples: ion exchange method. **02 Hours**
2. To estimation phosphate in water samples by spectrophotometry. **02 Hours**
3. Determination of chloride content in water samples: Potentiometric method **04 Hours**
4. Determination of bulk density of different types of soil samples. **02 Hours**
5. Determination of permanent, temporary and total hardness of water sample. **02 Hours**
6. Determination of Dissolved Oxygen content in water samples. **02 Hours**
7. To estimate Manganese in water samples by spectrophotometry. **02 Hours**
8. To estimation nitrite in water samples by spectrophotometry. **02 Hours**
9. Analysis of different types of soil for pH, conductivity, acidity and alkalinity. **04 Hours**
10. Determination of Chemical Oxygen Demand in water samples. **02 Hours**
11. Determination of Biological Oxygen Demand in water samples. **02 Hours**
12. Valorisation Experiments (any 1) a) Organic lab waste valorisation
    b) Preparation of bio plastic **04 Hours**
    c) Composting activity

REFERENCES:
Mandatory Reading:

1. Christan G. D.*AnalyticalChemistry*(5th edition). Wiley publication
2. De, A. K.(1995) *Environmental Chemistry*.Wiley eastern Ltd.
2. Iqbal,S.A.et.al.(1995)*Chemistry of Air and Air Pollution*. Discovery Publishing House, New Delhi

3. Katyal Jimmy et.al.(1993) *Environmental Pollution*. Anmol Publications, New Delhi

Supplementary Reading:

1. Manahan, S.E. (1994.) *Environmental Chemistry* Lewis Publishers
2. Neil,P. O. (2007). *Environmental Chemistry*. Blackie Academic & Professional
3. Raghuraman, K.et al. *Basic Principles of Analytical Chemistry*(4th edition).sheth publishers
4. Schroede, E.D.(1997).*Water & waste water treatment*. Mc. Graw Hill
5. Skoog et.al, *Principles of Analytical Chemistry*(4th International edition)Saunders college Publishers
6. Trivedi P.R. et.al.*Environmental Water and Soil Analysis*(1st edition).Akashdeep Publishing house , New Delhi
7. Tyagi, O.D. et.al.(1992).*A Text Book Of Environmental Chemistry*.Anmol Publications, New Delhi
8. Vanloon G.W. et.al. (2003)*Environmental Chemistry*. Oxford University Press
9. Salker, A.V. (2017) *Environmental Chemistry : Pollution and Remedial Perspective*. Narosa Publishing house, India

PRACTICAL BOOKS:

1. Manahan, S. E. (2017). *Environmental chemistry* (10th ed.). CRC Press.
2. Harris, W. (2013). *Environmental chemistry: A global perspective* (2nd ed.). Oxford University Press.
3. Ahuja, S. (2010). *Environmental chemistry: Principles and applications*. Academic Press.
4. Vogel, A. I., & Bassett, J. (2016). *Vogel's textbook of quantitative chemical analysis* (6th ed.). Pearson.
5. Skoog, D. A., West, D. M., Holler, F. J., & Crouch, S. R. (2014). *Fundamentals of analytical chemistry* (9th ed.). Cengage Learning

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3. https://www.nrdc.org/stories/water-pollution-everything-you-need-know
4. https://biologyreader.com/ozone-depletion.html
5. https://www.conserve-energy-future.com/sources-effects-methods-of-solid-waste-management.php

VOCATIONAL COURSE
THEORY
Course Title: Industrial Chemistry
Course Code: UG-CHE-VOC3
Credits: 3
Duration: 45 hours
Maximum Marks: 75

Course Objectives:

1. To understand the fundamentals of industrial chemistry.
2. To apply the knowledge of industrial processes.
3. To develop understanding about industrial Safety and Effluent management.
4. To develop practical skills by performing laboratory experiments.

Course Learning Outcomes:
On successful completion of the course, the student will be able to:
CLO1: Explain the fundamentals of industrial chemistry.
CLO2: Discuss and apply the knowledge of selected key industrial processes.
CLO3: Develop understanding about industrial safety and effluent management.
CLO4: Develop practical skills by performing laboratory experiments.

MODULE I: Fundamentals of Industrial Chemistry **15 Hours**

Metallurgy and industrial fuels: Introduction to metallurgy, Occurrence of metals in nature, various steps of metallurgy, furnaces and extraction of iron from iron ore. Industrial fuels: Coal gas, producer gas, water gas.

Mechanical properties of materials and change with respect to temperature, Metals and alloys- important metals and alloys, Glass- types, composition, manufacture, physical and chemical properties applications, Relevance of catalysis in modern industrial processes, Corrosion- various types of corrosion relevant to chemical industry- Mechanism, Preventive methods.

MODULE II: Industrial processes **15 Hours**

Halogenation: Introduction, type of halogenation reactions, halogenating agents, kinetics and mechanism of halogenation, manufacturing of chloroethane, chlorobenzene, chloral; Nitration: Introduction, type of nitration reaction, nitrating agents, kinetics and mechanism of nitration, manufacturing of nitrobenzene and p-nitroacetanilide; Sulphonation: Introduction, type of sulphonation reaction, sulphonating agents, mechanism of sulphonation reaction, commercial sulphonation of benzene and alkyl benzene; Physico chemical principles involved in the manufacture of HNO_3 (Ostwald's method) and NH_3 (Haber's method); Introduction, classification and applications of boilers and heat exchangers; Introduction, general classification, composition, characteristics and applications of paints.

MODULE III: Industrial Safety and Effluent management **15 Hours**

Meaning of industrial safety, industrial accidents, industrial hazards, MSDS and safety programme. Process Safety: a) Chemical reaction hazards: Fundamental understanding, various instruments used to understand chemical reaction hazards; b) Fire and Explosion Hazards: Fundamental understanding, various instruments used to understand fire and explosion hazards; Principles and equipments for aerobic, anaerobic treatment, adsorption, filtration, sedimentation, bag filters, electrostatic precipitators, mist eliminators, wet scrubbers, absorbers, solid waste management and reverse osmosis; Treatment of electronic waste.

PRACTICALS
Course Title: Industrial Chemistry
Course Code: UG-CHE-VOC3
Credits: 1
Duration: 30 hours
Maximum Marks: 25

List of experiments:

1. Synthesis of 1-nitronaphthalene from naphthalene (Nitration). **02 Hours**
2. Synthesis of 2,4,6-tribromophenol from phenol (Bromination). **02 Hours**
3. Synthesis of 4-hydroxybenzenesulphonic acid from phenol (Sulphonation). **02 Hours**
4. Synthesis of phthalic acid to phthalic anhydride (Dehydration). **02 Hours**

5. Synthesis of ethyl acetate from acetic acid and ethanol (Esterification). **02 Hours**
6. To prepare potash alum, $K_2SO_4.Al_2(SO_4)_3$. 24 H_2O, from aluminium foil. **02 Hours**
7. To estimate zinc in the Alloy (brass). **02 Hours**
8. Ore analysis: Calcium from limestone/ Iron from iron ore **04 Hours**
9. To estimate the amount of copper from copper salt by spectrophotometric method. **02 Hours**
10. To estimate copper from the Alloy (bronze). **02 Hours**
11. To determine the rate of corrosion on an Aluminium plate in basic medium. **02 Hours**
12. To determine the effect of temperature on rate of corrosion in acidic medium. **02 Hours**
13. To determine the effect of pH on the rate of corrosion on different metallic plates (Aluminium/Zinc). **02 Hours**

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1. Sharma, B. K. (2014). *Industrial Chemistry* (6th Edition).Goel Publishing House, Meerut.

Supplementary Reading:

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2. Madan, R. D. (2019). *Modern Inorganic Chemistry,* Revised edition, S. Chand and company Limited, New-Delhi.
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5. Cotton, F. A. et. al. *Basic Inorganic Chemistry* (2nd Edition). Wiley Eastern Ltd.
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PRACTICAL BOOK:

1. Jeffery, G. H.; Basett, J.; Mendham, J.; Denney, R. C. (1989). *Vogel's Text Book of Quantitative Chemical Analysis* (5th Edition). Longman Scientific and Technical.

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2. https://chem.libretexts.org/Bookshelves/General_Chemistry/Book%3A_General_Chemistry%3A_Principles_Patterns_and_Applications_(Averill)/02%3A_Molecules_Ions_and_Chemical_Formulas/2.06%3A_Industrially_Important_Chemicals
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