Annexure A (UG Programmes)

Name of the Programme: B. Sc. in Chemistry

COURSE STRUCTURE

SEMESTER	MAJOR CORE	MINOR/ VOCATIONAL	MULTIDISCIPLINARY COURSE (MDC)	VALUE ADDED COURSES (VAC)	ABILITY ENHANCEMENT COURSE (AEC)	SKILL ENHANCEMENT COURSE (SEC)
I	**UG-CHE-101** General Physical and Inorganic Chemistry	**Minor Stream UG-CHE-101** General Physical and Inorganic Chemistry	**UG-CHE-MDC1** Basics in Chemistry **UG-CHE-MDC2** Selected Topics in Organic and Inorganic Chemistry	-	-	**UG-CHE-SEC1** Skill Development in Chemistry
II	**UG-CHE-102** General Organic and Inorganic Chemistry	**Minor Stream UG-CHE-102** General Organic and Inorganic Chemistry	**UG-CHE-MDC3** Selected Topics in Food Chemistry			**UG-CHE-SEC2** Basic Laboratory Methods and Safety in Chemistry
III	**UG-CHE-201** Concepts in Chemistry - I	**Minor Stream UG-CHE-201** Concepts in Chemistry - I	**UG-CHE-MDC3** Fundamentals of Chemistry			**UG-CHE-SEC3** Basics of Analytical Chemistry
	UG-CHE-202 Concepts in Chemistry - II					
IV	**UG-CHE-203** Selected Topics in Physical Chemistry	**Minor Stream UG-CHE -VOC1** Spectroscopic Techniques				
	UG-CHE-204 Selected Topics in Organic Chemistry					
	UG-CHE-205 Selected Topics in Inorganic Chemistry					
	UG-CHE-206					

	Introduction to Pharmaceutical Chemistry					
V	**UG-CHE-301** Advanced Physical Chemistry -I	**Minor Stream UG-CHE -VOC2** Electroplating and Corrosion				
	UG-CHE-302 Advanced Organic Chemistry -I					
	UG-CHE-303 Advanced Inorganic Chemistry -I					
	UG-CHE-304 Applied Chemistry- III					
VI	**UG-CHE-305** Advanced Physical Chemistry -II	**Minor Stream UG-CHE -VOC3** Industrial Process				
	UG-CHE-306 Advanced Organic Chemistry -II					
	UG-CHE-307 Advanced Inorganic Chemistry -II					
	UG-CHE-PRJ Project **UG-CHE-308** Applied Chemistry- IV					
VII	**UG-CHE-401** Bio-Inorganic Chemistry/ Coordination Chemistry	**Minor Stream UG-CHE-409** Selected Topics in Inorganic and Organic Chemistry				
	UG-CHE-402 Surface Chemistry and Catalysis					
	UG-CHE-403 Stereochemistry and Name Reaction					
	UG-CHE-404					

	Research Methodology					
VIII	**UG-CHE-405** Organometallic Chemistry	**Minor Stream UG-CHE-410** Selected Topics in Analytical and Physical Chemistry				
	UG-CHE-406 Electrochemistry					
	UG-CHE-407 Heterocyclic Chemistry OR Synthetic Organic Chemistry					
	UG-CHE-408 Nanomaterials and Solid State Reactions					

PARVATIBAI CHOWGULE COLLEGE OF ARTS AND SCIENCE (AUTONOMOUS)

DEPARTMENT OF CHEMISTRY

ACADEMIC YEAR: 2022-2023

BoS APPROVED SYLLABI TO BE IMPLEMENTED FROM ACADEMIC YEAR: 2023-2024

SEMESTER I AND SEMESTER II (UG)

SEMESTER- I

CORE COURSE
THEORY
Course Code: UG-CHE-101
Course Title: General Physical and Inorganic Chemistry
Credits: 3
Duration: 45 Hours
Maximum Marks: 75

Course Objectives:

1. Will 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. Will help to get better understanding about the basics of Physical and Inorganic Chemistry.
3. Will be able to carry out experiments with required skills.
4. Will understand the atomic structure and learn about the elements in the periodic table.
5. Will gain knowledge about the covalent bonding in compounds and apply the VSEPR and MOT theories to explain the bonding.

Course Outcomes:

CO1: Apply mathematical concepts to solve the chemical reaction problem.
CO2: Apply symmetry rules used in X-ray diffraction studies to day today examples.
CO3: Apply the gas laws and interpret the PV isotherms of gases.
CO4: Understand the atomic structure and the periodicity of elements in the periodic table.
CO5: Apply the VSEPR and MOT theories to explain covalent bonding in different molecules.

SECTION- I (PHYSICAL CHEMISTRY)

UNIT I: Mathematical Concepts in Chemistry **06 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.

UNIT 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).

UNIT III: The Solid State **08 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 Weiss

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).

UNIT IV: 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 it's 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 (INORGANIC CHEMISTRY)

UNIT V: 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.

UNIT VI: 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 H2O, Molecular Orbital Theory, homonuclear and heteronuclear diatomic molecules (CO and NO), multi centre 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 Physical and Inorganic Chemistry
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] **(2 hours)**
2. To study the solubility of benzoic acid at room and below room temperature by volumetric method. **(2 hours)**
3. 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. **(2 hours)**
4. To investigate the order of the reaction between $K_2S_2O_8$ and KI using equal initial concentrations of both the reactants. **(4 hours)**
5. To study the hydrolysis of methyl acetate using two different initial concentrations in presence of mineral acid **(**HCl) as catalyst **(4 hours)**
6. To study the molecular condition of benzoic acid in toluene-water system. **(4 hours)**
7. To study the kinetics of Iodine-Clock reaction. **(4 hours)**
8. To study the oxidation of iodide ions by hydrogen peroxide as an iodine clock reaction. **(4 hours)**

INORGANIC CHEMISTRY

1. Estimation of Calcium by EDTA method. **(2 hours)**
2. To prepare 100 ppm Manganese solution using KMnO4 and carry out the further dilutions like 5,

10, 20 ppm. **(2 hours)**

3. To prepare 0.1 N Na2C2O4 solution and use it to standardize the given KMnO4 solution. **(2 hours)**

4. Preparation of chrome Red. **(2 hours)**

5. Preparation of ferrous ammonium sulphate. **(2 hours)**

PHYSICAL CHEMISTRY TEXT BOOK:

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

INORGANIC CHEMISTRY TEXT BOOK:

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

ADDITIONAL 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. 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.
6. Cotton, F. A., Wilkinson, G., *Advanced Inorganic Chemistry*, Wiley Publications.
7. Puri, B. R., Sharma, L. R., Kalia, K. C. *Principles of Inorganic Chemistry*, Vishal Page 6 of 73 Publishing Co.
8. House croft, C. E. and Sharpe, A. G., *Inorganic Chemistry*, Prentice Hall.

PRACTICAL BOOK:

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

WEB REFERENCES:

1.http://alpha.chem.umb.edu/chemistry/ch115/Mridula/CHEM%20116/documents/chapter_14auLectureSlides_000.pdf
2. https://www.livescience.com/53304-gases.html
3. https://www.slideshare.net/kumar_vic/solid-state-chemistry-17237117
4.https://chem.libretexts.org/Bookshelves/Physical_and_Theoretical_Chemistry_Textbook_Maps/Supplemental_Modules_(Physical_and_Theoretical_Chemistry)/Physical_Properties_of_Matter/States_of_Matter/Properties_of_Gases/Kinetic_Theory_of_Gases/Basics_of_Kinetic_Molecular_Theory
5. https://www.thoughtco.com/valence-shell-electron-pair-repulsion-theory-605773
6. https://www.britannica.com/science/covalent-bond
7. https://www.electrical4u.com/schrodinger-wave-equation/
8. http://www.chem4kids.com/files/atom_structure.html
9. https://pubchem.ncbi.nlm.nih.gov/periodic-table/

MULTI DISIPLINARY COURSES

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 Outcomes:

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

CO1: Understand the basic concepts in chemistry.

CO2: Discuss different types of pollution, its related harmful effects and the importance of green chemistry.

CO3: Develop practical skill by performing basic chemistry experiments in laboratory.

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

Introduction, Classification: Organic, Inorganic, Physical and Analytical, Reactants, products, catalysts (with two examples).

Physical: States of matter: solids, liquids, and gases.

Organic: Nomenclature and classification of some basic organic compounds (Hydrocarbons: Alkanes, alkenes and alkynes, alcohols, amines, and carboxylic acids with examples), and its selected applications. Purification techniques of solids (recrystallization, sublimation) and liquids (distillation).

Inorganic: Atomic structure and type of bonds: ionic, covalent, metallic; acids and bases; metals, non-metals, noble gases.

Analytical: Knowledge of basic chemistry instruments, preparation of solutions, standardization, normality, molarity, and molality.

UNIT 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. **(2 hours)**
2. Purification techniques of solid: Sublimation. **(2 hours)**
3. Purification techniques of liquids: Distillation. **(2 hours)**
4. Stoichiometric calculation for preparation of solutions. **(2 hours)**
5. Preparations of solution in terms of normality, molarity, ppm, percent. **(2 hours)**
6. Standardisation of solution: Acid and base. **(4 hours)**
7. Determination of the specific gravity of liquids using Pyknometer (any two). **(2 hours)**
8. Determination of melting point of solids (any two). **(2 hours)**
9. Determination of boiling point of liquids (any two). **(2 hours)**
10. Demonstration of experiments on conductometer. **(2 hours)**

11. Demonstration of experiments on pH meter. **(2 hours)**
12. Identification of Chemical type of organic compounds (any three). **(6 hours)**

TEXT BOOKS:

1. Gurdeep, R. Advanced Physical Chemistry, 27th Edition; Goel Publishing House, Meerut
2. Morrison, R. T. et. al. Organic Chemistry Pearsons Publications, Noida India.
3. Shriver, D. F. et. al. Inorganic Chemistry, 5th Edition, Oxford University Press
4. Skoog, D. A., et. al. Fundamentals of Analytical Chemistry, 8th Edition

REFERENCE BOOKS:

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

WEB REFERENCES:

1. https://wou.edu/chemistry/files/2017/01/CH105-Chapter-8-PDF-file.pdf
2.https://mysite.science.uottawa.ca/sgambarotta/sites/default/files/CHM%201311F/slide%20show/molecule/Ch08-12%20molecules.pdf
3.https://www.hansrajcollege.ac.in/hCPanel/uploads/elearning/elearning_document/Twelve_principle_of_GC.pdf
4. http://eagri.org/eagri50/ENVS302/pdf/lec07.pdf

Course Code: UG-CHE-MDC2

Course Title: Selected Topics in Organic and Inorganic Chemistry

Credits: 2

Duration: 30 Hours

Maximum Marks: 50

Objectives:

1. To make students understand the basic theory concepts in organic chemistry.
2. To provide knowledge about chemical bonding and different types of chemical bonds.
3. To provide basic practical knowledge by performing experiments in laboratory.

Course Outcomes:

On successful completion of the course, the student will be able to:
CO1: Understand the basic concepts in organic chemistry.
CO2: Explain the chemical bonding and its types.
CO3: Develop practical skill by performing basic chemistry experiments in laboratory.

UNIT 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).

UNIT II: Chemical Bonding **15 Hours**

Types of bonds; Ionic bond: nature of ionic bond, factors favouring formation of ionic compounds, properties of ionic compounds, examples of ionic compounds; Covalent bond: Lewis's concept of covalent bond, factors favouring the formation of covalent compounds, Valence Shell Electron Pair Repulsion Theory (VSEPR) applied to H_2O, NH_3, H_3O^+, SF_4, ICl^- and ClF_3. Valence Bond Theory (VBT) and its limitations, types of hybridization and shapes of simple inorganic molecules and ions, sigma, and pi bonds. Molecular Orbital Theory: LCAO method, homonuclear (N_2, O_2, and O_2^{2-}) and heteronuclear diatomic molecules (NO and CO), Bond order and bond strength. Co-ordinate bonds: conditions for the formation of co-ordinate bond, properties of co-ordinate compounds. Metallic bond: nature of metallic bond, properties of metallic compounds. Hydrogen bond: inter-hydrogen and intra-hydrogen bonding in compounds, properties of hydrogen bond. Van der Waals forces: types of Van der Waals forces with examples.

PRACTICALS

Course Code: UG-CHE-MDC2
Course Title: Selected Topics in Organic and Inorganic 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). **(8 hours)**
3. Standardisation of NaOH using potassium hydrogen phthalate. **(2 hours)**
4. Standardisation of $KMnO_4$ using oxalic acid. **(2 hours)**
5. To prepare 100 ppm Manganese solution using $KMnO_4$ and carry out the further dilutions like 5, 10, 20 ppm in 50 mL standard volumetric flasks. **(2 hours)**
6. Standardisation of HCl against Na_2CO_3. **(2 hours)**
7. Preparation of MnO_2. **(2 hours)**
8. Preparation of Ni-DMG complex. **(2 hours)**

TEXT BOOKS:

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.

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, 6th Edition, volume 1, Pearson India.
4. March, J., Advanced Organic Chemistry Reaction, Mechanism and Structure, 4th Edition, Wiley Publications.
5. Greenwood, N. N., Earnshaw, A., Chemistry of Elements, Pergamon, Oxford.
6. Huheey, J. E., Keiter, E. A., Keiter, R. L., Medhi, O. K. Inorganic Chemistry: Principles of Structure and Reactivity, Pearson Edu.
7. Lee J. D., Concise Inorganic Chemistry, Wiley-India.
8. Cotton F. A. and Wilkinson G., Basic Inorganic Chemistry, Wiley Eastern Ltd.

PRACTICAL TEXT 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/

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 Outcomes:

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

CO1: Determine the saponification value, iodine value and acid values of oils; test the adulterants in food items.
CO2: Apply the skills for the preparation of white phenyl and liquid soap.
CO3: Understand chemistry of soaps, synthetic detergents, alkyl-aryl sulphonates and floor cleaners.
CO4: Determine the pH of soft drinks and other beverages.
CO5: Understand the chemistry of food additives and adulterants; apply the knowledge for detecting and testing foods items for adulterants.

UNIT I: Fats and Oils **8 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.

UNIT II: Soaps, Detergents and Disinfecting agents **7 Hours**

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.

UNIT 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:

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)**

REFERENCE BOOKS:

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

SEMESTER- II

CORE COURSE
THEORY
Course Code: UG-CHE-102
Course Title: General Organic and Inorganic Chemistry
Credits: 3
Duration: 45 Hours
Maximum Marks: 75

Course Objectives:

1. Learn about the basic concepts in organic chemistry, like the hybridization in organic molecules, molecular interactions, etc.

2. Study the types of reaction, reactive intermediates, and reaction mechanism in organic chemistry.
3. Represent 3 D structures of organic molecules on 2 D surfaces.
4. Learn three important class of organic compounds, i.e., alkanes, 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:

CO1: Understand the fundamentals of organic chemistry.

CO2: Delineate the concept of stereochemistry and acquire knowledge of aliphatic hydrocarbons.

CO3: Identify given unknown organic compounds (solid) by carrying out various chemical tests and synthesize some organic derivatives.

CO4: Predict available oxidation states for s- and p-block elements.

CO5: Apply the knowledge of Normality and Molarity in preparation of different solutions.

SECTION- I (ORGANIC CHEMISTRY)

UNIT I: Fundamentals of Organic Chemistry **10 Hours**

Bond formation in organic compounds; sp, sp^2, sp^3 with respect to methane, ethene and acetylene (hybridisation 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 reaction; methods of determination of reaction mechanisms: determination of structure, intermediates, isotope effects, kinetic and stereochemical studies.

UNIT II: Stereochemistry **08 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 (up to 2 chiral carbons) and E/Z nomenclature (up to two C=C systems).

UNIT III: Study of aliphatic hydrocarbons **12 Hours**

Alkanes and Cycloalkanes**:** Physical properties of alkanes and cycloalkanes (stability of alkanes to be explained using Baeyer strain theory), sources of alkanes and cycloalkanes; chemical properties: combustion and pyrolysis of alkanes; methods of preparation: Corey-House reaction, Wurtz reaction.

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.

SECTION- II (INORGANIC CHEMISTRY)

UNIT 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.

UNIT 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 Organic and Inorganic Chemistry
Credit: 1
Duration: 30 Hours
Maximum Marks: 25

LIST OF EXPERIMENTS

ORGANIC CHEMISTRY

1. Purification of solid organic compounds by recrystallization followed by determination of melting point:
   a. Benzoic acid using water; b. m-Dinitrobenzene using ethanol **(2 hours)**
2. Purification of solid organic compounds by sublimation:
   a. Naphthalene b. Anthracene c. Camphor (any two) **(2 hours)**
3. Organic Synthesis (Any two):
   a. Benzoylation of β-naphthol and aniline. **(2 hours)**
   b. Bromination of aromatic compounds using $KBrO_3$ **(2 hours)**
   c. Anthraquinone from anthracene (Oxidation reaction) **(2 hours)**
4. 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. **(2 hours)**
2. Volumetric estimation of Fe^{2+} using internal indicator by potassium dichromate method. **(2 hours)**
3. To determine the alkali content in antacid tablet using standard HCl solution. **(2 hours)**
4. Volumetric estimation of Calcium from anhydrous Calcium Chloride. **(2 hours)**
5. To determine the Total Dissolved Solids (TDS) of Magnesium Sulphate. **(2 hours)**

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.

PRACTICAL TEXT 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.

REFERENCE BOOKS:

1. Bhattacharjee J. etal, Textbook of Chemistry, First edition, Rajhauns vitaran, Panaji Goa.
2. Bruise P. Y., Organic Chemistry, 7th Edition, Pearson Education Pvt. Ltd. New Delhi India.
3. Carey F., Organic Chemistry; 8th Edition, Tata McGraw Hill Education Pvt. Ltd. New Delhi India.
4. 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.
5. 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.
6. Sharpe and Emilus, Inorganic Chemistry.
7. Housecroft, C. E. and Sharpe, A. G. *Inorganic Chemistry,* Prentice Hall.

WEB REFERENCES:

1. https://www.khanacademy.org/science/organic-chemistry/bond-line-structures-alkanes-cycloalkanes
2. https://www.khanacademy.org/science/organic-chemistry/gen-chem-review
3. https://www.khanacademy.org/science/organic-chemistry/substitution-elimination-reactions
4. https://www.khanacademy.org/science/organic-chemistry/stereochemistry-topic
5. https://www.khanacademy.org/science/organic-chemistry/alkenes-alkynes
6. https://depts.washington.edu/eooptic/linkfiles/The%20Elements.pdf

MULTI DISIPLINARY COURSES

Course Code: UG-CHE-MDC3
Course Title: Selected Topics in Food Chemistry
Credits: 2
Duration: 30 Hours
Maximum Marks: 50

Course Objectives:

1. To make students understand about the importance of carbohydrates, proteins, and lipids in food chemistry.
2. To highlight the importance of vitamins and minerals in food chemistry and to deliver the knowledge of food contaminants.
3. To provide basic practical chemistry knowledge by performing some selected experiments related to food chemistry in laboratory.

Course Outcomes:

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

CO1: Understand the importance of carbohydrates, proteins, and lipids in food chemistry.
CO2: Explain the importance of vitamins and minerals in food chemistry and study the different food contaminants.
CO3: Develop practical skill on selected experiments related to food chemistry in laboratory.

UNIT I: Carbohydrates, Proteins and Lipids **15 Hours**

Carbohydrates: Nomenclature, chemical composition, and classification: Mono-, di-, oligo-, and polysaccharides, sources, physical and chemical properties, functions, general reactions of glucose.

Amino acids, peptides, Proteins: structure, function, chemical composition, classification of proteins, types of proteins based on structure: primary, secondary, tertiary and quaternary proteins.

Fats and oils: sources, nomenclature and classification, chemical composition, fatty acids, constituents and application of fat and oil from plants such as palm oil, canola oil, sunflower oil, coconut oil, groundnut oil, olive oil, corn oil and sesame seed oil. Properties of fats and oils, chemical reactions such as hydrolysis, hydrogenation, transesterification, rancidity, polymerization and hydrogenolysis. Analysis: saponification value, acid value, iodine value, ester value, acetyl value, Reichert value; methods of extraction and industrial scale production of oils, oil refining, side reactions during oil processing.

Waxes: sources, nomenclature and classification, chemical composition, characteristics of waxes, constituents, and applications of candelilla wax, jojoba wax, sunflower wax, rice bran wax, beeswax.

UNIT II: Vitamins, Minerals, and Food contaminants **15 Hours**

Vitamins: History; introduction; structure, classification: fat-soluble vitamins and water-soluble vitamins; dietary sources; important functions; causes and effects of vitamin deficiency in health; signs and symptoms of vitamin deficiency; vitamin fortification and supplementation.

Minerals: Introduction; classification: macro minerals and micro minerals; dietary sources; important functions; causes and effects of mineral deficiency in health; signs and symptoms of mineral deficiency; mineral fortification and supplementation; differences between vitamins and minerals.

Food contaminants: Microbial contamination, pesticides, halogenated hydrocarbons, heavy metals; occurrence, source, and effect on health.

PRACTICALS

Course Code: UG-CHE-MDC3
Course Title: Selected Topics in Food Chemistry
Credit: 1
Duration: 30 Hours
Maximum Marks: 25

LIST OF EXPERIMENTS

1. Estimation of vitamin C in citrus fruits (any two). **(8 hours)**
2. Determining the presence of carbohydrate in different samples by using Fehling's Test and iodine test. **(2 hours)**
3. Determining the presence of carbohydrate in different samples by using Seliwanoff's Test and Bial's Test. **(2 hours)**
4. Determination of iodine value of oils (any two). **(4 hours)**
5. Determination of acid value of oil. **(2 hours)**
6. Isolation of casein from milk. **(2 hours)**
7. Estimation of glucose in the given sample (any two). **(4 hours)**
8. To determine the concentration of glycine solution by formylation method. **(2 hours)**
9. Tests to differentiate between a reducing and nonreducing sugar. **(2 hours)**
10. Estimation of magnesium using EDTA method. **(2 hours)**

REFERENCE BOOKS:

1. Aurand, L. W. and Wood, A. E.; Food Chemistry. The AVI Publishing Co., Connecticut.
2. Belitz, H. D., Grosch, W. and Schieberler, P.; Food Chemistry. Springer, Berlin.
3. DeMan, J. M.; Principles of Food Chemistry. A Chapman and Hall Food Science Book, Aspen Publ., Inc., Gaithersburg, Maryland.
4. Fennama, O. R. (edition); Food Chemistry. Marcel Dekker, Inc., New York.
5. Gopalan, C., Rama Sastri, B.V., and Balasubramaniam, S. C.; Nutritive value of Indian Foods.

National Institute of Nutrition (NIN), Indian Council of Medical Research (ICMR), Hyderabad.
6. Meyer, L. H.; Food Chemistry. Reinhold Publ. Corporation, New York.
7. Potter, N. M.; Food Science; The AVI Publishing Co., Connecticut.
8. W.F. Tinto1, T. O. Elufioye and J. Roach University of the West Indies, Cave Hill Campus, St. Michael, Barbados, University of Ibadan, Ibadan, Oyo State, Nigeria.
9. Zempleni, J.; Rucker, R. B.; McCormick, D. B.; Suttie, J. W. Handbook of Vitamins, 4th Edition, CRC Press.

WEB REFERENCES:

1. https://sintak.unika.ac.id/staff/blog/uploaded/5812002253/files/fats_&_oils.pdf
2.https://webstor.srmist.edu.in/web_assets/srm_mainsite/files/2017/Oils-Fats-Waxes-Notes.pdf
3.https://www.sathyabama.ac.in/sites/default/files/course-material/2020-10/note_1456404597.pdf
4.https://www.researchgate.net/publication/342571945_Vitamins_and_Minerals_Types_Sources_and_their_Functions
5. https://www.iaea.org/topics/food-contaminants
6. https://web.vscht.cz/~dolezala/FCHS/14.%20Food%20contaminants.pdf

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TO INCORPORATE CHANGES, IN THE SYLLABI OF EXISTING COURSES OF SEMESTER III-VI

SEMESTER III

SKILL ENHANCEMENT COURSE

THEORY
Course Code: CHE. SEC-3
Course Title: Laboratory Techniques in Organic Chemistry (Theory and Practicals)
Credits: 4
Duration: 60 Hours
Maximum Marks: 100

Course Objectives:

1. Develop skill that are required in a Research Laboratory set up.
2. To make the students aware of the hazards in Organic Chemistry Laboratory and precautions.
3. To learn how to write a laboratory note book.
4. To learn how to use a hand book and other references.
5. To develop experimental skills required in Organic Chemistry Laboratory.

Course Outcomes:
On successful completion of the course the students will be able to:
CO1: Understand **s**ynthesis, isolation, purification of organic compounds.
CO2: Perform TLC and column chromatography.
CO3: Perform distillation.
CO4: Perform reactions involving inert atmosphere and anhydrous condition.
CO5: Perform industrially important organic reactions.

Unit I: Skill Enhancement Course in Laboratory Techniques in organic Chemistry15 hours
General introduction: Synthesis, isolation, purification and characterization. Safety in the laboratory, Laboratory note book. Handbook: CRC handbook, Merck index, Aldrich catalogue. Glassware: Joints, adapters, round bottom flask, columns and condensers, greasing of joints, cleaning and drying of glassware. Drying agents: Drying agents and using a drying agent. Handling of solid and liquid products. Recrystallization: Theory and practice, practice of solvent extraction and washing. Distillation: Clamping and distillation setup, boiling chip, steam distillation. Heating and cooling methods: Steam bath, Bunsen burner, Heating mantel, oil bath, proportional heaters and stepless controllers. Assembling reaction apparatus for: Refluxing, anhydrous reactions, Inert reaction condition, addition of reagents during a reaction, removal of noxious vapours. Preparation of TLC and staining techniques. Drying of solvents.

PRACTICALS **45 hours**
LIST OF EXPERIMENTS
1. Drying of Acetone. **07 hours**
2. Distillation of Ethyl acetate and Pet ether. **08 hours**
3. Cleaning glass ware and drying **04 hours**
4. Separation of colourless compound by thin layer Chromatography (Anthracene, Acetophenone, Benzophenone **04 hours**

5. Recrystallization of organic compounds having low and high solubility and melting point determination. **04 hours**
6. Extractions involving solvent extraction. **08 hours**
7. Preparation of PDC **02 hours**
8. Oxidation of cinnamyl alcohol using PDC: Synthesis, reaction monitoring, purification by column chromatography and characterization of product**.** **08 hours**

TEXT BOOKS:

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.

REFERENCES BOOKS:

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.

WEB REFERENCES:

1. https://www.linfield.edu/assets/files/chem/Courses/CHEM%20321/2014-labtechniques-chem321-53f4eb52cbe42.pdf
2. https://open.umn.edu/opentextbooks/textbooks/organic-chemistry-laboratory-techniques
3. https://doi.org/10.1021/acs.jchemed.5b00528
4. http://do.chem.uni.wroc.pl/system/files/Organic%20chemistry%20-%20laboratory%20methods_201617_0.pdf

PARVATIBAI CHOWGULE COLLEGE OF ARTS AND SCIENCE (AUTONOMOUS)

POST GRADUATE DEPARTMENT OF CHEMISTRY

ACADEMIC YEAR: 2022-2023

APPROVED M. Sc. ANALYTICAL CHEMISTRY COURSE STRUCTURE TO BE IMPLEMENTED FROM ACADEMIC YEAR: 2023-2024 ONWARDS

SEMESTER I

COURSES	CREDITS	HOURS
Discipline Specific Core (DSC)		
PGMP–CHE-DSC -401: General Inorganic Chemistry	**4**	**60**
PGMP–CHE-DSC -402: General Physical Chemistry	**4**	**60**
PGMP–CHE-DSC -403: Fundamentals of Organic Chemistry	**4**	**60**
PGMP–CHE-DSC -404: Laboratory Course in Physical Chemistry	**2**	**60**
PGMP–CHE-DSC -405: Laboratory Course in Organic Chemistry	**2**	**60**
Discipline Specific Electives (DSE)		
PGMP–CHE-DSE-401: Reaction Mechanisms in Organic Chemistry	**2**	**30**
PGMP–CHE-DSE-402: Topics in Physical Chemistry	**2**	**30**

SEMESTER II

COURSES	CREDITS	HOURS
Discipline Specific Core (DSC)		
PGMP–CHE-DSC -406: Spectroscopy in Chemistry	**4**	**60**
PGMP–CHE-DSC -407: Fundamentals of Chemical Analysis	**4**	**60**
PGMP–CHE-DSC -408: Spectral Methods of Analysis	**4**	**60**
PGMP–CHE-DSC -409: Laboratory Course in Analytical Chemistry	**2**	**60**
PGMP–CHE-DSC -410: Laboratory Course in Inorganic Chemistry	**2**	**60**
Discipline Specific Electives (DSE)		
PGMP–CHE-DSE-403: Topics in Inorganic Chemistry	**2**	**30**
PGMP–CHE-DSE-404: Diffraction Methods	**2**	**30**

SEMESTER III AND SEMESTER IV

Courses	PG Semester III	PG Semester IV
Discipline Specific Course (DSC)		
Discipline Specific Electives (DSE)	8	
Generic Electives (GE)	4	
Research Specific Electives (RSE)	8	4
Discipline Specific Dissertation (DSD)/Internship (I)		16
Total	**20**	**20**

PARVATIBAI CHOWGULE COLLEGE OF ARTS AND SCIENCE (AUTONOMOUS)

POST GRADUATE DEPARTMENT OF CHEMISTRY

ACADEMIC YEAR: 2022-2023

BoS APPROVED SYLLABI TO BE IMPLEMENTED FROM ACADEMIC YEAR: 2023-2024

SEMESTER I AND SEMESTER II (PG)

SEMESTER I

Course Code: PGMP–CHE-DSC-401
Course Title: General Inorganic Chemistry
Credits: 4
Duration: 60 Hours
Maximum Marks: 100

Course Objectives:

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

Course Outcomes:

On successful completion of the course, the student will be able to:
CO1: Identify different complexes and symmetry elements
CO2: Understand the importance of elements in biological systems
CO3: Understand molecular orbital theory for various molecules
CO4: Predict geometry of various molecules

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

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

UNIT II: Molecular Symmetry and Solid State Chemistry **15 Hours**

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

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

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

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

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

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

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

TEXT BOOK:

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

REFERENCE BOOKS:

1. Principles of Solid State Chemistry, H. V. Keer; New Age International Ltd, NewDelhi
2. Inorganic Chemistry: Principles of Structure and Reactivity, J. E. Huheey, E. A. Kiter;4th Edition, Addison-Wesley Publishing House
3. Advanced Inorganic Chemistry, F. A. Cotton and G. Wilkinson; 6th Edition, Wiley Eastern, New Delhi
4. Chemical Applications of Group Theory, 2nd Edn-F. A. Cotton, Wiley Eastern Ltd.
5. Symmetry and Spectroscopy of Molecules–K. Veera Reddy, New Age International, (2011).
6. Group Theory in Chemistry–M. S. Gopinathanan and V. Ramakrishnan, Vishal Publishing Co. (2007)
7. Nature of Chemical Bond, L. Pauling; 3rd Edition, Cornell University Press
8. Solid State Chemistry, D. K. Chakrabarty; 2nd Edition, New Age Publishers
9. Coordination Chemistry, D. Banerjea, Tata McGraw-Hill, New Delhi
10. Concise Inorganic Chemistry, J. D. Lee; 5th Edition, Chapman and Hall
11. Solid State Chemistry and Its Applications, A. R. West; John Wiley and Sons,Singapore
12. Basic Inorganic Chemistry, F. A. Cotton and G. Wilkinson; 3rd Edition, John Wileyand Sons, Singapore.

WEB REFERENCES:

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

Course Code: PGMP–CHE-DSC-402
Course Title: General Physical Chemistry
Credits: 4
Duration: 60 Hours

Maximum Marks: 100

Course Objectives:

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

Course Outcomes:

On successful completion of the course, the student will be able to:CO1: Apply the knowledge of thermodynamics

CO1: Propose the mechanism of different reactions taking place in the environmentCO3: Apply the knowledge of quantum chemistry to conjugated molecules

CO2: Apply the basic principle of miscibility of liquids

UNIT I: Quantum Chemistry **15 Hours**

Historical development of quantum theory, principle of quantum mechanics, wave particle duality, uncertainty principles; operators, functions, Eigen value equations; Schrodinger equation, application to simple system viz. free particle, particle in one dimensional, two dimensional and three dimensional box (quantization, separation of variables, degenerate wave functions); Hydrogen like atoms, Schrodinger equation and its solutions; atomic orbital wave function and interpretation; Hückel MO theory, secular equations, secular determinant, delocalization energy, charge density, pi-bond order, free valence, applications to C_2H_4,C_3H_5(radical), C_4H_6, C_4H_4, C_6H_6, C_6H_8.

UNIT II: Thermodynamics **15 Hours**

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

UNIT III: Chemical Kinetics **15 Hours**

General introduction to various types of order of reaction including fractional order; comparative study of transition state and collision state theory (derivation not required); Eyring equation; free radical reactions, complex reactions like decomposition of acetaldehydeand ozone; reaction between H_2 and Br_2; homogeneous, heterogeneous and acid-base catalysis; elementary enzyme reactions; autocatalysis and oscillatory reaction.

UNIT IV: Electrochemistry and Phase equilibria **15 Hours**

EMF series, decomposition potential and overvoltage, electrogravimetry, basic principles, completeness in deposition; separation with controlled potentials; constant current electrolysis; composition of electrolyte; potential buffers; physical characteristics of metal deposits; electroplating and electro less plating; electro synthesis; potentiostatic and dynamic related numerical problems; Phase rule- discussion of two component systems forming solid solutions with and without maximum

or minimum in freezing point curve; systems with partially miscible solid phases; three component systems- graphical representation; three component liquid systems with one pair of partially miscible liquids, influence of temperature; systems with two pairs and three pairs of partially miscible liquids; the role of added salts.

NOTE: Numerical to be solved in possible units

TEXT BOOKS:

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

REFERENCE BOOKS:

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

WEB REFERENCES:

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

Course Code: PGMP–CHE-DSC-403
Course Title: Fundamentals of Organic Chemistry
Credits: 4
Duration: 60 Hours
Maximum Marks: 100

Course Objectives:

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

Course Outcomes:

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

CO1: Identify the presence or absence of aromaticity in organic compoundsCO2: Understand and apply various concepts in stereo chemistry

CO3: Propose plausible mechanism of organic reactionsCO4: State various addition and elimination reactions

UNIT I: Stereochemistry **15 Hours**

Configurational nomenclature: *R* and *S*; D- and L- ; *E* and *Z*; *cis* and *trans*; *syn* and *anti* nomenclature; chirality in molecules with two and more chiral centres; conformational analysis of open chain compounds; *erythro* and *threo* nomenclature; structure, conformation and stereochemistry of

monocyclic cycloalkanes (cyclopropane, cyclobutane, cyclopentane, cyclohexane, cycloheptane and cyclooctane) with simple substituents; topicity and prostereoisomerism- topicity of ligands and faces; homotopic, enantiotopic and diastereotopicligands and faces; chemoselective, regioselective and stereoselective reactions;
stereochemistry of *cis*- and *trans*-decalins; conformation and reactivity of cyclohexane, substituted cyclohexanes 'stereochemistry of cyclohexene and cyclohexanone' 2-alkyl and 3- alkyl ketone effect; introduction to stereochemistry of compounds containing N, S and P.

UNIT II: Molecular orbitals, Delocalised chemical bonding, Structure and Reactivity 15 Hours
Molecular orbitals of simple acyclic and monocyclic systems, qualitative description; frontierorbitals; importance of FMOs in organic reactions; conjugation, cross conjugation, resonance,hyper conjugation and tautomerism; alternant and non-alternant hydrocarbons; aromaticity in benzenoid and non-benzenoid compounds; Huckel's rule; annulenes, aromatic, non-aromatic and antiaromatic compounds; Acidity and basicity- different concepts, HSAB concept and factors affecting it; effect of structure and medium on acid and base strength; concept ofsuper acids and super bases; electrophilicity and nucleophilicity, ambident nucleophiles and electrophiles, concepts and examples; tautomerism-concept, tautomeric equilibrium, relation with isomerism; types of tautomerism including ring, chain tautomerism and valence tautomerism; proto tropic shift in different systems.

UNIT III: Reaction Mechanism 15 Hours
Generation, structure, stability and reactivity of carbocations, carbanions, free radicals, carbenes and nitrenes; types of- reactions, mechanisms; thermodynamic and kinetic- requirements, control; the Hammond postulate and principle of microscopic reversibility; methods for determining reaction mechanisms like identification of products; determinationof the presence of intermediates (isolation, detection, trapping and addition of suspected intermediate); isotopic labeling; stereochemical evidence; kinetic evidence and isotope effect (sufficient reactions to exemplify each method be studied).

UNIT IV: Addition to carbon-carbon multiple bonds and elimination reactions15 Hours
Mechanism and stereochemistry of addition reactions involving electrophiles, nucleophiles and free radicals; addition of HCl, HBr, HI, HOH, R-OH, NH_3, H_2SO_4, and halogen Br_2 to carbon-carbon double and triple bonds in open chain and cyclic compounds; addition of H_2 toC-C multiple bonds; hydroboration-oxidation and oxy mercuration/ demercuration; elimination reaction- the E_2, E_1 and E_{1cb} mechanisms; orientation of the double bond, Saytzeff and Hofmann rule; effects of changes in the substrate, base, leaving group and medium on overall reactivity; comparison between E_1, E_2 and E_{1cb}; elimination verses substitution; mechanism and orientation in pyrolytic syn elimination; various examples involving cyclic and acyclic substrates.

TEXT BOOK:

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

REFERENCE BOOKS:

1. Stereochemistry and Chemistry of Natural Products, I. L. Finar; ELBS, Longmans
2. Stereochemistry, V. M. Potapov, MIR Publishers, Moscow
3. Organic Chemistry, F. A. Carey
4. Organic Chemistry, S.H. Pine; 5th Edition, McGraw-Hill International
5. Advanced Organic Chemistry, F. A. Carey, R. J. Sundberg; Vol I and II, Plenum Press
6. Fundamentals of Organic Reaction Mechanisms, M. Hamis, Carl C. Wamser, John Wiley and Sons

7. Organic Chemistry- A Concise Approach, F. M. Menger, D. J. Goldsmith and L. Mendell
8. Organic Laboratory Techniques; R. J. Fessenden, J. S. Fessenden, Brookes/Cole Publishing Company
9. Stereochemistry of Organic Compounds- Principles and Application, D. Nassipuri, 2nd Edition, Wiley Eastern Limited

10. Mechanism and Structure in Organic Chemistry, E. S. Gould et al.
11. Stereochemistry of Carbon Compounds, E. L. Eliel, Tata MacGraw Hill

WEB REFERENCES:

1. https://www.sciencedirect.com/topics/chemistry/stereochemistry
2. https://www.sciencedirect.com/topics/chemistry/detailed-reaction-mechanisms
3. http://web.chem.ucla.edu/~harding/notes/notes_14D_additionpibonds.pdf
4. http://www.chem.ucalgary.ca/courses/350/Carey5th/Ch05/ch5-4.html

Course Code: PGMP–CHE-DSC-404
Course Title: Laboratory Course in Physical Chemistry
Credits: 2
Duration: 60 Hours
Maximum Marks: 50

Course Objectives:

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

Course Outcomes:

On successful completion of the course, the student will be able to:
CO1: Handle instruments like conductometer, potentiometer and pH meter **CO2:** Understand stoichiometric calculations

EXPERIMENTS:

1. To study the kinetics of hydrolysis of ethyl acetate and to determine: Energy of activation; Entropy of activation and Free energy change
2. To study the kinetics of the reaction between $K_2S_2O_8$ and KI and to determine: Energyof activation; Entropy of activation and Free energy change
3. To determine the order of reaction between potassium $K_2S_2O_8$ and KI by graphical, fractional change and differential methods
4. To determine the degree of hydrolysis and hydrolysis constant of a salt obtained fromweak base and strong acid using conductometer
5. To determine the composition of a mixture of acetic acid, monochloroacetic acid and hydrochloric acid by conductometric titration
6. To determine the equivalence point from derivative plot and determine thedissociation constants of a dibasic, malonic acid
7. To determine the dissociation constants from the derivative plot and the of a tribasic, phosphoric acid
8. To determine the formal redox potential from the derivative plot of Fe^{2+} / Fe^{3+} andCe^{3+} / Ce^{4+} system by potentiometric method
9. To study three component system of $C_6H_5CH_3$; C_2H_5OH and H_2O and obtain tie line
10. To study three component system of CH_3COOH; $CHCl_3$ and H_2O and obtain tie line
11. To determine the molecular weight of high molecular weight polymer (Polystyrene)by viscosity measurement
12. To determine CMC of soap by conductometric measurements
13. To determine the surface tension of liquid at different temperatures and hence thecritical

temperature of the liquid

14. To determine: i. the phase of naphthalene and diphenyl system ii. Freezing pointdiagram of *o*- nitro phenol and *p* - toluidine
15. To determine the composition of copper and iron (III) by photometric titration using disodium salt of EDTA

REFERENCE BOOKS:

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

Course Code: PGMP–CHE-DSC-405
Course Title: Laboratory Course in Organic Chemistry
Credits: 2
Duration: 60 Hours
Maximum Marks: 50

Course Objectives:

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

Course Outcomes:

On successful completion of the course, the student will be able to:
CO1: Gain the understanding of stoichiometric requirements during organic syntheses CO2: Understand safe and good laboratory practices, handling of laboratory glassware,
chemical reagents and equipment
CO2: Learn common laboratory techniques including reflux, distillation, steam distillation,vacuum distillation and aqueous extraction
CO3: Synthesise the studied organic compounds and purify them

I. Laboratory Techniques

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

II. Organic Synthesis

6. Aliphatic electrophilic substitution: Preparation of iodoform from ethanol and acetone
7. Aromatic electrophilic substitution: Preparation of p-bromoacetanilide
8. Oxidation: i. Benzoic acid from toluene ii. Iso-borneol to camphor using Jones reagent
   iii. Cyclohexanone from cyclohexanol (any one)
9. Reduction: p-nitrophenyl methylcarbinol from p-nitro acetophenone by $NaBH_4$ andpurification of the product through distillation under reduced pressure
10. Bromination of an alcohol using KBr/ $KBrO_3$ (at micro scale level)
11. Aldol condensation: Dibenzal acetone from Benzaldehyde
12. Cannizzaro reaction using 4-chlorobenzaldehyde as substrate
13. Preparation of benzylideneaniline from benzaldehyde
14. Preparation of chalcone from benzaldehyde and acetophenone
15. Esterification: Preparation of Butyl acetate from 1-Butanol

III. Extractions of:

16. Cinnamaldehyde from cinnamon sticks
17. Caffeine from tea bags

REFERENCE BOOKS:

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

Course Code: PGMP–CHE-DSE-401
Course Title: Reaction Mechanisms in Organic Chemistry
Credits: 2
Duration: 30 Hours
Maximum Marks: 50

Course Objectives:

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

Course Outcomes:

On successful completion of the course, the student will be able to:
CO1: Understand organic reactions and be able to propose plausible mechanisms
CO2: Choose appropriate reagents to carry out substitution reactions
CO3: Understand the aromatic electrophilic and nucleophilic substitution reactions
CO4: Understand the aliphatic electrophilic and nucleophilic substitution reactions

UNIT I: Aliphatic Nucleophilic and Electrophilic Substitution 15 Hours

The S_N2, S_N1, mixed S_N1 and S_N2 and SET mechanisms; neighbouring group mechanism, neighbouring participation by π and σ bonds, anchimeric assistance; classical and non classical

carbocations, phenonium ions, norbornyl system, common carbocation rearrangements; the S_Ni mechanism; nucleophilic substitution at an allylic, aliphatic and vinylic carbon; reactivity effects of substrate structure, attacking nucleophiles, leaving group and reaction medium; bimolecular mechanisms- S_E2 and S_Ei; S_E1 mechanism; electrophilic substitution accompanied by double bond shifts; effects of substrates; leaving group and the solvent polarity on the reactivity.

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

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

TEXT BOOK:

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

REFERENCE BOOKS:

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

WEB REFERENCES:

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

Course Code: PGMP–CHE-DSE-402
Course Title: Topics in Physical Chemistry
Credits: 2
Duration: 30 Hours
Maximum Marks: 50

Course Objectives:

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

Course Outcomes:

On successful completion of the course, the student will be able to:
CO1: Understand the magnetic behaviour of materials
CO2: Understand the chemistry of polymers and its applications

CO3: Use photochemistry principle in various areas like lasers, flash photolysis
CO4: Understand the various reaction like photo reduction and photo oxidation

UNIT I: Magneto chemistry **15 Hours**

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

UNIT II: Photochemistry and Polymers **15 Hours**

Absorption and emission radiation of photochemical interest (Einstein's derivation equation, not expected); Frank-Condon principle; laws of photochemistry; Jablonski diagram illustrating fluorescence and phosphorescence; long range and short range energy transfer; flash photolysis and lasers; photo reduction; photo oxidation; photosensitised reactions and photosynthesis; mechanism of chemiluminescence; Polymers- introduction, types; molecular weight distributions; mechanism of free radical; determination of chain length; condensation polymerization; degree of polymerization from kinetic data (derivation not expected); polymers- conformers, thermodynamics; conducting polymers and applications.

TEXT BOOKS:

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

REFERENCE BOOKS:

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

WEB REFERENCES:

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

SEMESTER II

Course Code: PGMP–CHE-DSC-406
Course Title: Spectroscopy in Chemistry
Credits: 4
Duration: 60 Hours
Maximum Marks: 100

Course Objectives:

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

Course outcomes:

On successful completion of the course, the student will be able to:
CO1: Understand the basic concepts in spectroscopy
CO2: Have an understanding on the different spectroscopic methods in chemistry
CO3: Explain the theory of electronic spectroscopy
CO4: Identify and characterize organic compounds using spectroscopic methods

UNIT I: General Introduction and Infrared Spectroscopy **15 Hours**

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

UNIT II: Atomic Absorption, Emission and Electronic Spectroscopy **15 Hours**

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

UNIT III: NMR Spectroscopy **15 Hours**

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

UNIT IV: Mass Spectrometry, various techniques for structure determination **15 Hours** Basic principles; instrumentation; isotope abundances; molecular ion; metastable ions; fragmentation processes; fragmentation associated with simple components like alcohols, amines, alkenes, simple aromatic and aliphatic hydrocarbons, aldehydes, ketones, halogen compounds; structure elucidation using UV-VIS, IR, NMR, mass spectra.

TEXT BOOK:

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

REFERENCE BOOKS:

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

WEB REFERENCES:

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

Course Code: PGMP–CHE-DSC-407
Course Title: Fundamentals of Chemical Analysis
Credits: 4
Duration: 60 Hours
Maximum Marks: 100

Course Objectives:

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

Course Outcomes:

On successful completion of the course, the student will be able to:
CO1: Determine equivalence point of various titrations theoretically
CO2: Make basic quantitative calculations regarding a number of chemical concepts
CO3: Write and understand chemical reactions and stoichiometry
CO4: Master the concepts like chemical equilibria, complexation, solubility, acidity and basicity

UNIT I: Acid-Base Titrations and Conductometric Titrations 15 Hours

Acid-Base titrations- introduction, theory of acid-base indicators; range of indicator; selection of proper indicator; indicator errors; colour change; neutralization curves for strong acid-strong base, weak acid-strong base and weak base-strong acid weak acid-weak base titrations; poly functional acids and bases; titration curves for poly functional acids and bases; titration curves for amphiprotic species; determining the equivalence point; feasibility of acid- base titrations; magnitude of the equilibrium

constant; effect of concentration; typical applications of acid-base titrations.Basic aspects of conductometric titration; types of conductometric titration; advantages and disadvantages of conductometric titration; Introduction; theory; instrumentation; advantages, disadvantages and applications of High frequency titrations.

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

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

UNIT III: Complexometric Titrations **15 Hours**

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

UNIT IV: Gravimetric Analysis **15 Hours**

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

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TEXT BOOKS:

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

REFERENCE BOOKS:

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

WEB REFERENCES:

1. https://chem.libretexts.org/Bookshelves/Analytical_Chemistry/Book%3A_Analytical_Chemistry_2.1_(Harvey)/08%3A_Gravimetric_Methods/8.02%3A_Precipitation_Gravimetry
2. http://www.wiredchemist.com/chemistry/instructional/laboratory-tutorials/gravimetric-analysis/
3. https://chem.libretexts.org/Bookshelves/Ancillary_Materials/Demos%2C_Techniques%2C_and_Experiments/General_Lab_Techniques/Titration/Acid-Base_Titrations

4. https://opentextbc.ca/chemistry/chapter/14-7-acid-base-titrations/
5. https://chem.libretexts.org/Courses/Northeastern_University/09%3A_Titrimetric_Methods/9.5%3A_Precipitation_Titrations
6. https://chem.libretexts.org/Bookshelves/Analytical_Chemistry/Supplemental_Modules_(Analytical_Chemistry)/Quantifying_Nature/Volumetric_Chemical_Analysis_(Shiundu)/14.4%3A_Complex_ion_Equilibria_and_Complexometric_Titrations

Course Code: PGMP–CHE-DSC-408
Course Title: Spectral Methods of Analysis
Credits: 4
Duration: 60 Hours
Maximum Marks: 100

Course Objectives:

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

Course Outcomes:

On successful completion of the course, the student will be able to:
CO1: Understand the basics of emission, diffraction concepts
CO2: Understand the different phenomenon of emission occurring in an organism
CO3: Understand the use of EDAX
CO4: Apply the knowledge of Mossbauer and electron spin spectroscopy in identification of compounds

UNIT I: X-ray Absorption, Diffraction; Neutron Diffraction, Fluorescence Spectroscopy 15 Hours

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

UNIT II: Molecular Fluorescence, Phosphorescence and Chemiluminescence 15 Hours

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

UNIT III: Mossbauer Spectroscopy and Raman Spectroscopy 15 Hours

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

UNIT IV: Microscopy and Electron Spin Resonance Spectroscopy 15 Hours

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

TEXT BOOK:

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

REFERENCE BOOKS:

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

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1. https://serc.carleton.edu/research_education/geochemsheets/techniques/XRD.html
2. https://chem.libretexts.org/Bookshelves/Analytical_Chemistry/Map%3A_Principles_of_Instrumental_Analysis_(Skoog_et_al.)/15%3A_Molecular_Luminescence_Spectrometry
3. https://www.sciencedirect.com/topics/earth-and-planetary-sciences/mossbauer-spectroscopy
4. https://serc.carleton.edu/research_education/geochemsheets/techniques/mossbauer.html
5. https://www.google.com/url?sa=t&source=web&rct=j&url=https://www.nanoscience.com/techniques/atomic-force-microscopy/&ved=2ahUKEwjS-enSyJHnAhWXTX0KHWw1BqoQFjAaegQIAhAB&usg=AOvVaw2ou89f5fahKqUBqZgmLuIc&cshid=1579502355346

Course Code: PGMP–CHE-DSC-409
Course Title: Laboratory Course in Analytical Chemistry
Credits: 2
Duration: 60 Hours
Maximum Marks: 50

Course Objectives:

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

Course Outcomes:

On successful completion of the course, the student will be able to:
CO1: Handle and use various analytical instruments
CO2: Understand the quantitative approach towards various instruments
CO3: Perform qualitative and quantitative analysis
CO4: Develop good laboratory practices, both conceptually and practically

I. UV-visible Spectrophotometer

1. To estimate the amount of D-glucose in given solution using Anthrone reagent
2. To determine the molar absorptivity of KMnO4 and K2Cr2O7 and simultaneously determine the amount of Manganese and Chromium in the solution
3. To estimate the amount of chloride by spectrophotometry using mercury (II) thiocyanate method

II. Flame Spectrophotometer

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

III. Thermal Studies

1. TG-DTA studies on CaC2O4.H2O
2. TG-DTA studies on CuSO4.5H2O
3. TG-DTA studies on Zn EDTA
4. DSC study on pharmaceutical product

IV. Volumetric Method

1. To estimate the amount of Aluminium, Calcium and Magnesium from pharmaceutical sample

V. Ion Exchange Chromatography

1. To separate and estimate the amount of Ni and Co from the given mixture 11. To separate and estimate the amount of chloride and bromide from the given mixture.

VI. Solvent Extraction

1. To extract copper as copper dithiocarbamate (DTC) from CuSO4 using solvent extraction and estimate the amount of copper by spectrophotometric method.
2. To extract copper from CuSO4 as neocuproin complex by solvent extraction and estimation by spectrophotometric method.

VII. Conductometric Titration

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

REFERENCE BOOKS:

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

Course Code: PGMP–CHE-DSC-410
Course Title: Laboratory Course in Inorganic Chemistry
Credits: 2
Duration: 60 Hours
Maximum Marks: 50

Course Objectives:

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

Course Outcomes:

On successful completion of the course, the student will be able to:
CO1: Understand the chemistry of coordination compounds
CO2: To perform quantitative analysis for various coordination compounds
CO3: To quantitatively detect various metal ions from coordination compound
CO4: Interpret XRD spectra

Preparation and Characterisation of following Complexes

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

Quantitative Estimations

6. Estimation of Nitrite by volumetric method
7. Estimation of Calcium from Calcite ore
8. Estimation of Copper in Gun Metal alloy iodometrically
9. Titrate the Zn (II) by $K_4[Fe(CN_6)]$ and verify the composition of the complex $K_3Zn_3[Fe\ (CN)_6]_2$
10. To estimate the amount of Cu/Fe/ Zn from the soil sample by AAS method
11. To determine the amount of copper from copper ammonia complex by Spectrophotometric method.
12. To determine the amount of phosphate from water sample by heteropoly blue method.
13. To determine the amount of total chromium from water sample using 1, 5- diphenyl carbazide by spectrophotometry.
14. Spectrophotometric determination of chloride by methyl orange indicator

REFERENCE BOOKS:

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

Course Code: PGMP–CHE-DSE-403
Course Title: Topic in Inorganic Chemistry
Credits: 2
Duration: 30 Hours
Maximum Marks: 50

Course Objectives:

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

Course Outcomes:

On successful completion of the course, the student will be able to:
CO1: Understand the basics of acid and bases
CO2: Understand the chemistry of: p-block elements, d-block elements, lanthanide andactinides
CO3: Have an idea about the magnetic properties of elements from transition elements
CO4: Understand the importance of f- block elements

UNIT I: Main group elements and their selected compounds 15 Hours

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

UNIT II: Chemistry of transition and inner transition elements 15 Hours

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

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

Bronsted acidity, its periodic trends; Lewis acidity, classification of Lewis acids and bases; heterogeneous acid-base reactions.

TEXT BOOK:

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

REFERENCE BOOKS:

1. Inorganic Chemistry: Principles of Structure and Reactivity, J. E. Huheey, E. A. Kiter; 4thEdition, Addison-Wesley Publishing House
2. Chemistry of the Elements, N. N. Greenwood and A. Earn shaw; Pergamon Press, Exetr,Great

Britain
3. Advanced Inorganic Chemistry, F. A. Cotton, G. Wilkinson, Hurillo and Bochmann, 6th Edition, Wiley Inter science
4. Concise Inorganic Chemistry, J. D. Lee, 5th Edition, Chapman and Hall
5. Basic Inorganic Chemistry, F. A. Cotton and G. Wilkinson, Paul L. Gaus, 3rd Edition, JohnWiley and Sons

WEB REFERENCES:

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

Course Code: PGMP–CHE-DSE-404
Course Title: Diffraction Methods
Credits: 2
Maximum Marks: 50
Duration: 30 Hours

Course Objectives:

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

Course Outcomes:

On successful completion of the course, the student will be able to:
CO1: Interpret the XRD spectra
CO2: Understand the working of XRD
CO3: Handle the software like origin used in determination of crystal structure determination
CO4: Use Microsoft Excel to get X-ray analysis.

UNIT I: X-ray diffraction and Information from X-ray analysis 15 Hours

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

UNIT II: Problem solving through diffraction methods 15 Hours

Introduction to spreadsheet based software; Microsoft Excel; development of spreadsheets for- some simple test cases like Gaussian curve (study of effect of standard deviation and centre of Gaussian),

plotting of trigonometric functions like sin, cos and their linear combinations (Fourier synthesis for crystal structure determination); precise lattice parameter measurements; crystal structure determination- cubic; FCC, BCC and Hexagonal.

TEXT BOOK:

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

REFERENCE BOOKS:

1. X-ray diffraction: A practical Approach, C. Suryanarayana and M. Grant, Norton PlenumPress, New York
2. Elements of X- ray Diffraction, B. D. Cullity; Addison Wesley

WEB REFERENCES:

1. https://www.originlab.com/Origin
2. https://link.springer.com/chapter/10.1007/978-1-4614-3954-7_12
3. https://epdf.pub/queue/powder-diffraction-theory-and-practice.html

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SEMESTER III

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

Course Objectives:

1. Will 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. Attain practical skills in some classical and instrumental techniques.
3. Will gain knowledge about the chemistry of aromatic compounds.
4. Will write the mechanisms involved in electrophilic aromatic substitution reactions.
5. Will learn the chemistry of alcohols and diols.
6. Will comprehend the chemistry of 3d transition metals and compare them with their 4d and 5d analogues.
7. Will have an understanding of ionic solids in terms of their structure, ionic radii, packing efficiency, coordination number and their defects.

Course Outcomes:

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

CO1: Illustrate and apply the first law of thermodynamics and understand the concept of properties of liquids.

CO2: Interpret the Gibb's phase rule and pressure temperature diagrams in unary and binary systems.

CO3: Utilize the concept of aromaticity and apply the theoretical knowledge to write the synthesis of aromatic compounds and alcohols.

CO4: Identify given unknown organic compounds (liquids) by carrying out various chemical tests and synthesize some organic derivatives.

CO5: Explain the trends in periodic properties of transition elements with respect to their ionic radii, oxidation state, spectral properties and magnetic properties.

CO6: Describe crystalline solids in terms of their structure, ionic radii and coordination and explain the defects in their crystal structures.

SECTION- I (PHYSICAL CHEMISTRY)

Unit 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).

Unit 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)

Unit III: Arenes and Aromaticity **08 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 and ortho/para ratio, side chain reactions of benzene derivatives, Birch reduction.

Unit IV: 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, ketones, esters, nitriles and epoxides), reactions of alcohols- oxidation reactions using chromic acid, $KMnO_4$, PCC and PDC (structures of PCC and PDC), conversion of alcohols to ethers, Fischer Esterification.

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

SECTION- III (INORGANIC CHEMISTRY)

Unit 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.

Unit 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. **(4 hours)**
2. To investigate the molecular condition of benzoic acid in a mixture of water and toluene. **(4 hours)**
3. To determine the heat of neutralization of strong acid with strong base. **(2 hours)**

ORGANIC CHEMISTRY

1. Purification techniques for organic compounds (Liquids) and determination of physical constant. **(4 hours)**

   Distillation: a. Separation of acetone and toluene
   b. Separation of ethyl acetate and nitrobenzene
2. Organic synthesis: **(6 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 cationsand 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_3^{2-}, CO_3^{2}-, SO_4^{2-}, PO_4^{3-}

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

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.

ADDITIONAL 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.
5. Carey, F. C. and Giuliano, R. M. *Organic Chemistry*, Tata McGraw-Hill India.
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.

WEB REFERENCES:

1. https://www.livescience.com/50881-first-law-thermodynamics.html
2. https://www.thoughtco.com/surface-tension-definition-and-experiments-2699204
3. https://www.chem.uci.edu/~lawm/263%206.pdf
4. http://ion.chem.usu.edu/~sbialkow/Classes/3600/Overheads/Titration/Volumetric.html
5. https://facultystaff.richmond.edu/~rdominey/301/local/Titrimetry_Methods.pdf
6. https://www.khanacademy.org/science/organic-chemistry/aromatic-compounds
7. https://www.khanacademy.org/science/organic-chemistry/alcohols-ethers-epoxides-sulfides
8. https://nptel.ac.in/content/storage2/courses/104101005/downloads/LectureNotes/chapter%2013.pdf
9. https://nptel.ac.in/content/storage2/courses/104101005/downloads/LectureNotes/chapter%2011.pdf

PRACTICAL BOOK:

1. Khosla B. D., Garg V. C., Gulati A., Senior Practical Physical Chemistry, S. Chand and Co., New Delhi
2. Mendham J., Barnes J. D., Denney R. C., Thomas M. J., Sivasankar B., Vogel's Text book of Quantitative Chemical Analysis, Pearson.
3. Furniss, B., Brian, S., Vogel's Textbook of Practical Organic Chemistry, Pearson education.
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. Will 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. Will help to get better understanding about the basics of Physical and Inorganic Chemistry.
3. Will learn important classes of organic compound i.e., alkyl halides, ethers and carbonyl compounds.
4. Will obtain a comprehensive and detail understanding of the properties and compounds of the f-block elements i.e. the lanthanoids and actinoids.
5. Will gain understanding of coordination compounds, their nomenclature and the types of isomerism in coordination compounds.

Course Outcomes:

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

CO1: Apply symmetry rules used in X-ray diffraction studies to various examples.

CO2: Employ the theoretical concept to study solutions and to determine the properties of liquids

CO3: Apply the theoretical knowledge to write the synthesis of alkyl halides, ethers and carbonyl

compounds.

CO4: Identify given unknown organic liquid compounds by carrying out various chemical tests and synthesize some organic derivatives.

CO5: Explain trends in periodic properties of f-block elements and outline the extraction of lanthanoids and actinoids from its ore.

CO6: Name any coordination compound or write the formula based on its name and predict the isomers of a coordination compound.

SECTION- I (PHYSICAL CHEMISTRY)

UNIT 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).

UNIT 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)

UNIT III: Alkyl Halides **04 hours**

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

UNIT IV: Ethers **03 hours**

Properties of ethers; Symmetric and asymmetric ethers; crown ethers; Preparation of ethers: Williamson ether synthesis, alkoxymercuration-demercuration; Reaction of ethers with acids (HX); applications of ethers.

UNIT V: Aldehydes and Ketones **08 hours**

Properties of aldehydes and ketones; Geometry and polarity of the carbonyl group; Preparation of aldehydes: Oxidation of alcohols, reduction of acid chlorides, Ozonolysis of alkene; Preparation of ketones: oxidation of alcohols, Friedel-Crafts acylation, Reaction of acid chloride with organocopper compounds; Reactions of aldehydes and ketones: General mechanism of nucleophilic addition at carbonyl group; Oxidation and reduction of aldehydes and ketones; Reaction with amine derivative (imine formation with mechanism); Cannizaro reaction; Addition of carbanions (Aldol condensation) chlorination and bromination, mechanisms of nucleophilic substitution reactions of alkyl halides, S_N1 and S_N2 reactions with energy profile diagrams.

SECTION- III (INORGANIC CHEMISTRY)

UNIT 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.

UNIT 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. **(3 hours)**
2. To study the effect of surfactant on the surface tension of Toluene. **(3 Hours)**
3. To study the effect of different solutes on the boiling point of liquid. **(2 Hours)**
4. To study the solubility of benzoic acid at room and below room temperature by volumetric method. **(2 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 **(2 hours)**
2. Estimation of Nickel in hexamine nickel (II) chloride by EDTA method **(2 hours)**
3. Preparation of Tetraamine copper (II) sulphate monohydrate **(2 hours)**
4. Gravimetric estimation of Fe as Fe_2O_3 **(2 hours)**
5. Gravimetric estimation of Ni as Ni-DMG **(2 hours)**

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.

ADDITIONAL 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. Fina, r 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.

WEB REFRENCES:

1. https://www.thoughtco.com/surface-tension-definition-and-experiments-2699204
2. https://www.chem.uci.edu/~lawm/263%206.pdf
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
8. https://nptel.ac.in/content/storage2/courses/104101005/downloads/LectureNotes/chapter%2011.pdf
9. https://www.sciencedirect.com/topics/earth-and-planetary-sciences/magnetic-property
10. https://www.toppr.com/guides/chemistry/the-solid-state/imperfections-or-defects-in-a-solid/
11. https://www.quora.com/What-is-fajans-rule-in-chemistry
12. https://chem.libretexts.org/Bookshelves/Inorganic_Chemistry/Supplemental_Modules_(Inorganic_Chemistry)/Crystal_Lattices/Thermodynamics_of_Lattices/Lattice_Energy%3A_The_Born-Haber_cycle
13. https://www.chem.fsu.edu/chemlab/chm1046course/solids.html

PRACTICAL BOOK:

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.

THEORY

Course Code: UG-CHE-MDC3

Course Title: Fundamentals of Chemistry

Credits: 2

Duration: 30 Hours

Maximum Marks: 50

Course Objectives:

1. Will learn fundamentals of Chemistry.
2. Will learn to prepare solutions.
3. Will learn to theory of titrations.
4. Will be able to get a deeper understanding of the theory with practical knowledge.

Course Outcomes:

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

CO1: Understand states of matter

CO2: Calculate density

CO3: State gas laws

CO4: Write chemical formulae and equations

CO5: Prepare solutions

CO6: Perform chemical analysis

UNIT I: Matter **7 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).

UNIT II: Atom **4 hours**

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

Unit III: Chemical Formulas and Equations **8 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, stoichiometry, calculating amounts of reactants and products (numerical expected).

UNIT IV: States of Matter **7 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 (numerical expected).

UNIT V: Acid-base reactions **4 hours**

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

PRACTICALS

Course Code: UG-CHE-MDC3

Course Title: Fundamentals of Chemistry

Credit: 1

Duration: 30 Hours

Maximum Marks: 25

1. Titration of HCl against Na_2CO_3
2. Titration of potassium hydrogen phthalate against NaOH
3. Titration of succinic acid with NaOH
4. Measurement of pH using pH meter (any 2 buffer solutions)
5. Sublimation of any 2 solids
6. Melting point of a solid
7. Boiling point of a liquid
8. Measurement of density
9. Measurement of surface tension
10. Measurement of viscosity
11. Theoretical calculation of molarity, normality, molality and ppm.
12. Dilution of solution from higher concentration to lower concentrations.
13. Standardization of $KMnO_4$ with oxalic acid.
14. Standardization of $Na_2S_2O_3$ with $K_2Cr_2O_7$.
15. Preparation of solutions based on theoretical calculations

*** All the experiments are of 2 hours each.**

TEXT BOOK:

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

ADDITIONAL 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

1. https://sciencenotes.org/states-of-matter/
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-SEC3
Course Title: Basics of Analytical Chemistry
Credits: 2
Duration: 30 Hours
Maximum Marks: 50

Course Objectives:

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

Course Outcomes:

On successful completion of the course, the student will be able to:
CO1: Understand fundamentals of titrimetric analysis
CO2: Interpret titration curves
CO3: Choose indicator for a particular type of acid base titration
CO4: Perform separation of compounds
CO5: Perform qualitative and quantitative analysis

UNIT 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)

UNIT 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.

UNIT 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-SEC3

Course Title: Basics of Analytical Chemistry

Credit: 1

Duration: 30 Hours

Maximum Marks: 25

LIST OF EXPERIMENTS

Experiment:

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

ANALYTICAL CHEMISTRY TEXT BOOK:

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

REFERENCE BOOKS:

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 TEXT BOOK:

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

WEB REFRENCES

1. https://chem.libretexts.org/Bookshelves/Analytical_Chemistry/Analytical_Chemistry_2.1_(Harvey)/09%3A_Titrimetric_Methods/9.01%3A_Overview_of_Titrimetry
2. https://microbenotes.com/paper-chromatography/
3. https://www.embibe.com/exams/solvent-extraction/
4. https://chem.libretexts.org/Bookshelves/Analytical_Chemistry/Instrumental_Analysis_(LibreTexts

)/28%3A_High-Performance_Liquid_Chromatography/28.06%3A_Ion-Exchange_Chromatographyhttps://www.bing.com/search?q=types+of+acid+base+titrations&FORM=QSRE1
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. Will learn principles of Physical Chemistry and its applications in various processes.
2. Will be able to apply the principles of Physical Chemistry to industrial processes.
3. Will be able to get a deeper understanding of the theory with practical knowledge.

Course Outcomes:
On successful completion of the course, the student will be able to:
CO1: Understand Second and Third law of Thermodynamics
CO2: Formulate conditions for maximum yield in industrial processes
CO3: Explain theory of strong and weak electrolytes.
CO4: Explain photochemical processes
CO5: Explain properties of colloids
CO6: Perform instrumental and non-instrumental analysis

UNIT 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).

UNIT 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).

UNIT 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).

UNIT 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).

UNIT 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. **(2 hours)**
2. To verify Ostwald's dilution law by determining the equivalent conductance of a weak mono basic acid at different concentrations. **(2 hours)**
3. To determine the equivalent conductance of a strong electrolyte at several concentrations and hence verify Onsager's equation. **(2 hours)**
4. To determine solubility product of sparingly soluble salt by conductometric method **(2 hours)**
5. To determine hydrolysis constant of sodium acetate by conductometric method. **(2 hours)**
6. To estimate the amount of dibasic acid present in given solution against standard NaOH solution by conductometric method. **(2 hours)**
7. To determine hydrolysis constant of ammonium chloride by conductometric method. **(2 hours)**
8. To estimate the concentration of NH_4Cl salt by titration against NaOH by conductometric method. **(2 hours)**
9. To estimate the concentration of KCl salt by titration against $AgNO_3$ by conductometric method. **(2 hours)**
10. To estimate the concentration of Fe3+ salt by titration against $K_2Cr_2O_7$ by conductometric method. **(2 hours)**
11. To study the solubility of benzoic acid in water at different temperatures and to calculate the heat

of solution. **(2 hours)**

12. To determine the energy of activation for acid catalysed hydrolysis of methyl acetate. **(4 hours)**
13. To estimate the amount of monobasic (HCl) and dibasic acid (Oxalic acid) present in the mixture solution against NaOH by conductometric method. **(2 hours)**
14. To estimate the amount of H_2SO_4, CH_3COOH and $CuSO_4$ present in the mixture against NaOH by conductometric method. **(2 hours)**

TEXT BOOK:

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

ADDITIONAL 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 chemistry of carboxylic acids.
2. To deliver knowledge about chemistry of functional derivatives of carboxylic acids.
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 laboratory.

Course Outcomes:

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

CO1: Apply the chemistry of carboxylic acids.

CO2: Analyze the chemical reactions of functional derivatives of carboxylic acids.

CO3: Apply the chemistry of amines, diazonium salts and nitro compounds.
CO4: Understand the chemistry of cyanides and isocyanides.
CO5: Understand the chemistry of thiols and thioethers.
CO6: Develop practical skill by performing organic chemistry experiments in laboratory.

UNIT I: Carboxylic Acids **10 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.

UNIT II: Functional derivatives of carboxylic acids **10 hours**

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.

UNIT 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.

UNIT 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.

UNIT 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 Ester by Titration method**.** **(02 hours)**
   b) Estimation of Amide by Titration method. **(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 TEXT 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_Diazonium_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. Understand the acid and base concepts with respect to aqueous and non-aqueous solvent systems.
2. Understand the magnetic behavior of metal complexes and determine its magnetic properties.
3. Acquire knowledge about metal-ligand bonding in metal complexes with reference to VBT and CFT and calculate the CFSE for octahedral complexes.
4. Understand the thermodynamic and kinetic aspects of metal complexes that governs their stability.
5. Develop practical skills to carry out separation of metal ions by ion exchange method and analyze them using titrimetry or gravimetry.

Course Outcomes:
On successful completion of the course, the student will be able to:
CO1: Understand and integrate concepts of Acids and Bases and non-aqueous solvents wherever applicable in chemistry.
CO2: Analyze the magnetic properties of transition metal complexes as well as interpret the effect of temperature on magnetic properties.
CO3: Predict the magnetic behavior of metal complexes and calculate the magnetic moment of metal ions.
CO4: Employ the VBT and CFT theories that govern metal-ligand bonding in order to explain the stability of metal complexes.
CO5: Illustrate the crystal field splitting in tetrahedral and octahedral complexes and calculate the crystal field stabilization energy (CFSE).
CO6: Differentiate between thermodynamic stability and kinetic stability and apply it to transition metal complexes.
CO7: Determine the factors that govern the stability and lability of transition metal complexes and predict their reaction mechanism.
CO8: Develop practical skills to separate and estimate the amount of metal ions in solution and determine the stability and instability of complexes using spectrophotometry.

UNIT 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.

UNIT 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.

UNIT 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.

UNIT 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 BaSO4 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 ethylene diamine. **(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)**

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.

ADDITIONAL 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_(Housecroft)/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%20the%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%20coordination%20compound.
9. https://utkaluniversity.ac.in/wp-content/uploads/2022/03/Stability_Const_NDas.pdf

PRACTICAL BOOK:

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. The main objective of this course is to study the Chemistry and data treatment involved in pharmaceutical industries.
2. This course gives blend of chemical and pharmaceutical principles necessary for understanding structure–activity relationships and molecular mechanisms of drug action.
3. Will gain knowledge about the classes of drugs and synthesis of some selected drugs.

Course Outcomes:

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

CO1: Outline the significance of terminologies and regulation in pharmaceutical chemistry.

CO2: Discuss Safety in Pharmaceutical laboratories.

CO3: Handle and treat the statistical data of analysis

CO4: Apply practical knowledge for the synthesis of some pharmaceutical drugs.

CO5: Understand the medicinal chemistry in plants.

UNIT 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.

UNIT 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)

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

TEXT BOOK:

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.

REFERENCES BOOKS:

1. Indian Pharmacopoeia.
2. D. Lednicer, The Organic Chemistry of Drug Synthesis, New Jersey: John-Wiley and Sons, Inc.
3. Gennaro, A. R., Remington: The Science and Practice of Pharmacy, London: Mack Publishing Company.
4. Williams, D. A., Foye, W. O., Lemke, T. A., Foye's Principles of Medicinal Chemistry, Lippincott Williams and Wilkins.

REFERENCES BOOKS:

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

Course Objectives:

1. Understand the dual nature of light and the interaction of electromagnetic radiation with matter.
2. Learn the basic components of a spectroscopic instruments and their function.
3. Understand the principles and instrumentation of UV-Vis spectroscopy and Atomic Spectroscopic methods.
4. Solve numerical problems based on EMR theory and Beer-Lamberts law
5. Operate and carry out analysis on an UV-visible spectrophotometer.

Course Outcomes:

On successful completion of the course, the student will be able to:
CO1: Understand the theory of spectroscopy, electromagnetic radiation and the function of various components of a spectrophotometer.
CO2: Understand the principles and instrumentation of UV-Visible spectroscopy.
CO3: Solve numerical problems based on electromagnetic radiation theory and Beer-Lambert's law.
CO4: Understand the principles, instrumentation and applications of AES, AAS, ICP and Fluorimetry.
CO5: Develop skills to carry out qualitative and quantitative analysis based on absorbance measurements using a UV-visible spectrophotometer

UNIT 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.

UNIT 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)

UNIT 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. To calibrate the UV- Visible spectrophotometer for control of absorbance and limit of stray light.
3. Determination of Mn2+ ion concentration, by periodate method using spectrophotometer.
4. Determination of Fe3+ ion concentration by salicylic acid method using spectrophotometer.
5. To estimate the amount of nitrite in water sample by spectrophotometric method.
6. To determine the amount of K2CrO4 present in given sample by using UV-Visible

spectrophotometer.

7. To estimate the amount of paracetamol in tablet by spectrophotometric method.
8. To estimate the amount of aspirin in the given tablet by spectrophotometric method.
9. To verify the law of additivity of absorbance (KMnO4 and K2Cr2O7) at λmax of K2Cr2O7 and determine molar absorptivity.
10. To determine the phosphate concentration in a soft drink by spectrophotometric method.
11. Spectrophotometric methods for determining the stoichiometry of a complex formed between iron and 1,10- phenanthroline by continuous variation method.
12. Spectrophotometric methods for determining the stoichiometry of a complex formed between iron and 1,10- phenanthroline by mole ratio method.
13. To determine the dissociation constant of methyl red indicator by spectrophotometric method.
14. To determine the amount of Cr (VI) in the given solution as dichromate by least square method spectrophotometrically.
15. To determine the amount of nitrobenzene from the organic sample by spectrophotometric method.

*** All the experiments are of 2 hours each.**

TEXT BOOK:

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

REFERENCE BOOKS:

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. Christian, G. D., Analytical Chemistry, John Wiley, 5th Edition.
4. Ewing, G. W., Instrumental Methods of Chemical Analysis, 5th Edition, Mc-Graw Hill International Edition.
5. 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
5. http://liskeard.cornwall.sch.uk/images/Liskeard-Sixth-Form/Atomic-Absorption-Spectrometry.pdf

SEMESTER II

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 Outcomes:
On successful completion of the course the students will be able to:
CO1: Understand the concepts of diverse purification techniques and laboratory methods.
CO2: Understand the importance of laboratory safety.
CO3: Acquire laboratory skills by performing various purification techniques.

UNIT 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.

UNIT 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) **(4 Hours)**

2. Purification of solids by Sublimation and recording its melting point (any two solids) **(4 Hours)**
3. Purification of solvent by Distillation and recording its boiling point (any two liquids) **(4 Hours)**
4. Separation of a mixture of volatile and non-volatile solvents by Distillation (any two mixture) **(4 Hours)**
5. Separation of a mixture of organic compounds using solvent extraction technique **(8 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) **(2 Hours)**
7. Determination of mixed melting point of benzoic acid and β-naphthol **(4 Hours)**

TEXT BOOK:

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.

REFERENCES BOOKS:

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.

WEB REFERENCES:

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

Annexure B: PG Programmes
Name of the Programme: M. Sc. in Chemistry

COURSE STRUCTURE

SEMESTER III AND IV

COURSES	SEMESTER III	SEMESTER IV
Discipline Specific Electives (DSE)	8	
Generic Electives (GE)	4	
Research Specific Electives (RSE)	8	4
Discipline Specific Dissertation (DSD)/Internship (I)		16
Total	**20**	**20**

SEMESTER III

COURSES	CREDITS	HOURS
Discipline Specific Electives (DSE)		
CHAE-501: Calibrations and Validation	**2**	**30**
CHAE-502: Methods of Analysis	**2**	**30**
CHAE-503: Diffraction Methods	**2**	**30**
CHAE-504: Advanced NMR Spectroscopy	**2**	**30**
CHAE-505: Separation Techniques	**2**	**30**
CHAE-506: Quality Assurance and Quality Control in Analytical Chemistry	**2**	**30**
CHAE-507: Chemometrics	**2**	**30**
CHAE-508: Bio analytical Chemistry	**2**	**30**
Generic Electives (GE)		
CHGE–501: Food chemistry and Nutrition	**2**	**30**
CHGE–502: Environmental Chemistry	**2**	**30**
CHGE-503: Application of Chemistry in Everyday Life	**2**	**30**
Research Specific Electives (RSE)		
CHRE–501: Research Methodology and Academic writing	**4**	**60**
CHRE–502: Experiments in Analytical Chemistry	**4**	**120**
CHRE–503: Experiments on analytical instrumentation	**4**	**120**

SEMESTER IV

COURSES	CREDITS	HOURS
Research Specific Electives (RSE)		
CHRE–504: Synthesis of inorganic materials	**2**	**30**
CHRE–505: Catalysis	**2**	**30**
CHRE-506: Applied organic chemistry	**2**	**30**
CHRE-507: Nanomaterials	**2**	**30**
Discipline Specific Dissertation (DSD)/Internship (I)	**16**	**384**

SEMESTER III

DISCIPLINE SPECIFIC ELECTIVES (DSE)

Course Code: CHAE-501
Course Title: Calibrations and Validation
Credits: 2
Maximum Marks: 50
Duration: 30 Hours

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

Course Outcomes:
On successful completion of the course, the student will be able to:
CO1: Understand the qualification of laboratory equipment as a precondition of reliable analytical testing
CO2: Understand the basic rules of documentation in QA
CO3: Calibrate the instruments of industrial importance
CO4: Have the knowledge of ICH guidelines in method development

UNIT I: Regulations and Qualifications **15 Hours**
Regulations: Regulatory requirements for analytical method validation; validation of analytical methods; complete method validation package, analytical data, protocol, plan, revisions and change controls; International Conference on Harmonization (ICH) Guideline Q2A: Validation of analytical procedures; linearity and range criteria and their role in instrumental method validation; GMP (US), Qualification: Overview of qualification of instruments; installation, operation and performance qualification (IQ, OQ, PQ) of analytical equipments; method validation for UV Visible Spectrophotometer, IR Spectrophotometer, Spectrofluorometer, HPTLC, GC, HPLC; qualitative and quantitative method validation; parameters of validation; statistics in validation; detailed discussion on accuracy and precision role in method validation; protocols and interpretation.

UNIT II: Calibration **15 Hours**
Calibration of analytical balance and pH meter; role of quantification limit and specificity; Limit of Detection (LOD) and Limit of Quantification (LOQ); Robustness and method validation; Ruggedness of chromatographic method; Ruggedness of sample preparation procedure; Calibration verses Qualification verses Validation; Case study for HPLC, UV; calibration of various instruments used for drug analysis like HPTLC, UV-Visible Spectrophotometer, IR Spectrophotometer, Spectro fluorimeter, GC, HPLC.

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

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

WEB REFERENCE:

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

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

Course Objectives:

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

Course Outcomes:

On successful completion of the course, the student will be able to:
CO1: Choose the experimental conditions for the measurements and combine different Thermos-analytical techniques
CO2: Analyze and present the results of the measurements.
CO3: Understand the principles of thermo-analytical techniques and combine different Thermos-analytical techniques
CO4: Apply theoretical knowledge for practical analysis
CO5: Analyze and present the results of the measurements

UNIT I: Thermogravimetric Analysis and Differential Thermal Analysis 15 Hours

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

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

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

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

TEXT BOOK:

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

REFERENCE BOOKS:

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

WEB REFERENCES:

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

Course Code: CHAE-503
Course Title: Diffraction Methods
Credits: 2
Maximum Marks: 50
Duration: 30 Hours

Course Objectives:

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

Course Outcomes:

On successful completion of the course, the student will be able to:
CO1: Understand the working of XRD
CO2: Interpret the XRD spectra
CO3: Handle the software like origin used in determination of crystal structure
CO4: Use Microsoft Excel to get X-ray analysis

UNIT I: X-ray diffraction analysis **15 Hours**

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

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

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

TEXT BOOK:

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

REFERENCE BOOKS:

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

WEB REFERENCES:

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

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

Course Objectives:

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

Course Outcomes:

On successful completion of the course, the student will be able to:
CO1: Define the basic principles of NMR spectroscopy.
CO2: List the fundamental components and processes involved in NMR experiments.
CO4: Summarize the differences between 1D and 2D NMR experiments.
CO3: Interpret NMR spectra to extract information about chemical shifts, coupling constants, and peak integration.
CO4: Evaluate the appropriateness of NMR spectroscopy as a tool for solving particular chemical problems.
CO5: Innovate in the integration of NMR with other analytical techniques to solve interdisciplinary research problems.

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

Nuclear magnetic resonance- theory, quantum description; classical description of NMR; types of NMR spectra; applications of proton NMR in qualitative and quantitative analysis (in general); CW and PFT techniques; Types of CMR spectra-undecoupled- proton decoupled-off-resonance decoupled (SFORD)-selectivity decoupled and gated ^{13}CJ) and heteronuclear (^{13}C-^{1}H, ^{13}C-^{2}H) J couplings, nuclear overhauser effect, ATP (attached proton test), DEPT.
^{19}F and ^{31}P NMR Spectroscopy: Introduction, Fluorine coupling, coupling between Fluorine and Carbon, single fluorine and the CF_2 group substituents- alkyl fluorides, carbonyl compounds, phosphorus compounds, multifluoroalkenes; Trifluoromethyl group. Origin of the ^{31}P NMR spectra, coupling with hydrogen, carbon, metals, transition metal complexes containing phosphorus.

UNIT II: 2D-NMR Spectroscopy **10 Hours**

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

TEXT BOOK:

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

REFERENCE BOOKS:

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

WEB REFERENCES:

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

Course code: CHAE-501
Course Title: Separation Techniques
Credits: 2
Maximum marks: 50
Duration: 30

Course Objectives:

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

Course Outcomes:

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

CO1: Describe the methods of separation and their applications
CO2: Acquire technical knowledge, practical experience with respect to chromatography
CO3: Understand various chromatographic techniques employed
CO4: Learn applications of various processes for separation and purification of compounds

UNIT I: Chromatographic Techniques **15 Hours**

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

UNIT II: Miscellaneous Separation Techniques and Hyphenated Techniques 15 Hours

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

TEXT BOOK:

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

REFERENCE BOOKS:

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

WEB REFERENCES:

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

Course Code: CHAE-506
Course Title: Quality Assurance and Quality Control in Analytical Chemistry
Credits: 2
Maximum Marks: 50
Duration: 30 Hours

Course Objectives:

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

Course Outcomes:

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

CO1: Explain the basics of quality assurance and quality control

CO2: Know the types of packaging and regulatory aspects in food and pharmaceutical industries

CO3: Handle reagents and chemicals appropriately

CO4: Evaluate the quality assurance data

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

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

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

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

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

TEXT BOOK:

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

REFERENCE BOOKS:

1. Quality Assurance in Analytical Chemistry, W. Funk, V. Dammann, G. Donnevert;VCH Weinheim
2. Principles and Practice of Analytical Chemistry, F. W. Fifield, D. Kealy; BackwellScience Ltd. London
3. Vogel's Textbook of Quantitative Chemical Analysis; 6th Edition
4. Modern Analytical Chemistry, D. Harvey; McGraw-Hill Education
5. Analytical Chemistry, G. D. Christian; 5th Edition, John Wiley and Sons, NY
6. Instrumental Methods of Chemical Analysis, H. Kaur; Pragati Prakashan
7. Pharmacopeia of India, Volume I and II
8. Quality in the Analytical Chemistry Laboratory, E. Prichard; John Wiley
9. Principals of Package Development, Gribbinetal
10. Modern Packaging Encyclopaedia and Planning Guide- MacqraWreyco
11. Government of India Publications of Food Drug Cosmetic Acts and Rules

WEB REFERENCES:

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

Course Code: CHAE - 507
Course Title: Chemometrics

Credits: 2
Maximum Marks: 50
Duration: 30 Hours

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

Course Outcomes:
On successful completion of the course, the student will be able to:
CO1: Handle computers and data sheet
CO2: Handle statistical arrangements of data

UNIT I: Introduction to Data and Statistics **15 Hours**
Introduction; univariate statistics review; probability; variance and sampling, linear regression and calibration data, digitization, and the Nyquist Theorem, detection limit, S/N ratio, and signal filtering; review of linear algebra: scalars, vectors, and matrices, matrix notation and matrix operations orthogonality, analysis of variance (ANOVA)- 1 variable, analysis of variance- 2 variables; introduction to Matlab^{TM}: programmed, basics and layout, matrix operations in Matlab^{TM} the diary command and examples, ANOVA in Matlab^{TM} experimental design: factorial design, simple versus complex models, factorial design in Matlab^{TM}; half-factorial design.

UNIT II: Multivariate Methods **15 Hours**
Introduction to various multivariate methods; the six habits of a chemometrician; principle component analysis (PCA); data pretreatment- mean centering and normalization; PCA in Matlab^{TM}.
Classical least squares (CLS), CLS in Matlab^{TM}, inverse least squares (ILS).
Multiple linear regression (MLR); principle component regression (PCR); partial least squares, examples in Matlab^{TM}; summary of multivariate methods; pattern recognition- supervised versus unsupervised pattern recognition, K nearest neighbours (KNN); soft independent modelling for chemical analysis (SIMCA), summary of pattern recognition.

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

REFERENCE BOOK:
1. The computer program MATLAB^{TM} will be required for some portions of the course

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

Course Code: CHAE-508
Course Title: Bio analytical Chemistry
Credits: 2
Maximum Marks: 50
Duration: 30 Hours

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

Course Outcome:

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

CO1: Have valuable training inforensic science and biotechnology

CO2: Understand antibody-antigen interactions

CO3: Understand various bio analytical techniques used for medical diagnosis and research

CO4: Understand the working of various biosensors used to detect biological compounds

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

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

UNIT II: Biosensors and Bio Analytical Approaches 15 Hours

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

TEXT BOOK:

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

REFERENCE BOOK:

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

WEB REFERENCES:

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

GENERIC ELECTIVES (GE)

Course code: CHGE-501

Course Title: Food chemistry and Nutrition

Credits: 2

Maximum marks: 50
Duration: 30 Hours

Course Objectives:
The Course will enable the students to

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

Course Outcome:
On successful completion of the course, the student will be able to:
CO1: Identify the major classifications of dietary fibers, lipids, water-soluble and fat-soluble vitamins, major minerals, and trace minerals.
CO2: Explain the functions of macro and micro nutrients in the human body, specifically in digestion, absorption, and overall health.
CO3: Describe the nutritional significance of these nutrients and their roles in changing trends in dietary intake.
CO4: Interpret recommended dietary allowances and their importance in maintaining a balanced diet.
CO5: Apply knowledge of intentional additives, incidental additives, natural colors, flavoring agents, and their roles in food products.
CO7: Analyze the hazards in the food supply chain and identify potential sources of contamination.

UNIT I: Macro and Micro Nutrients **15 hours**
Introduction to macro and micro nutrients- Carbohydrates - Introduction, classification and dietary fibers; Proteins introduction, classification; Fats- Introduction and types of lipids; Vitamins- water soluble and fat-soluble vitamins; Minerals - Major minerals and trace minerals and their functions; Water and its functions. Role in human body-digestion and absorption. Nutritional significance and changing trends in dietary intake. Recommended dietary allowances.

UNIT II: Additives and Contaminants **15 hours**
Intentional additives, Incidental additives or contaminants, Natural colors and flavouring agents, Toxic trace elements, Metal uptake in canned foods, Plant protective agents- Pesticides; monitoring pesticides in food, Veterinary drugs, Persistent environmental chemicals, Naturally occurring toxicants; control and measures, Hazard identification in the food supply chain, Organic and inorganic contaminants in food- metals and metalloids, nitrates, hydrocarbons, Chemical migration from food packaging.

TEXT BOOK:

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

REFERENCE BOOKS:

1. Annual Reviews of Nutrition. Annual Review Inc, California, USA.
2. Shils, M.E.; Olson, J.; Shike, M. and Roos, C. (1998): Modern Nutrition in Health and Disease, 9th edition. Williams and Williams. A Beverly Co. London.
3. Bodwell, C.E. and Erdman, J.W. (1988) Nutrient Interactions. Marcel Dekker Inc. New York
4. World Reviews of Nutrition and Dietetics.
5. WHO Technical Report Series.

6. Indian Council of Medical Research. Recommended Dietary Intakes for Indians - Latest Recommendations.
7. Indian Council of Medical Research. Nutritive Value of Indian Foods - Latest Publication.
8. Berdanier, C.D. and Haargrove, J.L. (ed) (1996): Nutrients and Gene Expression: Clinical Aspects. Boca Raton, FL CRC Press.
9. Baeurle, P.A. (ed) (1994) Inducible Gene Expression. Part I: Environmental Stresses and Nutrients. Boston: Birkhauser.
10. Chandra, R.K. (ed) (1992): Nutrition and Immunology. ARTS Biomedical. St. John's Newfoundland.
11. International Life Sciences Institute Present Knowledge in Nutrition – latest edition

JOURNALS:

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

Course Code: CHGE-502
Course Title: Environmental Chemistry
Credits: 2
Maximum marks: 50
Duration: 30 Hours

Course Objectives:

The Course will enable the students to

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

Course Outcome:

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

CO1: Recognize the methods and technologies used to monitor and control air pollution, including those for SO2, NOx, CO, and SPM.

CO2: Identify various types of pollution, including air, water, soil, noise pollution etc.

CO4: Explain the causes and sources of different types of pollution.

CO5: Summarize the impact of pollution on ecosystems, human health, and the environment.

UNIT I: Air Pollution, Water Pollution and Soil Pollution 15 Hours

Air pollution- natural and anthropogenic sources of pollution, primary and secondary pollutants, transport and diffusion of pollutants, Methods of monitoring and control of air pollution, SO_2, NOx, CO, SPM.

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

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

UNIT II: Noise Pollution, Radioactive Pollution and Microplastics 15 Hours

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

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

Microplastic: occurrence, fate and waste management

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

TEXTBOOK:

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

REFERENCE BOOK:

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

REFERENCE LINK:

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

Course code: CHRE-503
Course Title: Application of Chemistry in Everyday Life
Credits: 2
Maximum marks: 50
Duration: 30 Hours

Course Objective:

The course will enable the students to

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

5. Examine chemical processes in household products and their impact on health and the environment.

Course Outcomes

On successful completion of the course students will be able to

CO1: Recall common chemical concepts and terminology used in daily life.

CO2: Recognize the chemical properties of everyday substances.

CO3: Comprehend the principles of chemical reactions and their relevance to daily experiences.

CO4: Explain how chemical processes affect various aspects of daily life, such as health, environment, and technology.

CO5: Analyze the impact of chemical processes on society, the environment, and industry.

CO6: Evaluate the safety and ethical considerations associated with the use of chemicals in everyday life.

UNIT I: Applications, Uses and Impact of Chemistry 15 Hours

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

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

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

UNIT II: Impact Of Chemistry in Other Fields 15 Hours

Chemistry & Art – History of colour, Use of colour to decorate the body and surroundings. Relationship between light and colour. Electromagnetic Spectrum, Cause of colour in objects, Properties of Light. The Nature and behaviour of light, mixing colours: Light vs. Pigments, Colorants: Pigments and Dyes. Chemistry of art conservation and restoration, Fakes and Forgeries in art.

Chemistry and Sports - Chemistry of sports materials, Use of performing enhancing drugs in sports

Gobar gas: Production, feasibility and importance of Biogas with special reference to Rural India; Fertilizers: Definition, classification - Urea, NPK and Super phosphates, uses and hazards.

TEXTBOOK:

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

REFERENCE BOOKS:

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

WEB REFERENCES

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

RESEARCH SPECIFIC ELECTIVES (RSE)

Course Code: CHRE-501
Course Title: Research Methodology and Academic writing
Credit: 4
Maximum marks: 100
Duration: 60 Hours

Course Objectives:
The Course will enable the students to

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

Course Outcomes:
Upon successful completion of this course students will
CO1: Demonstrate knowledge of research objectives, types, and approaches through the analysis of research significance and the application of criteria for quality research.
CO2: Create a compelling theory for a given research challenge.
CO3: Conduct research projects in accordance with research ethics and without engaging in any wrong doing.
CO4: Evaluate and critique academic writing to ensure adherence to established rules and standards.
CO5: Differentiate between various research writing styles and choose the most suitable for specific contexts.
CO6: Analyze the structure of paragraphs in academic writing and construct coherent and organized paragraphs.
CO7: Assess the credibility of sources, including journals and digital content, for research purposes.
CO8: Apply proper referencing and citation techniques throughout the writing process.

UNIT I: Understanding Research **15 Hours**
Research methodology – introduction, objectives, types of research, research approaches, significance of research, research process, criteria of a good research
Defining a research problem- selecting the problem, necessity of defining the problem, technique involved in defining the problem
Research design – meaning, need of research design, features of a good design, concepts related to research design, types
Design sample surveys- Introduction, sample design, sampling and non- sampling errors, types of sampling designs.

UNIT II: Tools and Techniques of Research Writing **15 Hours**
Measurement and scaling, quantitative and qualitative data, classification of measurement scales, goodness of measurement scales, sources of errors in measurement, techniques of developing measurement tools, scaling – classification and techniques
Data collection – introduction, experiments in surveys, collection of primary and secondary data, selection of appropriate methods for data collection, case study method

Data preparation process – questionnaire checking, editing, coding, classification, tabulation, graphical representation, data cleaning, data adjusting, problems in preparation process, types of analysis Interpretation and report writing- techniques, different steps in writing report, layout of research report, types of report, oral presentation, precautions for writing research reports

UNIT III: Introduction to Scientific Writing and Literature Review 15 Hours

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

UNIT IV: Thesis and Model Writing 15 Hours

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

TEXT BOOK:

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

REFERENCE BOOKS:

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

WEB REFERENCES:

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

Course Code: CHRE-502
Course Title: Experiments in Analytical Chemistry
Credits: 4

Duration: 120 Hours
Maximum Marks: 100

Course Objectives:

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

Course Outcomes:

On successful completion of the course, the student will be able to:
CO1: Understand the quantitative approach towards various instruments
CO2: Identify appropriate method to carry out quantitative analysis for desired samples
CO3: Perform titrimetric and spectrophotometric analysis
CO4: Develop good laboratory practices, both conceptually and practically

UNIT I: Analysis of Pharmaceutical Tablets / Samples

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

UNIT II: Ion Exchange Chromatography and Solvent Extraction Method

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

UNIT III: Electrochemical Method

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

UNIT IV: Simple Chromatography

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

UNIT V: Spectrophotometric Method

1. To determine pka value of methyl red indicator at room temperature

2. To determine the indicator constant and isobestic point of an indicator
3. To determine the stoichiometry and stability constant of ferric salicylic acid complex by Job`s method and mole ratio method
4. To determine the amount of each p-nitrophenol and m-nitrophenol from the mixturebyspectrophotometric titration using standard NaOH solution at λ_{max}= 280 nm
5. To record the UV absorption spectrum of acetone in n-hexane and identify the varioustransitions
6. To estimate the amount of aspirin and caffeine from APC tablet by UV-Visible spectrophotometry
7. To study the iodination of acetone by spectrophotometric method
8. To estimate the amount of arsenic in dried shrimp by UV-Visible spectrophotometry using molybdenum blue method.

UNIT VI: Interpretation Exercise

1. X-ray powder diffraction analysis of cubic compound:
    a. Determination of Lattice constants and crystallite Size
    b. Density
2. Interpretation of Mossbauer spectrum with reference to determination of: isomer shift;quadruple splitting; internal magnetic field; general comment
3. Interpretation of IR spectrum with reference to stretching vibration of: C=N; C=O; N-O;M-O
4. Interpretation of NMR spectrum with reference to calculation of chemical shifts and general comments
5. Interpretation of absorption spectra for:
    a. Verification of the position of ligands in spectrochemical series
    b. Calculation of spectral splitting parameters
    c. Determination of geometry of a given compound (octahedral, tetrahedral, squareplanar)
6. Statistical revaluation of spectrophotometric data

REFERENCE BOOKS:

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

VIDEO REFERENCES:

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

Course Code: CHRE-503
Course Title: Experiments on analytical instrumentation
Credits: 4
Duration: 120 Hours
Maximum Marks: 100

Course Objectives:

1. familiarize students with principles, components, and operation of spectroscopy,

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

Course Outcomes:
On successful completion of the course, the student will be able to:
CO1: Demonstrate proficiency in operating and maintaining analytical instruments
CO2: Analyze various types of chemical samples, demonstrating proper techniques
CO3: Interpret data obtained from instruments and use appropriate software for data processing and presentation.
CO4: Develop research skills including ability to conduct literature reviews, plan experiments and draw conclusions from data.
CO5: Exhibit awareness of laboratory safety practices and follow protocols while working with hazardous chemicals.

UNIT I: IR Spectroscopy

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

UNIT II: Potentiometry

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

UNIT III: Gas Chromatography

1. To develop and validate the analytical method of any one drug using GC
2. Synthesis of high boiling organic compound by derivatization and analyses by GC
3. Separation of alcoholic mixtures
4. Determination of alcoholic content in: i. Beer ii. Wine iii. Local drinks
5. Gas chromatographic analysis for: i. automobile exhaust ii. Cigarette smoke
6. Analysis of preservatives from solid and liquid samples (extraction, sample preparation andanalysis)
7. Internal normalization for the quantitative analysis of solvents using GC.
8. Determination of trace amounts of metals as their chelate complexes using GC.
9. Gas chromatographic analysis for a mixture of gases like O_2, N_2 and CO_2

UNIT IV: High Performance Liquid Chromatography

1. Determination of caffeine content in: i. Tea ii. Coffee iii. Soft drinks iv. Chocolates
2. Purity of the solvents using HPLC

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

UNIT V: TG/DTA/DSC

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

UNIT VI: Atomic Absorption Spectroscopy

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

REFERENCE BOOKS:

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

WEB REFERENCES:

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

SEMESTER IV

Course Code: CHRE-504
Course Title: Synthesis of Inorganic Materials
Credit: 2
Maximum marks: 50
Duration: 30 Hours

Course Objectives:
The course will enable the student to:

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

Course Outcome:
Upon successful completion of this course, the students will be able to:
CO1: Recall key reactions involved in synthesis methods for ceramic materials.
CO2: List the different precursor methods for material synthesis.
CO3: Identify the principles and processes of combustion synthesis.
CO4: Explain the concept of intercalation chemistry and its significance in material synthesis.
CO5: Analyze the advantages and limitations of various synthesis methods in the context of material properties and applications.

UNIT I: Methods of Synthesis – I **15 Hours**
Introduction, reactions employed in synthesis, ceramic procedures, precursor methods, combustion synthesis, Intercalation chemistry, sol-gel synthesis, ion exchange method, co-precipitation.

UNIT II: Methods of Synthesis – II **15 Hours**
Electrochemical methods; nebulized spray pyrolysis; arc and skull methods; Reactions at high pressures; intergrowth structures; Metal borides, carbides, and nitrides; metal fluorides; metal silicides, phosphides, sulfides, and related materials.

TEXTBOOK:

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

REFERENCE BOOKS:

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

WEB REFERENCES

1. https://link.springer.com/chapter/10.1007/978-1-4899-0095-1_8

2. https://pubs.acs.org/doi/10.1021/jacs.1c04888
3. https://www.nature.com/articles/s41597-022-01317-2
4. https://www.mdpi.com/1420-3049/27/7/2045
5. https://par.nsf.gov/servlets/purl/10040699

Course Code: CHRE-505
Course Title: Catalysis
Credit: 2
Maximum marks: 50
Duration: 30 hours

Course Objectives:
The course will enable the student to

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

Course Outcomes:
On successful completion of the course, the student will be able to
CO1: Explain the general principles of shape-selective catalysis and its application in zeolites.
CO2: Demonstrate an understanding of the thermodynamic considerations in catalytic reactions.
CO3: Describe the various types of solid catalysts.
CO4: Understand the properties and applications of clays in catalysis, including intercalation and pillared clays and identify catalyst deactivation mechanisms.
CO5: Compare and contrast different types of adsorptions, including monolayer adsorption and multilayer adsorption.
CO6: Evaluate the role of surface area and catalyst texture in catalytic reactions.

UNIT I: Fundamentals in catalysis **15 Hours**
Catalysis - general principle, thermodynamic considerations, types of solid catalysts, catalyst deactivation, types of adsorptions - monolayer adsorption, monolayer adsorption on homogeneous and heterogeneous surface; multilayer adsorption- polyani's theory of adsorption: adsorption on porous solids, catalyst texture, surface area - volumetric method, gravimetric method, flow method; pore size distribution- pore size from adsorption, mercury porosity meter, chemisorption -chemisorption of hydrogen, O_2, N_2 and CO, unsaturated hydrocarbons, chemisorption bond- covalent bond, ionic bond, quantum mechanical approach participation of d electrons.

UNIT II: Reaction kinetics and role of Catalyst **15 Hours**
Reaction kinetics- the rate determining step, rate expressions, geometric factor in catalysis balandin's multiplet theory, electronic effect in catalysis by metals, band theory, pauling's valence bond method, electronic structure and catalysis. catalysis by semiconductors; boundary layer theory of chemisorption, catalysis by acidic solids, zeolites – structure, zeolite pores, synthesis, acidity of zeolites, shape selective catalysis, zeolite based processes, aluminophosphate molecular sieves, clays-intercalation of clays, pillared clays, catalysis with clays, mesoporous materials, preparation of catalysts precipitation method, impregnation method, role of support, loading of the support, microporous solids- mesoporous solids role of diffusion.

TEXTBOOK:

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

REFERENCES:

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

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

Course Code: CHRE-506
Course Title: Applied organic chemistry
Credits: 2
Maximum Marks: 50
Duration: 30 Hours

Course Objective:

The course will enable the student to

1. Recall and define key terms related to retrosynthesis, such as synthons, synthetic equivalents, and disconnection approach.
2. Comprehend the principles of retrosynthetic analysis, including how to perform one-group and two-group C-X disconnections for aromatic compounds.
3. Understand important strategies for amine and alkene synthesis.
4. Develop synthetic routes for complex molecules using retrosynthetic principles, including the selection of appropriate protecting groups and chiral reagents.

Course Outcome:

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

CO1: Recall the fundamental principles of retrosynthesis, including the concept of synthons and synthetic equivalents.

CO2: Understand the disconnection approach in retrosynthetic analysis and its application in the synthesis of aromatic compounds, amines, and alkenes.

CO3: Apply important strategies of retrosynthesis for the synthesis of various functional groups and their interconversions.

CO4: Analyze protection and deprotection methods for hydroxyl, carbonyl, and amino groups, as well as chemo and regioselective protection techniques.

CO5: Evaluate the use of common protecting groups in peptide synthesis and methods for determining enantiomeric and diastereomeric excess in cyclic compounds.

UNIT I: Retrosynthetic Analysis and Protecting Group 15 hours

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

UNIT II: Asymmetric Synthesis **15 hours**

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

TEXTBOOK:

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

REFERENCES:

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

WEB REFERENCES

1. https://www.khanacademy.org/science/class-11-chemistry-india/xfbb6cb8fc2bd00c8:in-in-organic-chemistry-some-basic-principles-and-techniques
2. https://themasterchemistry.com/fundamental-principles-of-organic-chemistry/
3. https://leah4sci.com/organic-chemistry-retrosynthesis/
4. https://chem.libretexts.org/Bookshelves/Organic_Chemistry/Basic_Principles_of_Organic_Chemistry_(Roberts_and_Caserio)/13%3A_Polyfunctional_Compounds_Alkadienes_and_Approaches_to_Organic_Synthesis/13.10%3A_Protecting_Groups_in_Organic_Synthesis
5. https://www.sciencedirect.com/topics/biochemistry-genetics-and-molecular-biology/asymmetric-synthesis
6. https://www.britannica.com/science/asymmetric-synthesis

Course Code: CHRE-507
Course Title: Nanomaterials
Credit: 2
Maximum marks: 50
Hours: 30

Course Objective

The course will enable the student to

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

7. Examine the nature of nanoparticles in the environment, including exposure, effects, and risk assessment.

Course Outcome:

By the end of this course students will be able to

CO1: Memorize the fundamental properties and four generations of nanoproduct development.
CO2: Recall the basic principles of magnetization processes in nanoparticles.
CO3: Understand the concept of nanocomposites and their applications.
CO4: Apply knowledge of nanoparticle properties to predict their behaviour in various applications.
CO5: Analyze the phase transition of nanoparticles and its implications.
CO6: Assess the sources and sinks of atmospheric nanoparticles.
CO7: Comprehend the factors affecting the toxicology of nanomaterials.
CO8: Critically analyze the methods for making nanostructures using top-down techniques.

UNIT- I: Nanoscale Materials **15 Hours**

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

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

UNIT II: Environmental Fate and Transport of Nanomaterials **15 Hours**

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

TEXTBOOK:

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

REFERENCE BOOKS:

1. Introduction to Nanoscience and Nanotechnology, Chris Binns, John Wiley & Sons, 2010
2. Nanomaterials and Nanochemistry, Catherine Bréchignac, Philippe Houdy, Marcel Lahmani.
3. Nanoparticles in Medicine and Environment, Jan C.M. Marijnissen, Leon Gradoṅ, European materials research society.

WEB REFERENCES

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

Course Code: CHAD-501
Course Title: Dissertation
Credit: 16
Maximum marks: 400

Duration: 384 Hours

The dissertation must comprise of original research and may be conducted either at the Institute or with approval, in an outside institution or company e. g., the student's employers. The guiding teacher may serve some laboratory hours for industry work.
The dissertation work is to be submitted for: evaluation and Viva Voice examination at the end of Semester IV.
Written test must be conducted regarding the basic principles of techniques or instruments used with respect to the area of dissertation topic.
Students may be assessed based on designing the question bank by students on dissertation topic.

Course Code: CHAI-501
Course Title: Internship
Credit: 16
Maximum marks: 400
Duration: 192 Hours

MODULE A: Internship at Industry; Two weeks per Semester (Semester III and IV) **144 Hours**
MODULE B: Write up of the Internship work per Semester (Semester III and IV) **16 Hours**
MODULE C: Students to design four modules based on their experience at industry **32 Hours**

Annexure I: UG

Name of the Programme: B. Sc. In Chemistry

(Summary of changes incorporated in the existing approved syllabus if any)

Semester	Course Title	Existing (Indicate only the unit where the change is proposed)	Changes Proposed	Specify the reason for the change
II	UG-CHE-SEC2 Basic Laboratory Methods and Safety in Chemistry	-	Introduction of SEC	New Course
IV	UG-CHE-205 Selected Topics in Inorganic Chemistry	UG-CHE-203 Comprehensive Inorganic Chemistry	Change of Course Title	Updation in course title
	UG-CHE-204 Selected Topics in Organic Chemistry	UG-CHE-204 Comprehensive Organic Chemistry	Change of Course Title	Updation in course title
	UG-CHE-203 Selected Topics in Physical Chemistry	UG-CHE-205 Comprehensive Physical Chemistry	Change of Course Title	Updation in course title
	UG-CHE-203 Selected Topics in Physical Chemistry	Unit IV: Solid state and Theory of Dilute Solutions	Unit IV: Photochemistry and Colloid Chemistry	Repeated from previous semesters

Annexure I: PG

Name of the Programme: M. Sc. In Analytical Chemistry

(Summary of changes incorporated in the existing approved syllabus if any)

Semester	Course Title	Existing (Indicate only the unit where the change is proposed)	Changes Proposed	Specify the reason for the change
III	**CHAE-501:** Calibrations and Validation	-	Change course code from CHAE-505 to CHAE-501	Updation in in the course code
	CHAE-504: Advanced NMR Spectroscopy	Unit I: NMR and ^{13}C NMR spectroscopy	Inclusion of F NMR and P NMR and change in unit title as '^{13}C NMR, ^{19}F NMR & ^{31}P NMR spectroscopy'	Updation in in the unit I title and content
	CHAE-505: Separation Techniques	Unit I: Advanced chromatographic techniques	Change of unit 1 title from 'Advanced chromatographic techniques' to 'Chromatographic techniques'	Updation in name suitable of course
	CHGE-503: Application of Chemistry in Everyday Life	-	Generic Elective Course	New Course
	CHRE–501: Research Methodology & Academic writing Chemistry	**CHRE–501:** Research Methodology & **CHRE–502:** Academic writing	Merge the two units equivalent to 04 Credits	Restructuring the syllabus structure
	CHRE–502: Experiments in Analytical Chemistry	-	Research Specific Elective course	New Course
	CHRE–503: Experiments on analytical instrumentation	-	Research Specific Elective course	New Course
IV	**CHRE–504:** Synthesis of inorganic materials	-	Inclusion of sub unit 'co-precipitation'	Updation in content of the course