PARVATIBAI CHOWGULE COLLEGE OF ARTS AND SCIENCE (AUTONOMOUS)

DEPARTMENT OF CHEMISTRY

ACADEMIC YEAR: 2022-2023

APPROVED COURSE STRUCTURE TO BE IMPLEMENTED FROM AY: 2023-2024 ONWARDS

SEMESTER	CORE COURSES					MULTI DISIPLINARY COURSES	INTERNSHIP	SKILL ENHANCEMENT COURSES
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	---	---
III	**UG-CHE-201** Concepts in Physical and Inorganic Chemistry	**UG-CHE-202** Concepts in Organic and Inorganic Chemistry		---	**Minor Stream UG-CHE-201** Concepts in Physical and Inorganic Chemistry	---	---	---
IV	**UG-CHE-203** Comprehensive Inorganic Chemistry	**UG-CHE-204** Comprehensive Organic Chemistry	**UG-CHE-205** Comprehensive Physical Chemistry	**UG-CHE-206** Applied Chemistry – I **UG-CHE-207** Applied Chemistry – II	**UG-CHE - VOC1** Instrumental Methods of Analysis	---	---	---
V	**UG-CHE-301** Advanced Physical Chemistry -I	**UG-CHE-302** Advanced Organic Chemistry -I	**UG-CHE-303** Advanced Inorganic Chemistry -I	**UG-CHE-304** Applied Chemistry- III	**UG-CHE - VOC2** Electroplating and Corrosion	---	**UG-CHE-INT** Internship	---
VI	**UG-CHE-305** Advanced Physical Chemistry -II	**UG-CHE-306** Advanced Organic Chemistry -II	**UG-CHE-307** Advanced Inorganic Chemistry -II	**UG-CHE-PRJ** Project **UG-CHE-308** Applied Chemistry- IV	**UG-CHE - VOC3** Industrial Process	---	---	---
VII	**UG-CHE-401** Bio-Inorganic Chemistry/ Coordination Chemistry	**UG-CHE-402** Surface Chemistry and Catalysis	**UG-CHE-403** Stereochemistry and Name Reaction	**UG-CHE-404** Research Methodology	**Minor Stream UG-CHE-409** Selected Topics in Inorganic and Organic Chemistry	---	---	---
VIII	**UG-CHE-405** Organometallic Chemistry	**UG-CHE-406** Electrochemistry	**UG-CHE-407** Heterocyclic Chemistry OR Synthetic Organic Chemistry	**UG-CHE-408** Nanomaterials and Solid State Reactions	**Minor Stream UG-CHE-410** Selected Topics in Analytical and Physical Chemistry	---	Dissertation	---

*** Implementation of fourth year (Semester VII & VIII) is subject to approval from DHE**

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

WEB REFERENCES:

1. https://serc.carleton.edu/research_education/geochemsheets/techniques/XRD.html
2. https://chem.libretexts.org/Bookshelves/Analytical_Chemistry/Map%3A_Principles_of_Instrumental_Analysis_(Skoog_et_al.)/15%3A_Molecular_Luminescence_Spectrometry
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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