B.Sc. / B.Sc. (Honors) Chemistry-I semester

2021 – 2022 onwards

ANALYTICAL/INORGANIC/PHYSICAL CHEMISTRY-I

Title of the Course: DSC-1: **Course Code: CHE-101T**

Number of Theory Credits	Number of lecture hours/ semester	Number of practical Credits	Number of practical hours/ semesters
4	56	2	56

Course Outcome

At the end of the course, the student will be able to:

CO-1: Describe basic laboratory practices safety, and precautions in the chemistry lab, the electronic configuration of the elements, the concept of chemical analysis, and the long form of the periodic table.

CO-2: Understand and explain the principle of titrimetric analysis, limitations of classical mechanics, the periodic table, and properties of s,p,d, and f-block elements.

CO-3: Apply the concepts of analytical techniques, the Schrodinger wave equation for particles in one dimension, and ionization enthalpy.

CO-4: Analysis and interpretation of statistical data, titration curves, radial and angular distribution curves, and distinguishing properties of the elements of the periodic table.

CO-5: Evaluate the properties of the elements of the periodic table such as bond order, effective nuclear charge, group electronegativity, and application of analytical chemistry.

Course Outcome	Competency Level
CO1	CL1,2
CO2	CL 1,2,3
CO3	CL3,4
CO4	CL3,4,5
CO5	CL3,4,5

Contents of Theory Course Semester- 1	56 Hrs
Unit – I	**14 hrs**
Basic laboratory practices, calibration of glassware (pipette, burette and volumetric flask), Sampling (solids and liquids), weighing, drying, dissolving, Acid treatment, Rules of work in analytical laboratory, General rule for performing quantitative determinations (volumetric and gravimetric), Safety in Chemical laboratory, Rules of fire prevention and accidents, First aid. Precautions to be taken while handling toxic chemicals, concentrated/fuming acids and organic solvents. **Language of analytical chemistry**: Definitions of analysis, determination, measurement, techniques and methods. Significant figures, Classification of analytical techniques. Choice of an analytical method. Errors and treatment of analytical data: Limitations of analytical methods – Errors: Determinate and indeterminate errors, some important terms replicate, outlier, Accuracy, precision, ways of expressing accuracy, absolute error, relative error, minimization of errors. Statistical treatment of random errors, mean, median, range, standard deviation and variance. External standard calibration. Numerical problems. Regression equation (least squares method), correlation coefficient (R2), limit of detection (LOD), limit of quantification (LOQ), linear dynamic range (working range), sensitivity, selectivity, method validation, figures of merit of analytical methods (no problems).	**(4hrs)** **(6 hrs)** **(4 hrs)**
Unit – II	**14 hrs**
Titrimetric analysis: Basic principle of titrimetric analysis. Classification, preparation and dilution of reagents/solutions. Equivalent masses of compounds Normality, Molarity and Mole fraction. Use of $N_1V_1 = N_2V_2$ formula, preparation of ppm level solutions from source materials (salts), conversion factors. Numerical problems. **Acid-base titrimetry**: Titration curves for strong acid vs. strong base, weak acid vs. strong base and weak base vs. strong acid titrations. Titration curves, quantitative applications – selecting and standardizing a titrant, inorganic analysis - alkalinity, acidity.	**(2 hrs)**

Redox titrations: Nernst equation-Theory of redox indicators **Complexometric titrimetry:** Indicators for EDTA titrations - theory of metal ion indicators, titration methods employing EDTA - direct, back, displacement and indirect determinations, Application-determination of hardness of water. **Precipitation titrimetry**: Titration curves, titrants and standards, indicators for precipitation titrations involving silver nitrate - Volhard's and Mohr's methods and their difference. **Gravimetric Analysis**: Requisites of precipitation, mechanism of precipitation, factors influencing precipitation, co-precipitation, post-precipitation. Advantages of organic reagents over inorganic reagents, reagents used in gravimetry : 8-hydroxy quinoline (oxine) and dimethyl glyoxime (DMG).	**(3hrs)** **(3hrs)** **(2hrs)** **(4hrs)**
Unit – III	**14 hrs**
Limitations of classical mechanics. Wave mechanics: de Broglie equation, Heisenberg's Uncertainty Principle and its significance. Quantum Mechanics- ..Schrödinger's wave equation, derivation (time independent) significance of ψ and ψ^2. Eigen values and functions Applications of Schrödinger's wave equation - Particals in one-dimension box Quantum numbers and their significance. Quantum mechanical operators- (i) Hamiltonian operator; (ii) Laplacean operator Normalized and orthogonal wave functions. Sign of wave functions. Postulates of quantum mechanics Radial and angular wave functions for hydrogen atom. Radial and angular distribution curves. Shapes of s, p, d and f orbitals. Contour boundary and probability diagrams. Pauli's Exclusion Principle, Hund's rule of maximum multiplicity, Aufbau's principle and its limitations- Electronic configurations of the elements (Z=1-30), effective nuclear charge, shielding/screening effect, Slater's rules. Variation of effective nuclear charge in Periodic table**.**	**(5hrs)** **(6hrs)** **(3hrs)**
Unit – IV	**14hrs**
s, p, d and f-block elements, the long form of periodic table. Detailed discussion of the following properties of the elements, with reference to s and p-block elements: (a) Atomic radii (van der Waals) (b) Ionic and crystal radii. (c) Covalent radii	

(d) Ionization enthalpy, successive ionization enthalpies and factors affecting ionization energy. Applications of ionization enthalpy (e) Electron gain enthalpy; trends of electron gain enthalpy. (f) Electronegativity, Pauling's/ Mulliken's/ Allred Rachow's/ and Mulliken-Jaffé's electronegativity scales. Variation of electronegativity with bond order, partial charge, hybridization, group electronegativity. Trends in the chemistry of the compounds of groups 13 to 17 (hydrides, carbides, oxides and halides) are to be discussed.	(**8 hrs)**

Recommended Books/References:

1. Vogel's Textbook of Quantitative Chemical Analysis, J. Mendham, R.C. Denney, J.D.Barnes and M.J.K. Thomas, 6th edition, Third Indian Reprint, Pearson Education Pvt. Ltd.(2007).
2. Fundamentals of Analytical Chemistry, D.A. Skoog, D.M. West, Holler and Crouch, 8th edition, Saunders College Publishing, New York (2005).
3. Basic Inorganic Chemistry, F A Cotton, G Wilkinson and P. L. Gaus, 3rd Edition. Wiley. India December 1994
4. Analytical Chemistry, G.D. Christian, 6th edition, Wiley-India (2007).
5. Douglas, B.E; Mc Daniel, D.H. & Alexander, J.J. Concepts & Models of Inorganic Chemistry 3rd Ed., John Wiley Sons, N.Y. 1994.
6. Cotton, F.A. & Wilkinson, G. Advanced Inorganic Chemistry, Wiley, VCH, 1999.
7. Concise Inorganic Chemistry: J D Lee, 4thEdn, Wiley, (2021)
8. Fundamentals Concepts of Inorganic Chemistry, Vol 1 and 2, 2nd Edition, Asim K Das, CBS Publishers and Distributors, (2013)

Practicals Chemistry -I Semester

Formative Assessment (Internal assessment) Practicals.	
Assessment Occasion/ type	**Weightage in Marks**
Continuous evaluation and class test	20
Record/viva voce	05
Total	**25**

Course Outcome

At the end of the course, the student will be able to:

CO-1: To handle the glassware, prepare the dilute solutions, and perform the experiments with prepared reagents**.**
CO-2: Strengthen the concepts of mole and stoichiometry.
CO-3: To determine the analyte through volumetric and gravimetric analysis and understand the chemistry involved in each method of analysis.

PART- A Analytical Chemistry (Titrimetric Analysis)

List of Experiments:

1. Calibration of glassware, pipette, burette and volumetric flask.
2. Estimation of sodium carbonate and sodium bicarbonate in a mixture by acid-base titration method.
3. Estimation of alkali present in soaps/detergents/antacids.
4. Estimation of iron (II) using potassium dichromate by redox titration method.
5. Estimation of oxalic acid using potassium permanganate solution by redox titration method.
6. Estimation of chlorine in bleaching powder using iodometric method.
7. Standardization of silver nitrate and determination of chloride in a water sample.
8. Determination of percentage of manganese dioxide from pyrolusite ore.

PART-B Inorganic Chemistry.

List of experiments to be conducted:

TITRIMETRY

1. Estimation of carbonate and hydroxide present in a mixture.
2. Estimation of oxalic acid and sodium oxalate in a given mixture using standard $KMnO_4$/NaOH solution.
3. Standardization of potassium permanganate solution and estimation of nitrite in a water sample.
4. Standardization of EDTA solution and estimation of hardness of water.

GRAVIMETRY

1. Determination of Ba^{2+} as $BaSO_4$.
2. Estimation of Ni^{2+} as $Ni(DMG)_2$ complex.
3. Determination of Cu^{2+} as CuSCN.
4. Estimation of Fe^{2+} as Fe_2O_3

Recommended Books/References:

1. Mendham, J., A. I. Vogel's Quantitative Chemical Analysis Sixth Edition, Pearson, 2009.
2. Svehala G. and Sivasankar I. B, Vogel's Qualitative Inorganic Analysis, Pearson, India, 2012.
3. Practical Volumetric Analysis, Peter A C McPherson, Royal Society of Chemistry, Cambridge, UK (2015).
4. Mann, F.G. & Saunders, B.C. Practical Organic Chemistry, Pearson Education (2009)
5. Furniss, B.S.; Hannaford, A.J.; Smith, P.W.G.; Tatchell, A.R. Practical Organic Chemistry, 5th Ed., Pearson (2012)

B.Sc. / B.Sc. (Honors) Chemistry- II Semester

ORGANIC/PHYSICAL/INORGANIC CHEMISTRY

Title of the Course: DSC – 2 **Course Code:CHE.T2-2**

Number of Theory Credits	Number of lecture hours/semester	Number of practical Credits	Number of practical hours/ semesters
4	56	2	56

Course Objectives:

- To explain the nature of bonding in organic compounds using concepts such as conjugation, resonance, etc.
- To emphasize methods of synthesis of alkanes, alkenes and alkynes along with their reactions and mechanisms.
- To illustrate the types of aromatic electrophilic and aromatic nucleophilic substitution reactions with examples.
- To describe the mechanisms of S_N1 and S_N2 reactions taking suitable examples.
- To discuss the crystalline state in detail using the terms unit cell, Bravias lattices, Miller indices, Crystal systems, symmetry elements and lattice planes.
- To give a comprehensive description of the gaseous state in terms of molecular velocity, their distribution based on Maxwell-Boltzmann law, types of molecular velocities, molecular collision parameters, critical phenomena and liquefaction of gases.
- To discuss the important properties of liquid state such as viscosity, surface tension, refraction and parachor by defining them and elaborating on their experimental determination.
- To learn the methods of determining molecular weights of solutes by measuring colligative properties and the concept of distribution law along with its applications

Course outcomes:

On completion of the course the students will learn and able to explain

- Describe the nature of bonding in organic compounds using concepts such as
- Learn methods of synthesis of alkanes, alkenes and alkynes along with their reaction mechanisms.
- Illustrate types of aromatic electrophilic and aromatic nucleophilic substitution reactions with examples

- Write the mechanisms of S_N1 and S_N2 reactions taking suitable examples
- Describe the crystalline state in detail using the terms unit cell, Bravias lattices, Miller indices, Crystal systems, symmetry elements and lattice planes.
- To describe the gaseous state in terms of molecular velocity, their distribution based on Maxwell-Boltzmann law, types of molecular velocities, molecular collision parameters, critical phenomena and liquefaction of gases.
- Explain important properties of liquid state such as viscosity, surface tension, refraction and parachor by defining them and elaborating on their experimental determination
- Learn methods of determining molecular weights of solutes by measuring colligative properties and the concept of distribution law along with its applications

Content of Theory Course 2	**56Hrs**
Unit – I	**14hrs**
Classification and nomenclature of organic compounds (bifunctional, heterocyclics and bridged compounds), hybridization, shapes of organic molecules, influence of hybridization on bond properties. **Nature of bonding in Organic molecules** Formation of covalent bond, types of chemical bonding, localized and delocalized, conjugation and cross conjugation, with examples. Concept of resonance. Electronic displacements: Inductive effect, electrometric effect, resonance and hyper conjugation, aromaticity, Huckel's rule, anti-aromaticity explanation with examples. Strengths of organic acid and bases: Comparative study with emphasis on factors effecting pK values. Relative strength of aliphatic and aromatic carboxylic acids - acetic acid and chloroacetic acid, acetic acid and propionic acid, acetic acid and benzoic acid. Steric effect - relative stability of trans and *cis*-2-butene. Types of bond cleavages- homolytic and heterolytic cleavages. Types of reagents - electrophiles, nucleophiles, nucleophilicity and basicity. Types of organic reactions - substitution, addition, elimination, and rearrangement explanation with examples. **Chemistry of Aliphatic hydrocarbons**, **carbon - carbon sigma bonds** Formation of alkanes: Wurtz reaction, free radical substitution, halogenation **Carbon-carbon pi bonds:** Formation of alkenes and alkynes by elimination reaction. Mechanism of E1, E2, reactions. Saytzeff and Hofmann eliminations.	**(2hrs)** **(4hrs)** **(4hrs)**

Addition of HBr to propene, free radical addition of HBr to propene. Addition of halogens to alkenes-carbocation and halonium ion mechanism. Ozonolysis - ozonolysis of propene, hydrogenation, hydration, hydroxylation and epoxidation of alkenes, explanation with examples, addition of hydrogen halides to alkynes. Conjugated Dienes - 1,2 and 1,4- addition reactions in conjugated dienes. Diels-Alder reaction.	**(4hrs)**
Unit – II	**14hrs**
Nucleophilic substitution at saturated carbon. Mechanism of S_N1 and S_N2 reactions with suitable examples. Energy profile diagrams, stereochemistry and factors effecting S_N1 and S_N2 reactions. Aromatic electrophilic substitution reactions, mechanisms, σ and π complexes, halogenation, nitration, sulphonation, Friedel Crafts alkylation and acylation with their mechanism. Activating and deactivating groups. Orientation influence, *ortho* - *para* ratio (Cl, NO_2, CH_3, NH_2, OH). Aromatic nucleophilic substitution reaction: S_NAr mechanism, *ipso* substitution. Example -conversion of 2,4-dinitrochlorobenzene to 2,4-dinitrophenyl hydrazine. Introduction to benzyne. Stability based on Huckel rule of aromaticity. Generation of benzyne with mechanism. Green Chemistry- Principles.	**(4 hrs)** **(5 hrs)** **(5hrs)**
Unit – III	**14hrs**
Solids: Forms of solids**:** Unit cell and space lattice, anisotropy of crystals, size and shape of crystals. Laws of Crystallography: Law of constancy of interfacial angles, law of rational indices, law of symmetry (symmetry elements), crystal systems, Bravais lattice types and identification of lattice planes. Miller indices and its calculation, X–Ray diffraction by crystals: Bragg's law and derivation of Bragg's equation, single crystal and powder diffraction methods. Defects in crystals, glasses and liquid crystals. Numerical problems. **Gaseous state:** Molecular velocity, collision frequency, collision diameter, collision cross section, collision number and mean free path and coefficient of viscosity, calculation of σ and η, variation of viscosity with temperature and pressure.	**(7hrs)**

Maxwell-Boltzmann distribution law of molecular velocities (most probable, average and root mean square velocities). Relation between RMS, average and most probable velocity and average kinetic energies. (mathematical derivation not required), law of equipartition of energy. Behaviour of real gases: Deviation from ideal gas behaviour. Compressibility factor (Z) and its variation with pressure for different gases. Causes of deviation from ideal behaviour, vander Waals equation of stat (No derivation) and application in explaining real gas behaviour. Critical phenomena - Andrews isotherms of CO_2, critical constants and their derivation from van der Waals equation, Experimental determination of critical constants. Continuity of states, Law of corresponding states. Joule Thomson effect. Inversion temperature, application of J-T effect, liquification of air by Linde's process. Numerical problems.	**(7hrs)**
UNIT-IV	
Liquid state **Surface tension**: Definition and its determination using stalagmometer, effect of temperature and solute on surface tension. **Viscosity**: Definition, coefficient of viscosity. Determination of viscosity of a liquid using Oswald viscometer. Effect of temperature, size, weight, shape of molecules and intermolecular forces. **Refraction**: Specific and molar refraction- definition and advantages. Determination of refractive index by Abbes Refractometer. Additive and constitutive properties. **Parachor:** Definition, atomic and structure parachor, elucidation of structure of benzene and benzoquinone. Viscosity and molecular structure. Molar refraction and chemical constitution. Numerical problems**.** Dilute solutions. Review of colligative properties. Experimental determination of molar mass of solute by: 1.Berkely-Hertely method 2. Beckmann method 3. Landsberger method and Numerical problems Distribution Law: Nernst distribution law - Statement. Distribution coefficient, factors affecting distribution coefficient, validity of distribution law, modification of distribution law when molecules undergo a) association b) dissociation. Application of distribution law in Solvent extraction. Derivation for simple and	**(7hrs)** **(3hrs)** **(4hrs)**

multiple extractions. Principles of distribution law in Parke's process of desilverisation of lead. Numerical problems.	

Recommended Text books/references:

1. Atkins, P. W. & Paula, J. de Atkin's Physical Chemistry 8th Ed., Oxford University Press (2006).
2. Physical Chemistry by Samuel Glasstone, ELBS (1982).
3. A Text book of Physical Chemistry, A S Negi& S C Anand, New Age International Publishers (2007).
4. Principles of Physical Chemistry, Puri, Sharma & Pathania, Vishal Publishing Co.
5. A Text Book of Physical Chemistry P.L.Soni , O.P. Dharmarhaand and U.N.Dash, Sultan Chand and Sons.
6. Advanced Physical Chemistry, Gurdeep Raj, Goel Publishing House (2018)
7. Morrison, R. N. & Boyd, R. N. Organic Chemistry, Dorling Kindersley (India) Pvt. Ltd. (Pearson Education)
8. Finar, I. L. Organic Chemistry (Volume I), Dorling Kindersley (India) Pvt. Ltd. (Pearson Education)
9. McMurry, J. E. *Fundamentals of Organic Chemistry,* 7th Ed. Cengage Learning India Edition, 2013
10. Organic Reaction mechanism by V. K. AhIuwalia and K. Parashar Oxford, U.K. : Alpha Science International, 2011.
11. Organic Chemistry by S. M. Mukherji, S. P. Singh and R. K. Kapoor. New age publishers Publication Date.2 February 2017
12. A Guide book to mechanism in Organic Chemistry by Peter Sykes. Pearson. (January 2003)
13. F. A. Carey, Organic Chemistry, Seventh Edition, Tata McGraw Hill (2008).
14. J. Clayden, N. Greeves, S. Warren, Organic Chemistry, 2nd Ed., (2012), Oxford University Press.

Pedagogy: ICT tools, Chalk & Talk, Models & Charts, MOOC

Formative Assessment (Internal assessment) Theory.	
Assessment Occasion/ type	**Weightage in Marks**
Continuous evaluation and class test	20
Seminars/Class work	10
Assignments/Discussions	10
Total	40

Practicals Chemistry-II Semester

Formative Assessment (Internal assessment) Practicals.	
Assessment Occasion/ type	**Weightage in Marks**
Continuous evaluation and class test	20
Record/viva voce	05
Total	**25**

PART A: Organic Chemistry

Course Objectives:

- To get training on how to plan and execute single step synthesis of small organic molecules.
- To learn and to get trained on how to how to purify a compound and to learn the crystallization techniques.
- To understand the mechanism involved in the transformation, calculate the percentage yield and report the physical constant

Course outcomes:

- Students would learn the importance of green methods over conventional methods.
- Students gain the basic knowledge as how to select a solvent for crystallization of organic compounds and get trained as how to purify a compound.
- Students would understand the mechanism behind the reaction and role of catalysts in enhancing reaction rate and yield.

List of experiments to be conducted.

1. Selection of suitable solvents for purification/crystallization of organic compounds.
2. Preparation of acetanilide from aniline using Zn/acetic acid (green method).
3. Synthesis of *p*-nitro acetanilide from acetanilide using nitrating mixture.
4. Bromination of acetanilide (i) Conventional method and/or (ii) With ceric ammonium nitrate and potassium bromide (green method).
5. Preparation of methyl *m*-nitro benzoate from methyl benzoate by nitration method.
6. Hydrolysis of methyl *m*-nitro benzoate to *m*-nitro benzoic acid (conventional method).

7. Bromination - preparation of tribromophenol from phenol.
8. Preparation of dibenzalacetone (green method).

PART – B: Physical Chemistry

Course Objectives:

- To learn techniques for the measurement of viscosity, surface tension and refractive index
- To determine the composition of a liquid mixture by Refractometry
- To understand the concept of distribution coefficient and Nernst Distribution law

Course outcomes:

The student will be able to

- Determine the density, viscosity, surface tension, refractive index of liquids
- Determine the percentage composition of liquid mixtures using Abbe's Refractometer
- Explain the concept of distribution coefficient and Nernst Distribution law

List of experiments to be conducted.

1. Safety practices in the chemistry laboratory, knowledge about common toxic chemicals and safety measures in their handling, cleaning and drying of glasswares.
2. Determination of density using specific gravity bottle and viscosity of liquids using Ostwald's viscometer (ethyl acetate, toluene, chlorobenzene or any other non-hazardous liquids).
3. Study of the variation of viscosity of sucrose solution with the concentration of a solute
4. Determination of the density using specific gravity bottle and surface tension of liquids using Stalagmometer (ethyl acetate, toluene, chlorobenzene or any other non-hazardous liquids).
5. Determination of molar mass of non-electrolyte by Walker-Lumsden method.
6. Determination of specific and molar refraction by Abbes Refractometer (ethyl acetate, methyl acetate, ethylene chloride).
7. Determination of the composition of liquid mixture by refractometry (toluene & alcohol, water & sucrose).
8. Determination of partition/distribution coefficient - i) Acetic acid in water and cyclohexane. ii) Acetic acid in water and butanol iii) Benzoic acid in water and toluene.

Note:

1. Questions from both sections should be given in each batch.

2. In the first 20 minutes the Teacher should discuss in detail the theory, principle, procedure and calculations.

3. Instructions to be given for operating instruments, weighing chemicals and precautions while handling chemicals.

Recommended Books/References

1. Mendham, J., A. I. Vogel's Quantitative Chemical Analysis Sixth Edition, Pearson, 2009.
2. Svehala G. and Sivasankar I. B, Vogel's Qualitative Inorganic Analysis, Pearson, India, 2012.
3. Practical Volumetric Analysis, Peter A C McPherson, Royal Society of Chemistry, Cambridge, UK (2015).
4. Khosla, B. D.; Garg, V. C. & Gulati, A. Senior Practical Physical Chemistry, R. Chand & Co.: New Delhi (2011).
5. Garland, C. W.; Nibler, J. W. & Shoemaker, D. P. Experiments in Physical Chemistry 8th Ed.; McGraw-Hill: New York (2003).
6. Halpern, A. M. & McBane, G. C. Experimental Physical Chemistry 3rd Ed.; W.H. Freeman & Co.: New York (2003).
7. Athawale V. D. amd Mathur P. Experimental Physical Chemistry, New Age International (2001)

B.Sc. / B.Sc. (Honors) Chemistry-III semester

2022 – 2023 onwards

Title of the Course: ANALYTICAL and ORGANIC CHEMISTRY II

Course Code: CHE-301T

Number of Theory Credits	Number of lecture hours/ semester	Number of practical Credits	Number of practical hours/ semesters
4	56	2	56

Course Objectives:

1. Interrelationship among frequency, wavelength and wave number and importance of validation parameters of an instrumental method will be taught
2. Principle, instrumentation and applications of spectrophotometry, nephelometry and turbidometry will be taught
3. Fundamentals of separation methods and principles of paper, thin layer and column chromatography will be taught
4. Principle, types and applications of solvent extraction will be taught
5. Principle and mechanism of ion-exchange, types of resins and domestic andindustrial applications of ion-exchange chromatography will be taught
6. The concept of mechanism and its importance will be taught to the student
7. Concept and importance of intermediates in organic chemistry will be taught takingproper examples
8. The various techniques for identification of reaction mechanism will be taught to thestudent taking proper examples
9. Concept of stereochemistry and its importance will be taught.
10. The various projection formulae and the techniques of designating the moleculesinto R, S, D, L will be taught taking proper examples
11. The theory and concept of Cis-, Trans- isomerism and its importance and thetechniques to differentiate between them will be taught taking examples

Course Outcomes

After the completion of this course, the student would be able to

1. Understand the importance of fundamental law and validation parameters inchemical analysis
2. Know how different analytes in different matrices (water and real samples) can be determined by spectrophotometric, nephelometric and turbidometric methods.
3. Understand the requirement for chemical analysis by paper, thin layer and column chromatography.
4. Apply solvent extraction method for quantitative determination of metal ions indifferent samples
5. Utilize the ion-exchange chromatography for domestic and industrial applications
6. Explain mechanism for a given reaction.
7. Predict the probable mechanism for an reaction, explain the importance of reaction intermediates, its role and techniques of generating such intermediates.
8. Explain the importance of Stereochemistry in predicting the structure and propertyof organic molecules.
9. Predict the configuration of an organic molecule and able to designate it.
10. Identify the chiral molecules and predict its actual configuration

Contents of Theory Course Semester- III	**56 hrs**
Unit I	**14 hrs**
Quantitative analysis-Instrumental methods Electromagnetic spectrum, absorption of electromagnetic radiation, Definition and unitsof frequency, wavelength, wave number, Beer's law, Beer-Lambert law derivation,deviations from Beer's law, limitations, construction of calibration graph (Plot of absorbance versus concentration), Evaluation Procedures- standard addition, Internal standard addition, validation parameters-detection limits, sensitivity, dynamic/linearity range, Instrumentation, single beam and double beam spectrophotometers, quantitative applications of colorimetry (determination of Fe, Ti, Cu, Ni, and $PO4^{3-}$) and numericalproblems on application of Beer's law. **Nephelometry and Turbidimetry:** Introduction, principle, instrumentations of nephelometry and turbidimetry; effects of concentration, particle size and wavelength onscattering; choice between nephelometry, applications of nephelometry and turbidimetry (determination of $S04^{2-}$ and $PO4^{3-}$)	**10 hrs** **4 hrs**
Unit II	**14 hrs**

Separation methods **Fundamentals of chromatography**: General description, definition, terms and parameters used in chromatography, classification of chromatographic methods, criteria for selection of stationary and mobile phase and nature of adsorbents. **Column chromatography**: Principle, column efficiency, factors affecting the column efficiency, van Deemter's equation and its modern version. **Paper chromatography**: Principle, theory and applications **Thin layer chromatography (TLC)**: Principle, mechanism, Rf value, efficiency of TLC plates, methodology–selection of stationary and mobile phases, development, spray reagents, identification and detection, qualitative applications. **Ion exchange chromatography:** Principle, resins, types with examples- cation exchange and anion exchange resins, mechanism of cation and anion exchange process and applications of ion- exchange chromatography (softening of hard water, separation of lanthanides, industrial applications). **Solvent Extraction:** Principle, types- batch, continuous, efficiency, selectivity, distribution coefficient, Nernst distribution law, derivation, factors affecting the partition, relationship between % extraction and volume fraction, Numerical problems on solvent extraction. Solvent extraction of iron and copper.	**3 hrs** **4 hrs** **3hrs** **4hrs**
UNIT III	**14 hrs**
Stereochemistry of Organic Compounds: Fischer projection, Newmann and Sawhorse projection formulae and their interconversions. Geometrical isomerism: Cis-trans and syn-anti isomerism, E/Z notations. Optical Isomerism: Optical activity, Specific rotation, Chirality/Asymmetry, Enantiomers, Molecules with two or more chiral centres, Diasteroisomers, meso structures, Racemic mixtures and Resolution, Relative and absolute configuration, D/L and R/S designations (for single carbon stereo centres) with C.I.P rules.	14 hrs
UNIT IV	**14 hrs**

Reaction Intermediates: Generation, Stability and Reactions of, i) Carbocations ii) Carbanions iii) Free Radicals iv) Carbenes and Nitrenes v) Arynes. Applications: **i)** Carbocations: Dienone-phenol; and Pinacol-Pinacolone Rearrangement. **ii)** Carbanions: Perkin Reaction, Aldol condensation, Claisen-Schmidth condensation. **iii)** Free Radicals: Sand Meyer Reaction, Benzene to benzene hexachloride **iv)** Carbenes and Nitrenes: Singlet and Triplet states, relative stability and reactions: addition to C-C double bond. **iv)** Arynes: Formation, Diels-alder reaction to dienes	8 hrs
Methods for Identifying Reaction Mechanism: Product analysis- Isolation and Identification of Intermediates, Stereochemical Evidences, Effect of Catalyst, crossover Experiments, Isotopic studies, Kinetic Studies.	6 hrs

References:

1. Fundamental of Analytical Chemistry, D.A. Skoog, D.M. West, Holler and Crouch Ninth edition. Saunders College Publishing, New York (2014).
2. Analytical Chemistry, G.D. Christian, 6th edition, John Wiley & Sons, (2007)
3. Analytical Chemistry, 7th Edition: Seventh Edition Gary D. Christian, Purnendu (Sandy) Dasgupta, Kevin Schug Wiley Global Education, (2013)
4 Quantitative Analysis, R.A. Day and A.L. Underwood, 6th edition, PHI Learning Pvt Ltd. New Delhi (2015).
5 Vogel's Textbook of Quantitative Chemical Analysis, J. Mendham, R.C. Denney, J.D. Barnes and M.J.K. Thomas, 6th edition, Third Indian Reprint, Pearson Education Pvt. Ltd. (2007).
6. Organic Reaction Mechanism by V.K. Ahluwalia and R.K. Parashar (Narosa Publishers) [2002], Organic Chemistry by S.M. Mukherji, S.P. Singh and R.K. Kapoor New age publishers (Feb 2017)
7. Organic Chemistry by Robert T. Morrison, Robert N. Boyd Dorling Kindersley (India) Pvt Ltd. Pearson Education India; 7th edition (1 January 2010)
8. F. A. Carey, Organic Chemistry, Seventh Edition, Tata McGraw Hill (2008)

9. Organic Chemistry by FINAR (Vol I and II) Pearson Education India; 6th edition (1 January 2002)

10. Introduction to Organic Chemistry by John E. McMurry CENGAGE LEARNING (RS); 1st edition (1 January 2008)

11. Stereochemistry of Organic Compounds Ernest L. Eliel, Samuel H. Wilen. Wiley publishers; 1st edition (1 January 2008)

12. P Sykes, A Guide Book to Mechanism in Organic Chemistry, 6th Edition (1997), Orient Longman, New Delhi.

13. 1 Solomons, T.W G., Fryhle, B. Craig. Organic Chemistry, John Wiley & Sons, Inc (2009).

Pedagogy: ICT tools, Chalk & Talk, Models & Charts, MOOC

Formative Assessment (Internal assessment) Theory.	
Assessment Occasion/ type	**Weightage in Marks**
Continuous evaluation and class test	20
Seminars and SSR	10
Assignments and Attendance	10
Total	40

PRACTICALS- III Semester

Title of the Course: ANALYTICAL and ORGANIC CHEMISTRY Lab-II

Course Code: CHE-301P

Course Objectives

1. To impart skills related to preparation of stock and working solutions and handling of instrumental methods
2. To know the principle of colorimetric analysis and construction of calibration plot
3. To understand the chemistry involved in colorimetric determination of metal ions andanions
4. To determine Rf values of different metal ions present in a mixture
5. To impart knowledge on the importance of functional groups in organic compounds.
6. Techniques to identify the functional groups in an compound by performing physical andchemical tests
7. To record its melting point/boiling point.
8. To prepare suitable derivative for that compound and to characterize it.

Course Outcomes

After the completion of this course, the student would be able to

1. Understand the importance of instrumental methods for quantitative applications
2. Apply colorimetric methods for accurate determination of metal ions and anions in wateror real samples
3. Understand how functional groups in an compound is responsible for its characteristicproperty
4. Learn the importance of qualitative tests in identifying functional groups.
5. Learn how to prepare a derivative for particular functional groups and how to purify it'

PART-A (Analytical Chemistry)

1. Colorimetric determination of copper using ammonia hydroxide
2. Colorimetric determination of iron using thiocyanate solution
3. Colorimetric determination of nickel using DMG solution
4. Colorimetric determination of titanium using hydrogen peroxide
5. Colorimetric determination of nitrite in a water sample (diazo coupling Reaction using Griess reagent)
6. Colorimetric determination of phosphate as ammonium phosphomolybdate
7. Determination of Rf values of two or three component systems by TLC
8. Separation of different metal ions by paper chromatography (Cu, Ni and Cu) or Solvent extraction of ironusing oxine solution **(demonstration)**

PART-B (Organic Chemistry)

Qualitative analysis of bifunctional Organic compounds such as

1) Salicylic acid,2) Glucose 3) Methyl salicylate

4)p-Amino benzoic acid, 5) p-Chloro benzoic acid 6) Salicylaldehyde,

7)Acetophenone, 8) Benzoic acid 9) Salicylamide 10) Benzamide etc.

(Atleast 6-8 compounds to be analyzed in a semester)

References

1) Vogel's Textbook of Quantitative Chemical Analysis, J. Mendham, R.C. Denney, J.D. Barnes and M.J.K. Thomas, 6th edition, Third Indian Reprint, Pearson Education Pvt.Ltd.(2007)

2) Vogels Text Book of Qualitative Chemical Analysis, ELBS

Formative Assessment (Internal assessment) Practicals	
Assessment Occasion/ type	**Weightage in Marks**
Continuous evaluation and Attendance	05
Class Test	15
Record	05
Total	**25**

B.Sc. / B.Sc. (Honors) Chemistry-IV semester

2022 – 2023 onwards

Title of the Course: Inorganic and Physical Chemistry-II

Course Code: CHE-401T

Number of Theory Credits	Number of lecture hours/ semester	Number of practical Credits	Number of practical hours/ semesters
4	56	2	56

Course Objectives:

1. Different types of bonding in molecules/compounds/ions
2. The structures of molecules/compounds/ions based on different models/theories
3. Properties of compounds based on bonding and structure
4. The fundamentals of thermodynamics including the laws, the concept ofentropy and free energy functions and their applications.
5. The concepts of surface chemistry, catalysis and their applications.
6. The theoretical and experimental aspects of chemical kinetics including basictheories of reaction rates and methods of determining order.
7. Electrochemistry dealing with electrolytes in solution. Conductance measurements and applications. Concept of ionic mobility and their determination.

Course Outcomes:

After the completion of this course, the student would be able to

1. Predict the nature of the bond formed between different elements
2. Identify the possible type of arrangements of ions in ionic compounds
3. Write Born - Haber cycle for different ionic compounds
4. Relate different energy parameters like, lattice energy, entropy, enthalpy andsolvation energy in the dissolution of ionic solids
5. Explain covalent nature in ionic compounds
6. Write the M.O. energy diagrams for simple molecules
7. Differentiate bonding in metals from their compounds
8. Learn important laws of thermodynamics and their applications to variousthermodynamic systems

9. Understand adsorption processes and their mechanisms and the function andpurpose of a catalyst
10. Apply adsorption as a versatile method for waste water purification.
11. Understand the concept of rate of a chemical reaction, integrated rate equations, energy of activation and determination of order of a reaction based on experimental data
12. Know different types of electrolytes, usefulness of conductance and ionic mobility measurements
13. Determine the transport numbers

Contents of Theory Course Semester- 1V	**56 Hrs**
Unit – I	**14 hrs**
Structure and Bonding -I The ionic bond :Structures of ionic solids Radius ratio rules, Calculation of some limiting radius ratio values, Coordinationnumber 3 (planar triangle), Coordination number 4 (tetrahedral), Coordination number 6 (octahedral), Close packing (CCP). **Classification of ionic structures**: Ionic compounds of the type AX (ZnS, NaCl, CsCI) Ionic compounds of the type AX_2 (Calcium fluoride (fluorite) and Rutile structureLayer structures CdI_2 , Cadmium iodide structure Limitations of radius ratio concept Lattice energy and Born-Haber cycle,(MgO & $CaCl_2$) Born-Lande equation and itsdrawbacks, Kapustinskii equation, solvation energy and solubility of ionic solids,polarizing power and polarizability, Fajan's rules with applications. Numerical problems **Covalent bond**: Valence bond theory, The Lewis theory, The octet rule, Exceptions to the octet rule, Sidgwick- Powell theory. Valence shell electron pair repulsion (VSEPR) theory, Effect of lone pairs, electronegativity, isoelectronic principle, Examples using VSEPR theory: BF_3 and BF_4^-, $NH_3$and NH_4^+, H_2O, PCl_5, CIF_3, SF_4, $I_3^-$and I_3^+, SF_6, and IF_7. Limitations of VSEPR	**(3hrs)** **(7 hrs)** **(4 hrs)**
Unit – II	**14 hrs**
Structure and Bonding -II Concept of resonance, resonance energy, hybridisation, types of hybridization, Review on sp, sp^2 &sp^3. Hybridisation of dsp^2 dsp^3, d^2sp^3, sp^3d^2 with examples and energetics of hybridization. Bent's rule, Limitations of Valence Bond Theory.	**(3 hrs)**

Molecular Orbital theory: LCAO concept: s-s, s-p, p-p, p-d and d-combinations of orbitals, bonding, nonbonding and antibonding molecular orbitals, non-bonding combinations of orbitals, Rules for linear combination of atomic orbitals Examples of molecular orbital treatment for homonuclear diatomic molecules H_2 molecule, H^+ He_2 molecule, He^+ molecule ion, Li_2 molecule, Be_2 molecule B_2 molecule, C_2 molecule, N_2 molecule, N_2^+,O_2 molecule, O^- and O_2^{2-} M.O. energy diagrams of heteronuclear diatomic molecules with examples (NO, NO^+CO and HCl). Calculation of bond order, relationship between bond order, bond energy and bond length, magnetic properties based on MOT. **Metallic Bonding**: General properties of metals : Conductivity, Lustre, Malleability and cohesive forceCrystal structures of metals and Bond lengths Theories of bonding in metals: Free electron theory, Valence bond theory, Molecular orbital or band theory of solids Prediction of conducting properties of conductors. insulators and semiconductors, extrinsic and intrinsic semiconductors using M.O. theory.	**(7hrs)** **(4hrs)**
Unit – III	**14 hrs**
First Law of Thermodynamics Thermodynamic Processes, Reversible and Irreversible Processes, Nature of Heat and Work, Internal Energy, First Law of Thermodynamics, Enthalpy of a System, Work done in isothermal and adiabatic expansion of an ideal gas, Numerical problems, Joule -Thomson Expansion, Relation between Joule-Thomson coefficient and other thermodynamic parameters. **Second law of Thermodynamics** Concept of entropy, thermodynamic scale of temperature, Statements of the Second Law of Thermodynamics, molecular and statistical interpretation of entropy, Calculation of entropy change for reversible and irreversible processes, Free Energy Functions: Gibbs and Helmholtz energy, Variation of S, G, A with T, V and P, Numerical problems, Free energy change and spontaneity, Gibbs-Helmholtz equation. **Third Law of Thermodynamics** Statement of third law, concept of residual entropy, calculation of absolute entropy	

ofmolecules. **Surface Chemistry** **Adsorption** Types of adsorption isotherms. Freundlich adsorption isotherm (only equation), its limitations. Langmuir adsorption isotherm (derivation to be done) and BET equation(derivation not included). **Catalysis** Types of Catalysis and theories with examples (intermediate compound theory and adsorption theory), Theory of acid base catalysis, Michaelis-Menten mechanism. Heterogeneous catalysis: surface reactions, unimolecular, bimolecular surface reactions. Autocatalysis with examples. Applications: Design process to removal of toxic compounds from industrial wastewater and treatment of portable water requirements.	**(9hrs)** **(5hrs)**
Unit – IV	**14hrs**
Chemical Kinetics Differential and integrated form of rate expressions up to second order reactions, Derivationof expression of rate constant of second order reaction (a=b and a ≠ b), Problems on rate constant (a=b), Methods of determination of order of a reaction: Method of half life period and differential method. Temperature dependence of reaction rates; Arrhenius equation, activation energy, Numerical problems on Arrhenius equation in calculating energy of activation and rate constants. Collision theory of reaction rates, Lindemann's mechanism, qualitative treatment of the theory of absolute reaction rates. Experimental determination of kinetics of (i) inversion of cane sugar by polarimetricmethod (ii) spectrophotometric method for the reaction between potassium persulphate and potassium iodide. **Electrochemistry – I** Arrhenius theory of electrolytic dissociation. Merits and Demerits, Conductance, Specific conductance, equivalent and molar conductivity and their variation with dilution. Molar conductivity at infinite dilution. Numerical problems. Kohlrausch's law of independent migration of ions and its applications, Debye-Huckel-Onsager equation. Ionic mobilities and their determinations, transference numbers and theirrelation to ionic mobility's, determination of transference numbers using Hittorf and MovingBoundary methods.	**(7 hrs)**

Applications of conductance measurement: (i) degree of dissociation of weak electrolytes (ii) ionic product of water (iii) solubility and solubility product of sparingly soluble salts (iv) conductometric titrations (acid base titrations only) and (v) Hydrolysis constants of salts. Numerical problems.	**(7 hrs)**

Recommended Books/References:

1. Peter Atkins & Julio De Paula, Physical Chemistry, 9th Ed., Oxford University Press (2010)
2. G W Castellan, Physical Chemistry, 4th Ed., Narosa (2004)
3. R G Mortimer, Physical Chemistry 3rd Ed., Elsevier: Noida, UP (2009)
4. B R Puri, L R Sharma and M S Pathania, Principal of Physical Chemistry, VishalPublishing Co.
5. B S Bahl, G D Tuli and Arun Bahl, Essentials of Physical chemistry, S Chand &Company Ltd.
6. A S Negi and S C Anand, A textbook of Physical Chemistry, New Age International Publishers.
7. B N Bajpai, Advanced Physical chemistry, S Chand and Company ltd.
8. R L Madan, Chemistry for Degree Students, Semester I, II, III and IV, S Chand and Company Ltd.
9. P L Soni, O P Dharmarha and U N Dash, Textbook of Physical Chemistry, Sultan Chand and Sons.

Pedagogy: ICT tools, Chalk & Talk, Models & Charts, MOOC

Formative Assessment (Internal assessment) Theory.	
Assessment Occasion/ type	**Weightage in Marks**
Continuous evaluation and class test	20
Seminars and SSR	10
Assignments and Attendance	10
Total	40

Practical Chemistry -IV Semester

Title of the Course: Inorganic and Physical Chemistry Lab-II

Course Code: CHE-401P

Course objectives:

To attain practical knowledge about:

1. Analytical skills in detecting the constituents present in unknown samples by systematically carrying out the qualitative analysis.
2. The methods of determining rates of chemical reactions.
3. Designing electrochemical cells and making measurements related to it.
4. Determination of physical characteristics of electrolytes using conductivity measurements in solution.
5. Adsorption phenomenon, mechanism and basic models to explain adsorption.
6. Simple techniques like conductometry to obtain physicochemical parameters of electrolytes.

Course outcomes:

At the end of the course student would be able to

1. Understand the chemical reactions involved in the detection of cations and anions.
2. Explain basic principles involved in classification of ions into groups in semi-microqualitative analysis of salt mixture
3. Carryout the separation of cations into groups and understand the concept of commonion effect.
4. Understand the choice of group reagents used in the analysis.
5. Analyse a simple inorganic salt mixture containing two anions and cations
6. Use instruments like conductivity meter to obtain various physicochemicalparameters.
7. Apply the theory about chemical kinetics and determine the velocity constants ofvarious reactions.
8. Learn about the reaction mechanisms.
9. Interpret the behaviour of interfaces, the phenomena of physisorption and chemisorptions and their applications in chemical and industrial processes.
10. Learn to fit experimental data with theoretical models and interpret the data

List of Experiments:

Part A- Inorganic Chemistry Practicals

Qualitative semi-micro analysis of mixtures containing 2 anions and 2 cations.Emphasis should be given to the understanding of different reactions.

The following cations and anions are suggested.

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

Anions: CO_3^{2-}, CH_3COO^- , Cl^- , Br^-, I^- , NO_3^- , BO_3^{3-} , SO_4^{2-} , $C_2O_4^{2-}$and PO_4^{3-}

Spot tests and flame tests to be carried out wherever possible.

Part B- Physical Chemistry Practicals

1. Determination of the enthalpy of neutralization of a strong acid with strong base.
2. Verification of Freundlich and Langmuir isotherms for adsorption of acetic acid onactivated charcoal.
3. The study of kinetics of potassium persulphate and potassium iodide volumetrically.
4. Determination of velocity constant for acid catalyzed hydrolysis of methyl acetate.
5. Determination of velocity constant for the saponification of ethyl acetate ($a=b$) volumetrically.
6. Determination of equivalent conductivity of strong electrolyte and verification of DHO equation.
7. Determination of dissociation constant of weak acid by conductivity method.
8. Conductometric titration of strong acid and strong base.
9. Conductometric titration of weak acid and strong base.
10. Determination of the hydrolysis constant of aniline hydrochloride conductometrically.
11. Determination of solubility product of sparingly soluble salt conductometrically.

Recommended Books/References:

1. Vogel's Qualitative analysis, Revised by G. Svehla, Pearson education,2002
2. J B Yadav, Advanced Physical Chemistry, Krishna Prakashan Media (P) Ltd,Meerut.
3. Khosla, B. D.; Garg, V. C. & Gulati, A. Senior Practical Physical Chemistry, R.Chand & Co.: New Delhi (2011).
4. Garland, C. W.; Nibler, J. W. & Shoemaker, D. P. Experiments in Physical Chemistry8th Ed.; McGraw-Hill: New York (2003).
5. Halpern, A. M. &McBane, G. C. Experimental Physical Chemistry 3rd Ed.; W.H. Freeman & Co.: New York (2003).

Formative Assessment (Internal assessment) Practicals	
Assessment Occasion/ type	**Weightage in Marks**
Continuous evaluation and Attendance	05
Class Test	15
Record	05
Total	**25**

V - Semester

Inorganic chemistry - III & Organic chemistry - III

Title of the Course: DSC-5: **Course Code: CHE-501T**

Number of Theory Credits	Number of lecture hours/ semester	Number of practical Credits	Number of practical hours/ semesters
4	56	2	56

Course Outcomes:

1. To understand the nomenclature, geometry, and magnetic properties of Coordination compounds.
2. To understand the structure and various applications of organometallic compounds in the different fields.
3. To acquire knowledge on nuclear reactions and radioactive decay
4. To understand the steel production processes, alloy characteristics, applications, and the distinct functions of alloying elements.
5. Explore the reactivity of aldehydes, ketones, and amines including their reactions with various reagents, such as nucleophiles and oxidizing agents.
6. Learn methods for the synthesis of carboxylic acids and reactions of derivatives of carboxylic acid.
7. To understand the concept of tautomerism and applications of active methylene compounds.
8. To understand and apply various rearrangement reactions.

INORGANIC CHEMISTRY – III (28 Hours)

UNIT-I

Coordination compounds 10 hours

Coordination compounds- difference between double salts and complex salts with examples. Ligands

-definition and their classification (mono, bi, tri, tetra, penta and hexadentate ligands and ambidentate ligands), examples for each class.

Coordination number- definition with examples. Nomenclature of coordination compounds in detail.

Theories of structure and bonding: explanation for the formation of complexes by Werner's Theoryin detail and its limitations. EAN rule- statement with illustrations.

Valence bond theory: postulates, low spin and high spin complexes with examples, limitations ofVBT.

Crystal field theory: (octahedral, tetrahedral and square planar complexes). Crystal field splitting andcrystal field stabilization energies- definition and illustrations with examples. Limitations of CFT. Magnetic properties of $[CoF_6]^{3-}$, $[Co(NH_3)_6]^{3+}$, $Fe(CN)_6]^{4-}$,$[Fe(CN)_6]^{3-}$. Spectral properties of $[Ti(H_2O)_6]^{3+}$, $[Co(H_2O)_6]^{3+}$, $[CoCl_4]^{2-}$. Isomerism in complexes: Structural isomerism - ionization, linkage, hydrate and coordination isomerism with examples. Stereoisomerism- geometrical and optical isomerism of coordination compounds with coordination number 4 and 6 with examples.

Organometallic compounds 4 hours

Organometallic compounds - ligands, classification (hapticity). Synthesis and structure of $K[PtCl_3(\eta^2\text{-}C_2H_4)]$ and $[Fe(\eta^5 - C_5H_5)_2]$.

Metal carbonyls: Structures of $Cr(CO)_6$, $Co_2(CO)_8$, $Mn_2(CO)_{10}$; eighteen electron rule and its deviations with examples. Applications of coordination/organometallic compounds: cis-platin incancer therapy, Na_2Ca EDTA in the treatment of heavy metal (Pb, Hg) poisoning, Wilkinson's Catalyst in alkene hydrogenation, Monsanto acetic acid process.

UNIT-2

Nuclear and Radiochemistry 8 hours

Review of the property of radioactivity, types of radiations and their properties, atomic number and mass number, isotopes and isobars.

Nucleus – nucleons, nuclear force, nuclear density, stability - explanation using meson theory, n/p ratio, n versus p graph. Mass defect; Binding energy - definition, graph, calculation of binding energy to show that 1 *amu* = 931MeV. Explanation of the instability of the nuclei. Problems.

Radioactive decay law, derivation of $N = N_0 e^{-\lambda t}$, half life period of a radioisotope, relationship between half life and decay constant, numerical problems. Radioactive equilibrium - explanation, introduction of the terms parent and daughter elements. Group displacement law - statement and explanation taking examples; radioactive series - U, Th, Ac and Np series (mention of the first and last stable elements, number of α and β particles. Type of series namely 4n, (4n+1), (4n+2) and (4n+3).

Artificial radioactivity: Rutherford's first artificial transmutation, induced radioactivity; nuclear reactions – differences between chemical and nuclear reactions; reason for the large amount ofQ value; symbolic representation of a nuclear reaction, introduction of the term projectile, comparison of neutron, proton, α, γ and deuteron as projectiles. Examples of nuclear reaction induced by γ-radiation, α, n, p and deuteron. Nuclear fission - explanation with an example, chain reaction, principle of atomic bomb, calculation of energy liberated, fissionable isotopes. Nuclear fusion - explanation with an example, thermonuclear reaction, advantages and disadvantages of fusion over fission, principle of hydrogen bomb. Nuclear reactors - principle, working of a thermal reactor, diagram, and explanation of the terms like nuclear fuel, control rods, moderators

and coolant. Breeder reactors- brief explanation of the functioning. Atomic energy programme in India. Use of radio isotopes in tracer technique - agriculture (phosphorous in agriculture research), medicine(phosphorous to check crack in bones, sodium/iodine to detect clots in blood vessels), food preservation.

Carbon dating - formation of radioactive carbon in the atmosphere. Explanation of the determination of age of wood or peat or fossil. Numerical problems on carbon dating.

Steel and Alloys 6 Hours

Manufacture of steel by Bessermer process. (Removal of silicon, decarbonisation,demanganisation, desulphurisation, dephosphorisation) and surface treatment (argon treatment, heat treatment, nitriding, carburizing). Composition and properties of different types of steels (role of Ni, Cr, Mo, Si, Mn, V, W, Al).

Classification of alloys - ferrous alloys (iron base alloys -cast iron and steel, tool steel, stellite hard alloy) and non-ferrous alloys (copper, lead and tin alloys – composition of brass, bronze, cupro nickel, manganin, constantan, antifriction bearing, cable alloys, solders, Pb-Sn, Pb-Sb) Specific properties of elements in alloys (role of Ti in Al and Mg alloys, Ni in copper and iron alloys, Sn and Cu in lead base alloys)

ORGANIC CHEMISTRY – III (28 Hours)

UNIT-III

Aldehydes and Ketones 5 hours

Nomenclature: Relative reactivity of aldehydes and ketones towards Nucleophilic addition reactions. General mechanism of condensation with ammonia and its derivatives ($NH_2–R$; R = $–NH_2$, –OH, $–NH–CO–NH_2$).

Mechanisms of: acetal formation, Claisen condensation, Knoevenagel condensation and benzoin condensation. Reduction: Reduction by $LiAlH_4$ and $NaBH_4$. Mechanism of Clemmensen and Wolff-Kishner reductions.

Tautomerism and Enolates 5 hours

Tautomerism in carbonyl compounds – keto-enol tautomerism; oxime-nitroso tautomerism. Acidity of α-hydrogen atoms in aldehydes, ketones and active methylene compounds (example: diethyl malonate, ethyl acetoacetate and acetyl acetone).

Preparation of diethyl malonate from acetic acid and synthetic applications of diethyl malonate (preparation of monocarboxylic acids - butanoic acid, dicarboxylic acid - adipic acid, unsaturated acids -cinnamic acid, ketones - butanone, cyclic compounds - barbituric acid).

Preparation of ethyl acetoacetate (from ethyl acetate). Synthetic applications of ethyl acetoacetate (preparation of monocarboxylic acids - butanoic acid, dicarboxylic acid - succinic acid, unsaturated acids- crotonic acid and cinnamic acid, ketones - butanone).

Rearrangements 4 hours

Wagner - Meerwein, Fries, Beckmann, Hoffmann rearrangements. Benzil - benzilic acid rearrangement, Favorskii rearrangements and Baeyer - Villiger oxidation.

UNIT-IV

Carboxylic acids and their derivatives 7 hours

Nomenclature of Di and tri carboxylic acids: Action of heat on dicarboxylic acids (oxalic acid, malonic acid, succinic acid, glutaric acid and adipic acid).

Hydroxy acids: Reactions of tartaric acid and citric acid – (i) action of heat and (ii) reduction with HI.

Reactions of acid chlorides (example: acetyl chloride) - hydrolysis, reaction with alcohol, ammonia and lithium dialkylcuprates.

Reactions of acid anhydrides - hydrolysis, reaction with alcohol, ammonia.Reactions of amides - hydrolysis, reduction.

Reactions of esters - alkaline hydrolysis, ammonolysis and alcoholysis. Mechanism of ester hydrolysis - acid and base catalysed (acyl O-cleavage: $B_{AC}2$, $A_{AC}2$; alkyl O-cleavage: $A_{AL}1$ mechanisms).

Amines 7 hours

Classification, nomenclature, preparation of alkyl and aryl amines - reductive amination of carbonyl compounds (Ethanamine and 2-propanamine), Gabriel phthalimide synthesis (Ethanamine), reduction of nitrobenzene, Hoffmann's bromamide reaction. Relative basicity of amines in aqueous solution, explanation using inductive, resonance, steric and solvation effects [(a) ammonia, methyl amine, dimethyl amine and trimethyl amine (b) methyl amine and aniline].

Reactions - amines as nucleophiles (methylation and acylation), formation of quaternary ammonium salts (reaction of tertiary amine and alkyl halide), distinguishing reactions of 1°, 2° and 3° amines (Reactions with equations for Hinsbergs test).

Diazotization: formation of benzene diazonium chloride.

Synthetic applications of benzenediazonium chloride in the preparation of (i) chlorobenzene, bromobenzene and benzonitrile by Sandmeyer's reaction (ii) phenol (iii) phenyl hydrazine and aniline by reduction reaction and (iv) p-hydroxyazobenzene and 1- phenylazo-2-naphthol by coupling reaction.

Reference Books:

1. Lee J D, Concise Inorganic Chemistry, 5 th Edition, 5th Edition, Wiley India Pvt Ltd,2014.
2. Huheey, J.E., Keiter, E.A., Keiter, R.L. & Medhi, O.K. Inorganic Chemistry: Principlesof Structure and Reactivity, Pearson Education India, 2006.
3. Glasstone S, Source Book on Atomic Energy, Affiliated East West Press Pvt. Ltd. NewDelhi, 1967.
4. Cotton F A and Wilkinson G, Manfred B & Russel N S Inorganic Chemistry a Comprehensive Text, 6th Edition, Wiley Inter Science Publishers, 1999.
5. Shriver D, Weller M, Overton T, Rourke J and Armstrong F, Inorganic Chemistry, 6thEdition, W H Freeman and Company, New York, USA.
6. Mark Weller, Tina Overton, Jonathan Rourke, Fraser Armstrong, Inorganic Chemistry International Edition, Oxford University Press, 7th edition, 2018.

7. Housecroft C E and Sharpe A. G, Inorganic Chemistry, 5 th Edition, Pearson Education Limited, Essex, 2018.

8. R. C. Mehrotra, Organometallic Chemistry, New Age International (P) Ltd. Publishers,2nd edition, 2004.

9. Jens-Volker Kratz, Karl Heinrich Lieser, Nuclear and Radiochemistry: Fundamentals and Applications, 1st edition, 2013.

10. Friedlander G, Macias E S, Kennedy J W and Miller J M, Nuclear and Radiochemistry,3rd Edition, John Wiley and Sons Inc., 1981.

11. Arniker H J, Essentials of Nuclear Chemistry, New Age International Publishers, 4thedition, 2011.

12. Kotz, J, C., Treichel, P.M. & Townsend, J.R. General Chemistry Cengage Learning IndiaPvt Ltd., New Delhi (2009)

V Semester B.Sc., Practical

Course Title: Inorganic Chemistry -III

Course Code: CHE-501P

Formative Assessment (Internal assessment) Practicals.	
Assessment Occasion/ type	**Weightage in Marks**
Continuous evaluation and class test	20
Record/viva voce	05
Total	**25**

COURSE OUTCOME:

1. The students will be able to estimate the various elements through volumetric and gravimetric analysis and understand the chemistry involved in each method of analysis.
2. The students will be able to prepare and analyze the inorganic complexes and understand the mechanism behind the reaction and the role of catalysts in enhancing reaction rate and yield.

I. Volumetric analysis – To perform

1. Volumetric estimation of Zn.
2. Volumetric estimation of Mg.
3. Volumetric estimation of Ni.
4. Volumetric estimation of Fe haematite.
5. Volumetric estimation of Ca in lime stone.
6. Volumetric estimation of Cu in brass

II. Preparation and quantitative analysis of inorganic complexes – Procedure writing

1. *Cis*- and *trans*- potassium dioxalatodiaquachromium(III) complex [analysis of oxalate and chromium]
2. Hexamminecobalt(III) chloride [analysis of cobalt]
3. Preparation of pentamminechlorocobalt(III) chloride.

III. Gravimetric analysis

1. Gravimetric determination of Fe in iron ore as Fe_2O_3.
2. Gravimetric determination of Ni in Cu and Ni solution.
3. Gravimetric determination of Fe in Fe and Cr solution.

Reference Books:

1. Jeffery G H, Bassett J, Mendham J and Denney R C, Vogel's Textbook of Quantitative Chemical Analysis, 5thEdition, Longman Scientific & Technical, Essex, England, 1989.
2. Vogel's Text book of Qualitative Chemical Analysis, J. Bassett, G. H. Jeffery and J. Mendham, ELBS (1986).
3. Vogel's text book of Quantitative Chemical Analysis, 5th Edition, J. Bassett, G. H. Jeffery and J. Mendham,

Physical Chemistry - III & Spectroscopy - I

Title of the Course: DSC-6: **Course Code: CHE-502T**

Number of Theory Credits	Number of lecture hours/ semester	Number of practical Credits	Number of practical hours/ semesters
4	56	2	56

Course Outcomes:

1. Explain the theories of chemical kinetics, thermodynamical formulation of reaction rates and conceptualize steady state kinetics, and kinetics of Chain reactions.
2. To understand the photochemical and photo physical processes and their quantum yield expressions.
3. To understand of the common ion effect, buffer systems, pH calculations and various theories of indicators.
4. To explore the knowledge of the importance of phase diagrams and freezing mixtures in the field of material science.
5. To know different types of electrochemical cells, types of electrodes and electrode potential.
6. To develop expertise on the fundamental concepts of quantum mechanics and its application in chemistry.
7. To develop a good understanding of the electromagnetic spectrum and describe the principles of Rotational, Vibrational, Raman, Electronic, and NMR spectroscopy.

PHYSICAL CHEMISTRY - III (42 Hours)

Unit -I

Chemical Dynamics 8 hours

Macroscopic and microscopic kinetics, Review of theories of reaction rate-Collision theory and Transition state theory, Comparison of collision theory with transition state theory, Arrhenious equation-characteristics, Significance of energy of activation, Temperature coefficient and its evaluation. Thermodynamical formulation of reaction rates (Wyne-Jones and Eyring treatment), Reaction between ions in solutions - Influence of ionic strength on reaction rates (primary and secondary salt effects). Numerical problems.

Concept of Steady state kinetics, Chain reactions - chain length and chain inhibition, comparison of photochemical and thermal reactions, Mechanisms of thermal and photochemical reactions between hydrogen-bromine and hydrogen-chlorine. Comparative study of thermal and photochemical hydrogen-halogen reactions.

Photochemistry 6 hours

Laws of photochemistry (Grotthus - Draper and Stark-Einstein laws). Quantum yield (definition, Einstein and its significance). Actinometry (explain uranyl oxalate actinometer for measurement of energy of radiation absorbed). Examples of low and high quantum yields (examples for $\phi = 1, \phi < 1$ and ϕ very high): Photochemical combination of (i) H_2 and Cl_2 (ii) H_2 and Br_2 (iii) dissociation of HI. Photochemical equilibrium (Statement) and the differential rate of photochemical reactions (derivation of an expression for rate). Photosensitized reactions (explanation taking example), quenching (explanation taking example). Singlet and triplet states, Fluorescence and phosphorescence (explanation using Jablonski diagram). Role of photochemical reactions in biochemical processes (bioluminescence), photo stationary states, chemiluminescence (definition and example).

UNIT-II

Phase Equilibria 8 hours

Phases, components and degrees of freedom of a system (explanation of the terms taking suitable examples), criteria of phase equilibrium (thermal, mechanical and chemical). Gibb's Phase Rule and its thermodynamic derivation.

Phase diagrams of one-component systems (water and sulphur - phase diagram, explanation of the various equilibria, triple point, effect of external pressure on transition temperatures, calculation of degree of freedom). Two component systems (condensed phase rule) involving eutectics, congruent and incongruent melting points (lead-silver system- phase diagram, effect of impurity elements on the melting point, calculation of degree of freedom, eutectic mixture - definition, composition and applications, cooling of molten mixtures and Pattinson's process. $FeCl_3$ - H_2O system phase diagram, freezing mixture-definition and applications. Na - K system phase diagram).

Ionic equilibria 6 Hours

Common ion effect: statement and example (ammonium hydroxide - ammonium chloride and acetic acid - sodium acetate). Buffers: Types and examples. Buffer action and buffer capacity. pH of buffers-Henderson's equation and its derivation for acidic and basic buffers. Problems in calculating the pH of

buffers. Solubility product and ionic product definitions and their applications in the precipitation ofII and IV group basic radicals in the qualitative analysis of simple salt mixtures. Analytical and biological applications of buffers. Numerical problems.

Theories of indicators (Mentioning the different theories). Acid-base theory by taking phenolphthalein and methyl orange as examples.

UNIT-III

Electrochemistry
8 Hours

Reversible and irreversible cells (Definition and examples, Introduction of an electrochemical cell and explanation taking suitable examples). Concept of EMF of a cell (origin of EMF in an electrochemical cell, oxidation and reduction reactions, single electrode potential, reduction and oxidation potentials and formula for EMF). Measurement of EMF of a cell (compensation method, mention of standard cell-Weston cadmium cell) Nernst equation (derivation from free energy concepts for a cell and then to a single electrode) and its importance. Numerical problems. Types of electrodes [examples and their applications (i) metal/metal ion electrode - Zn/Zn^{2+} and Cu/Cu^{2+} (ii) metal/insoluble salt/anion electrode-calomel and Ag/AgCl electrodes.

(iii) metal/gas-ion electrode- hydrogen electrode (iv) inert metal/ organic compound electrode-quinhydrone electrode (v) Glass electrode (vi) Red-ox electrode]. Standard electrode potential (definition, explanation of the importance of reference electrodes, mention of primary-SHE and secondary reference electrodes-calomel electrode, convention of representing a cell, differences between standard reduction potential and standard oxidation potential,) Electrochemical series (definition, SRP values of common reference electrodes, uses). Thermodynamics of a reversible cell (equations depicting relationship between free energy change, enthalpy change, entropy change, equilibrium constant and EMF), calculation of thermodynamic properties: ΔG, ΔH and ΔS from EMF data. Calculation of equilibrium constant from EMF data (Numerical problems). Concentration cells with transference and without transference (definition and examples) Liquid junction potential (definition) and salt bridge (significance). pH determination using hydrogen electrode, Glass and quinhydrone electrodes (setting up of a suitable electrochemical cell, measurement of EMF and calculation of pH).

Quantum Mechanics - II 6 hours

Concepts of Operators: Laplacian, Hamiltonian, Linear and Hermitian operators. Angular Momentum operators and their properties. Commutation of operators. Solutions of Schrödinger wave equation for aparticle in a three-dimensional box. Quantum mechanical degeneracy, tunneling (no derivation). Application of Schrödinger equation to harmonic oscillator and rigid rotator (*Equations to be assumed*). Eigen functions and eigen values of angular momentum. Ladder operator method for angular momentum.

Schrödinger equation to hydrogen atom in spherical polar co-ordinates (No derivation). Solution
of Θ, Φ, R equation and statements of solution of R equation. Total wave functions of hydrogen atom. Quantum numbers and their characteristics.

UNIT-IV

SPECTROSCOPY - I (14 Hours)

Molecular Spectroscopy:

Interaction of electromagnetic radiation with molecules (emissionand absorption spectra, electromagnetic spectrum in terms of wave length/wave number,difference between atomic and molecular spectra and molecular energy levels) and various types of spectra (UV, IR, MW, Raman, and NMR and mention of the region), Born - Oppenheimer approximation (statement and explanation).

Rotation spectroscopy

(Expressions for energy of diatomic rigid rotor in terms of *joule* and m^{-1}, rotational constant, reduced mass, moment of inertia and spacing between rotational levels) Selection rules [statement, expression for frequency for transition between J to (J+1), condition for absorption and spacing between spectral lines], intensities of spectral lines (explanation based on populations of energy levels), determination of bond lengths of diatomic molecules.Numerical problems.

Vibrational spectroscopy

Classical equation of vibration (mention of expression for frequency/wave number for diatomic S H O), computation of force constant (definition of force constant, significance and statement of Hooke's law) amplitude of diatomic molecular vibrations (potential energy curve for diatomic SHO, expression for vibrational energy (from solutions to Schrödinger wave equation), zero point energy, selection rule, condition for absorption and fundamental vibrational frequency). Anharmonicity (difference in potential energy curves for SHO and others), Morse potential (energy expression for anharmonic oscillator, selection rules), dissociation energies, fundamental frequencies, overtones (compare the intensities), hot bands, degrees of freedom for polyatomic molecules (linear and non-linear – explanation taking suitable examples), modes of vibration (stretching and bending vibrations – types, comparison of frequencies, sketching of vibrational modes for CO_2 and H_2O), concept of group frequencies. Vibration-rotation spectroscopy – (pure vibrational spectra in liquids and mixing of vibration and rotational levels) diatomic vibrating rotator (expression for energy, selection rule and expression for energy change), P, Q, R branches explanation using diagram).

Raman spectroscopy

(Raman scattering, Rayleigh scattering, polarisability and Raman shift) Qualitative treatment of Rotational Raman effect (selection rule, expression for energy difference of a rigid diatomic rotor); Vibrational Raman spectra (selection rule) Stokes and anti-Stokes lines (explanation using diagram); their intensity difference, rule of mutual exclusion (explanation using molecules such as CO_2, O_2, N_2 etc.).

Electronic spectroscopy

(Complexity of electronic spectra), Franck-Condon principle (statementand demonstration using potential energy vs. internuclear distance plot), electronic transitions (HOMO, LUMO, bonding, antibonding and non-bonding orbitals, energy level diagram, examplesfor $\sigma \rightarrow \sigma^*$, $\pi \rightarrow \pi^*$, $n \rightarrow \sigma^*$ and $n \rightarrow \pi^*$ transitions). Dissociation and pre-dissociation (chemical reactions and non-radiative transitions), calculation of electronic transitions of polyenes using free electron model (qualitative explanation of electronic spectra of conjugated systems using free electron molecular orbital theory and formula for calculation of frequency ofelectronic transition taking butadiene as an example).

Nuclear Magnetic Resonance (NMR) spectroscopy

Principles of NMR spectroscopy (nuclear spin, examples for half integral, zero and integral values, magnetic moment, orientations in an external magnetic field and absorption of radiofrequency and magnetic resonance), Larmor precession (definition, Larmor frequency and an expression),

Reference Books:

1. Atkins P and Ronald Friedman, Molecular Quantum Mechanics, 5th Edition, Oxford University Press, New York, 2011.
2. Barrow, G.M. Physical Chemistry Tata McGraw-Hill (2007).
3. Castellan, G.W. Physical Chemistry 4th Ed. Narosa (2004).
4. Chandra, A. K. Introductory Quantum Chemistry Tata McGraw-Hill (2001). House, J. E. Fundamentals of Quantum Chemistry 2nd Ed. Elsevier: USA, 2004.
5. Towe, J. P. & Peterson, K. Quantum Chemistry, Academic Press (2005).
6. Callen, Herbert *Thermodynamics and an Introduction to Themostatistics*, 2nd edition, John Wiley & Sons, 1985.
7. V. S. Bagotsky, Fundamentals of Electrochemistry, John Wiley & Sons, Inc. 2006.
8. Samuel Glasstone, An Introduction to Electrochemistry, Read Book Publishers, 2008.
9. K. L. Kapoor, A Text Book of Physical Chemistry: Quantum Chemistry and Molecular Spectroscopy, 5th edition, McGraw Hill Education (India) Private Limited, 2014.
10. Colin.N. Banwell and Elaine M, Fundamentals of Molecular Spectroscopy, 4th edition, McGraw Hill Education, 2017.

V Semester B.Sc., Practical

Course Title: Organic Chemistry and Physical Chemistry-III

Course Code: CHE-502P

Formative Assessment (Internal assessment) Practicals.	
Assessment Occasion/ type	**Weightage in Marks**
Continuous evaluation and class test	20
Record/viva voce	05
Total	**25**

Course Outcome

1. Students will be able to plan and execute single and two-step synthesis of small organic molecules.
2. Students would understand the mechanism behind the reaction.
3. Students will be able to determine different physical parameters.

Preparation -To perform

1. Preparation of aspirin from salicylic acid
2. Preparation of paracetamol from p-aminophenol
3. Preparation of m-dinitro benzene from nitrobenzene
4. Preparation of m-nitro benzoic acid from methyl benzoate
5. Cannizarro reaction: Benzaldehyde
6. Sandmeyer reaction: 4-chlorotoluene from 4-toluidine
7. Pechmann reaction: resorcinol and ethyl acetoacetate
8. Synthesis of 2,4,6-tribromoaniline

Determination of melting point of an unknown sample.

(Urea, Benzamine, Salicylic acid and Benzoic acid)

Chemical kinetics Experiments – Procedure writing

1. Study the hydrolysis of methyl acetate in presence of two different concentrations of HCl and report the relative strength.
2. Analysis of a binary mixture of two miscible liquids and to determine the composition of the given unknown mixture.
3. Evaluation of Arrehenius parameter for the reaction between $K_2S_2O_8$ versus KI (first order).
4. Study the hydrolysis of methyl acetate in the presence of HCl at different temperatures and report the energy of activation.
5. Study of variation of viscosity of a liquid with temperature, determine the constant A and B.

Reference Books:

1. Comprehensive practical organic chemistry: Preparation, Quantitative and quantitative Analysis by Nandeshwarappa, B P (2017)
2. Advanced Practical Organic Chemistry, Second Edition June 1994 by John Leonard, Barry Lygo, Garry Procter
3. Experiments in Physical Chemistry, Sixth Edition (by David P. Shoemaker, Carl W. Garland, and Joseph W. Nibler), May 1997.

Discipline Core Course

VI – Semester

Inorganic chemistry - IV & Physical chemistry - IV

Title of the Course: DSC-7: **Course Code: CHE-601T**

Number of Theory Credits	Number of lecture hours/ semester	Number of practical Credits	Number of practical hours/ semesters
4	56	2	56

Course Outcomes:

1. To develop a solid understanding of the different materials used in industry, including their properties, applications, and manufacturing processes.
2. To acquire an understanding of various fertilizer types, their categorization, and the production methods for different fertilizers.
3. To understand the various nanostructures and their classification and knowledge of conducting polymers, superconductors, and fullerenes.
4. To understand the concepts of nanomaterial, conducting polymers, superconductors, and fullerenes.
5. A comprehensive understanding of electro analytical methods about voltammetry, including polarography and cyclic voltammetry, and thermal methods of analysis.
6. To understand the fundamental principles of thermodynamics and apply these concepts effectively to solve practical problems.
7. To understand the fundamental principles of instrumental analysis.
8. To understand the physical properties, molecular structures, and the practical applications of concepts like pyro electricity, piezoelectricity, ferroelectricity, and various electrical effects.

INORGANIC CHEMISTRY – IV (28 Hours)

UNIT - I

Industrial Materials- I 6 Hours

Refractories: Definition**.** Properties of a good refractory, classification, determination of PCE values.

Abrasives: Definition and classification with examples, applications, hardness-definition andmagnitude of hardness, manufacture and importance of carborandum and tungsten carbide.

Glass: Properties, types, manufacture of soda glass. Composition and applications of borosilicate,metallic glass, optical glasses and polycarbonate glass, safety glass, fire and bullet proof glasses.

Ceramics: Raw materials and their roles, varieties of clay, production of ceramic ware, glazing,ceramic insulators.

Cement: Raw materials, manufacture of Portland cement (by wet process), setting of cement, role of water and gypsum.

Industrial Materials - II 7 Hours

Paints and Varnishes: Constituents of oil and emulsion paints and their role. Constituents of varnishes.

Fuels: Characteristics, calorific value - definition and its determination using bomb calorimeter.

Coal – varieties. Gaseous fuels- advantages, constituents and their significance. Production of Coalgas, composition of LPG. Octane number-definition and significance.

Explosives: Classification, preparation of dynamite and TNT. Propellants: Characteristics, classification and their applications.

Fertilisers 4 Hours

Different types of fertilizers (definition and examples) Classification based on agrochemical nature (Direct and Indirect) Based on number of basic nutrients (Simple, double/triple, micro and complex) Based on application (Single and mixed fertilizers)

Manufacture of the following fertilizers (Method, drying and finishing)

Urea (Sindri method), Ammonium nitrate (Production-Prilling process, drying- Stengel process; Finishing- Nitrochalk / parting agents), Calcium ammonium nitrate (From ammonia. nitric acid and limestone), Ammonium phosphates and polyphosphate (from ammonia and phosphoric acid), Superphosphate (from rock phosphate and sulphuric acid), Potassium

chloride (Manufacture from Carnallite, Sylvinite), Potassium sulphate (Manufacture from Kainite).

Chemistry of Newer materials 11 Hours

Nanomaterials: Overview of nanostructures and nanomaterials (Introduction, Nanostructures - types with examples. Nano materials-Size, shape, specific surface area, crystallinity, solubility and surface morphology; Reasons for special properties attributed to materials with nano size) Classification(Classification of nano materials based on dimensions & type of material - organic, inorganic) Preparation of gold and silver metallic nanoparticles (Turkevich method) self-assembled nanostructures (definition, types of synthesis). Carbon nanotubes (definition, SWCNT & MWCNT, brief structure & applications) and inorganic nanowires (examples).

Conducting polymers: Introduction, definition and examples- polyaniline, polyacetylene. Mechanism of conduction. Qualitative treatment of doping. Properties: elasticity with high electricalconductivities, Engineering and biological applications.

Superconductors: Introduction, definition, type-1, type-2 and atypical. Preparation of high temperature superconductor- $Y_1Ba_2Cu_3O_{x\pm\delta}$. BCS theory (qualitative treatment only) and general applications of high temperature super conductors.

Fullerenes: Introduction, definition, preparation and isolation of C_{60}. Structure and chemical reactions (redox reactions, electrophilic aromatic substitution and bromination) of C_{60}.Commercial uses of C60.

PHYSICAL CHEMISTRY – IV (28 Hours)

Electroanalytical methods 12 Hours

Introduction. Classification of electroanalytical methods (explanation of the principle of pH meter, conductometer and potentiometer). Potentiometric (acid base and redox, calibration, choice of electrodes) and conductometric (acid base - 4 types, conductivity cell, cell constant and its determination) titrations. Techniques used for the determination of equivalence points (comparison of use of indicator and graphical method). Techniques used for the determination of pKa values (conductometry and potentiometry). Advantages of conductometric and potentiometric methods.

Voltametry: Polarography – Type of mercury electrodes – types of mass transport – Faradaic and non-Faradaic currents. Polarogram – sign conventions.

Cyclic voltametry: Principle – explanation of electro-oxidation and electro-reduction based on Frontier orbitals. Reversible and irreversible and quausi reversible electrochemical processes. Ilkovic equation and its applications. Current - potential relation for a cathodic process - half wave potential and its significance. Experimental setup for electrochemical reversible system based on potassium ferricyanide.

Thermal methods of analysis: (Introduction to gravimetry) Theory of thermogravimetry (TG), basic principle of instrumentation. Techniques for quantitative estimation of Ca and Mg.

Thermodynamics 8 Hours

Gibb's-Helmholtz equation - derivation from dG = VdP – SdT. Concepts of partial molar properties - partial molar free energy, chemical potential, partial molar volume and its significance. Derivation of Gibbs-Duhem equation.

Concept of fugacity: Determination of fugacity by graphical method. Activity and activity coefficient and its significance.

Derivation of van't Hoff reaction isotherm, van't Hoff reaction isochore and Clausius-Clapeyron equation. The application of Clausius-Clapeyron equation to the determination of ΔT_b and ΔT_f (in detail with derivations). Numerical problems. Nernst heat theorem (qualitative treatment only).

Flame atomic and absorption spectrometry 4 Hour

Basic principles of instrumentation (choice of source, monochromator, detector, choice of flame and burner designs). Techniques of atomization and sample introduction. Method of background correction. Sources of chemical interferences and their method of removal.

Physical properties and Molecular structures 4 Hours

Dipole moment (a brief review). Polarization and orientation of dipoles in an electric field. Clausius-Mossotti equation (derivation). Electrical properties of solids: types of solids-metals, insulators and semiconductors. Pyroelectricity, piezoelectricity, ferroelectricity, inverse piezoelectricity. Definition and examples. Thomson effect, Seebeck effect and Peltier effect - definitions with examples.

Reference Books:

1. C. A. Heaton, An Introduction to Industrial Chemistry, Springer Science and Business Media, 1996.
2. B. K. Sharma, Industrial Chemistry Part-1, Krishna Prakashan, 2023.
3. R. M. Felder, R. W. Rousseau: Elementary Principles of Chemical processes, Wiley Publishers, New Delhi.
4. W. D. Kingery, H. K. Bowen, D. R. Uhlmann: Introduction to Ceramics, Wiley publishers, New Delhi.
5. Vandana Meshram, A text book of Industrial Chemistry, Educational Publisher and Distributor, 2017.
6. Geoffrey A. Ozin , Andre C. Arsenault, Ludovico Cademartiri, Chad A. Mirkin, Nano

chemistry: A Chemical Approach to Nanomaterials, 2nd edition, Royal Society of Chemistry, 2003.

7. Charles P. Poole, Frank J Owens, Introduction to Nanotechnology, Wiley-Interscience, 2008.

8. Colin.N. Banwell and Elaine M, Fundamentals of Molecular Spectroscopy, 4th edition, McGraw Hill Education,2017.

9. Puri, Sharma, Pathania, Principles of Physical Chemistry, 48th edition, Vishal Publishing company.

10. Barrow, G.M. Physical Chemistry Tata McGraw-Hill (2007).

VI Semester B.Sc., Practical

Course Title: Physical chemistry-IV

Course Code: CHE-601P

Formative Assessment (Internal assessment) Practicals.	
Assessment Occasion/ type	**Weightage in Marks**
Continuous evaluation and class test	20
Record/viva voce	05
Total	**25**

Course Outcome:

1. To estimate the analytes through conductometric and potentiometric titration methods.
2. To demonstrate skills in pH meter to assess pKa values, pH, the degree of hydrolysis, dissociation constants, and isoelectric points in various compounds.

Practical 7 – Physical chemistry-IV

I. Determination of percentage of sodium chloride by finding the CST of phenol-water system. – To perform

II. Potentiometric Experiments – To perform

1. To estimate the amount of potassium dichromate using FAS potentiometrically.
2. Determination of dissociation constant of H_3PO_4 using potentiometric method.Acid mixture versus NaOH.
3. Titration of weak acid against a strong base using quinhydrone electrode and calculation of pK_a and K_a of the weak acid.

pH metric Experiments – To Perform

1. Determination of pK_a value of phosphoric acid by pH meter.
2. Determination of pH of acetic acid with sodium acetate buffer by pH metry method.
3. Determination of degree of hydrolysis of aniline hydrochloride at room temperature and calculation of dissociation constant of the base by pH metry.
4. To determine the acidic and basic dissociation constant of an amino acid and determination of isoelectric point by pH metry.

Conductometric Experiments – Procedure writing

1. Conductometric titration of weak acid versus weak base.
2. Acid mixture versus NaOH.
3. Weak acid with salt versus NaOH.
4. Strong acid with salt versus NaOH.
5. Determination of pH of a buffer by using quinhydrone electrode and comparison of the pH values obtained with glass electrode.

Reference Books:

4. Experiments in Physical Chemistry, Sixth Edition (by David P. Shoemaker, Carl W. Garland, and Joseph W. Nibler), May 1997.
5. Khosla, B. D.; Garg, V. C. & Gulati, A. Senior Practical Physical Chemistry, R.Chand & Co.: New Delhi (2011).
6. 4. Garland, C. W.; Nibler, J. W. & Shoemaker, D. P. Experiments in Physical Chemistry8th Ed.; McGraw-Hill: New York (2003).
7. 5. Halpern, A. M. &McBane, G. C. Experimental Physical Chemistry 3rd Ed.; W.H.Freeman & Co.: New York (2003).

Organic chemistry - IV & Spectroscopy – II

Title of the Course: DSC-8: **Course Code: CHE-602T**

Number of Theory Credits	Number of lecture hours/ semester	Number of practical Credits	Number of practical hours/ semesters
4	56	2	56

Course Outcome:

1. Recognize and classify heterocyclic compounds based on their ring structures and heteroatoms.
2. Understand the principles and strategies involved in the total synthesis of complex natural products.
3. A thorough knowledge of the structure, chemistry and functions of biomolecules like carbohydrates, lipids and proteins
4. To understand the various polymers, their preparation, structure, properties, and applications.
5. A comprehensive understanding of chemotherapy and drug classification and synthesis of specific drugs and the structure and uses of important antibiotics
6. The basic characteristics of enzyme and its classification, mechanism enzyme action, enzyme kinetics, enzyme inhibition and co-enzymes
7. A comprehensive understanding of the classification of vitamins and their biological significance.
8. To introduce students to various spectroscopic techniques, including UV-Vis, IR, NMR, and their applications in organic compound analysis.

ORGANIC CHEMISTRY – IV (42 Hours)

Heterocyclic compounds 5 Hours

Introduction: Nomenclature of heterocyclic compounds. Aromaticity of pyrrole, furan, thiophene and pyridine. Comparison of their aromaticity and with benzene Structure, reactivity, synthesis and reactions of: pyrrole, furan, thiophene, pyridine. Structures of indole, pyrimidine and purine.

Chemistry of Natural Products 12 Hours

Carbohydrates: Introduction and classification (based on number of monosaccharide units and sugarsand non-sugars) with examples. Monosaccharides: Definition with examples, classification of monosaccharides (based on functional group).

Aldoses: Structures of D-aldohexoses (glucose, galactose and mannose). Open and Haworth structures. Epimers (Example: D-galactose and D-glucose, D-glucose and D-mannose). Elucidationof open chain structure of D-glucose. Limitations of open chain structure of glucose. Mechanism of mutarotation and anomeric effect.

Elucidation of ring structure and size of D-glucose by oxidation with HIO_4 and HNO_3.

Ketoses: Structure of fructose-pyranose and furanose forms. Inter-conversion of glucose and fructoseDisaccharides: Definition with examples. Formation of glycosidic bond with examples. Haworth and conformational structures of maltose, lactose and sucrose.

Terpenes and terpenoids: Occurrence, isoprene rule and classification (on the basis of number of isoprene units, acyclic and cyclic). Elucidation of structure and synthesis of citral (from methyl heptenone) and zingiberene (from methylheptenone and *p*-methoxyphenylmagnesium bromide). Structures and uses of limonene, menthol, α-terpineol, and camphor.

Alkaloids: Introduction, classification (based on heterocyclic ring present) and general characteristics. Structural elucidation and synthesis of nicotine (from succinimde). Structures and uses of ephedrine, caffeine, cocaine, atropine, quinine and morphine.

Polymers 5 Hours

Brief introduction (definition of polymers and polymerization); preparation, structure, properties and application of the following polymers: Polyolefins – polystyrene and styrenecopolymers (BUNA-S), polyvinyl acetate. Acrylic polymers – polyacrylonitrile. Fluoropolymers - teflon, Polyamides - nylon-6,6. Phenol formaldehyde resins – Bakelite. Polyurethanes. Silicone polymers and Polycarbonates.

Pharmaceutical chemistry 4 Hours

Chemotherapy. Drugs: classification of drugs (i) drugs used for the treatment of diseases due to infection (antimalarial, sulpha drugs, antibiotics and antiseptic drugs with examples) (ii) drugs used for the treatment of diseases not due toinfection (antipyretics, analgesics, anesthetics, tranquilizers and hypnotics, narcotics, anticonvulsants, cardiac or cardiovascular and diuretics drugs with examples**).** Synthesis of (i) asprin (from phenol), (ii), paracetamol (from phenol), (iii) chlorophenaramine, (iv) sulphanilamide (from acetanilide). Structure and uses of (i) Penicillin and (ii) cephalosporin.

Lipids 5 hours

Introduction, Classification -simple, complex and derived with examples.

Fatty acids: definition, classification as saturated and unsaturated with examples and structure (lauric, myristic, palmitic, stearic, oleic, linoleic, linolenic and arachidonic acids). Essential fatty acids - definition with examples.

Triglycerides: Structure of simple and mixed glycerides, properties of triglycerides- acid and alkali hydrolysis, saponification number and its significance, iodine number and its significance, rancidity (oxidative and hydrolytic), causes and prevention. Biological importance of triglycerides.

Phosphoglycerides: General structure of 3-Sn–phosphatidic acid, lipid bilayer (as in cell membrane), micelles, liposomes and its applications, structure and biological importance of lecithin, cephalin, phosphatidylserine, phosphatidylinositol.

Cholesterol: structure, biological & clinical significance.

Amino acids & Protiens 5 Hours

α - *Amino acids*: introduction, structure, classification on the basis of polarity of R - groups, essential and non-essential amino acids. Preparation of glycine by Gabriel method. zwitter ion, reaction of amino acids with Ninhydrin, peptide bond, Sanger's, Edman's reaction and their significance.

Proteins: levels of organisations of proteins: primary, secondary, tertiary and quaternary structures with examples (α - helix, β - pleatedsheet, triple helix and heamoglobin). Denaturation and renaturation. Anfinsen's experiment; separation of proteins by PAGE.

Enzymes 4 hours

Introduction, holoenzyme (apo enzyme and co-enzyme). Active site, specificity (Group, absolute andstereo selectivity with examples). Classification of enzymes (EC code number not required) with examples.Enzyme substrate interaction- Fischer and Koshland models.

Enzyme kinetics - factors affecting rate of enzymatic reactions - enzyme concentration, substrateconcentration (mention M. M. equation), pH and temperature. Allosteric enzymes - definition and example. Enzyme inhibitions - Competitive, noncompetitive and uncompetitive inhibition with one example foreach.

Vitamins 2 Hours

Classification. Biological importance and deficiency symptoms of Vitamins A, Vitamin B1 (thiamine), Vitamin B6 (pyridoxine), folic acid, pantothenic acid, riboflavin, Vitamin C, Vitamin E (α-tocopherol), Vitamin H (biotin), Vitamins K_1 and K_2.

SPECTROSCOPY – II: **Organic Spectroscopy** (14 Hours)

UV Spectroscopy 4 Hours

Introduction. Types of electronic transitions, λ_{max}, Chromophores and Auxochromes, Bathochromic and Hypsochromic shifts. Beer-Lambert's law. Woodward – Fieser rules for calculation of λ_{max} Conjugated dienes and α, ß unsaturated carbonyl compounds. Influence of conjugation on λ_{max} absorption in UV-Visible region. Comparison of UV spectra of acetone and methyl vinyl ketone. Graphical representation of spectra of 1,3-butadiene, benzene and lycopene. Applications of UV-Visible spectroscopy.

IR Spectroscopy 4 Hours

Introduction. Basic priniciples of IR Spectroscopy. Conditions for IR active organic compounds. Stretching and bending modes of vibrations. Factors affecting the position of IR absorption peak (atomic and force constant-electronic effects and hydrogen bonding). Types of IR region (functional group region and finger print region). Explanation of stretching frequencies of –OH (free and H-bonded), alkyl C–H, alkenyl C–H, alkynl C–H, C–C, C = C, C–O and C = O groups. (IR spectra of benzene, ethanol, phenol, acetaldehyde, acetone and acetic acid – mention the absorption of functional groups and their identification). Applications of IR spectroscopy.

Nuclear Magnetic Resonance spectroscopy 6 hours

Basic principles of proton magnetic resonance: Nuclear magnetic spin quantum number I, influence of the magnetic field on the spin of nuclei, spin population, saturation using radio frequency. Nuclear magnetic resonance. Chemical shift (δ values), uses of TMS as reference. Nuclear shielding and de-shielding effects. Equivalent and non-equivalent protons. Effect of: (i) electronegativity of adjacent atoms (ii) magnetic induction by pi (π) electrons-Magnetic anisotropy on chemical shift values. Spin-spin splitting and spin-spin coupling (qualitative treatment only). H-NMR spectra of: (i) methane (ii) CH_3–Cl (iii) CH_2Cl_2 and (iv) $CHCl_3$ using –I effect. First order splitting rules: Spectra of: (i) Cl_2CHCHO (ii) 1,1,2- trichloroethane and (iii) CH_3CH_2Cl

Reference Books:

1. Kalsi, P S Textbook of Organic chemistry 1st ed., New Age International (P) Ltd. Pub.
2. Finar, I L, Organic Chemistry (Volume 2: Stereochemistry and the Chemistry of Natural products), (Pearson Education)
3. Organic Chemistry M. K. Jain, Nagin & Co., 1987.
4. A Guide to Mechanism in Organic Chemistry P. Sykes, Orient Longman, 2005.

5. Organic Spectroscopy V. R. Dani, Tata McGraw Hill, 1998.

6. Organic Spectroscopy W. Kemp, ELBS IV Edition, 1998.

7. Synthetic Drugs G. R. Chatwal, Himalaya Publications, 2000.

8. Clayden J, Greeves N, and Warren S, Organic Chemistry, 2nd Edition, Oxford UniversityPress, New York, 2012.

9. Smith M B, and March J, March's Advanced Organic Chemistry, 6th Edition, John-Wileyand Sons, New York, 2007.

10. Pavia D L, Lampman G M, Kriz G S and Vyvyan J R, Introduction to Spectroscopy, 5thEdition, Cengage Learning, Delhi, 2015.

VI Semester B.Sc., Practical

Course Title: Organic Chemistry-IV

Course Code: CHE-602P

Formative Assessment (Internal assessment) Practicals.	
Assessment Occasion/ type	**Weightage in Marks**
Continuous evaluation and class test	20
Record/viva voce	05
Total	**25**

Course Outcome

1. To develop skills in quantitative analysis of amino acids, ketones, and phenols.
2. To learn the importance of qualitative tests in carbohydrates and proteins.
3. To expertise in synthesizing a variety of organic compounds.

Practical 8 – Organic chemistry-IV

I. Quantitative analysis

1. Titrimetric estimation of amino acids.
2. Saponification value of oil.
3. Estimation of glucose by Fehling's method.
4. Estimation of keto group.
5. Estimation of phenols.
6. Iodine value of oil (chloramine-T method).

II. Qualitative Test for Carbohydrates and Proteins

III. Preparation (Two / three stages)

1. 2,4-Dinitrophenylhydrazine from chloronitrobenzene.
2. Anthranilic acid from phthalic acid.
3. Benzanilide from benzophenone.
4. Benzilic acid from be

Reference Books:

1. A Handbook of Organic Analysis 4th edition (2014) CBS Publishers & Distributors.

2. Comprehensive practical organic chemistry: Preparation, Quantitative and quantitative Analysis by Nandeshwarappa, B P (2017)

3. Advanced Practical Organic Chemistry, Second Edition June 1994 by John Leonard, Barry Lygo, Garry Procter