MAA PATESWARI UNIVERSITY, BALRAMPUR

FOUR YEARS

B. Sc. CHEMISTRY Program

Syllabus

(For the Academic Session-2025 onwards)

Maa Pateswari University, Balrampur

B.Sc. Chemistry

S. No.	Semester	Paper	Paper Name	No of Credits
1	B.Sc. I Sem	CHM-101	Fundamentals of Chemistry	4+0
2	B.Sc. I Sem	CHM-102	Qualitative Analysis (*Practical*)	0+2
3	B.Sc. II Sem	CHM-103	Basic Organic Chemistry, Solid State and Chemistry of s- and p-block Elements	4+0
4	B.Sc. II Sem	CHM-104	Chemical Analysis (*Practical*)	0+2
5	B.Sc. III Sem	CHM-201	Chemical Dynamics, Organic & Coordination Chemistry	4+0
6	B.Sc. III Sem	CHM-202	Physical Analysis (*Practical*)	0+2
7	B.Sc. IV Sem	CHM-203	Quantum Mechanics & Organic Synthesis-A	4+0
8	B.Sc. IV Sem	CHM-204	Separation Technique and Volumetric Analysis (*Practical*)	0+2
9	B.Sc. V Sem	CHM-301	Analytical Techniques and Organic Synthesis-B	4+0
10	B.Sc. V Sem	CHM-302	Polymer, Coordination and Inner-Transition Metal Chemistry	4+0
11	B.Sc. V Sem	CHM-303	Qualitative and Quantitative Analysis (*Practical*)	0+2
12	B.Sc. VI Sem	CHM-304	Organic Synthesis-C	4+0
13	B.Sc. VI Sem	CHM-305	Chemical Energetics & Bioinorganic Chemistry	4+0
14	B.Sc. VI Sem	CHM-306	Physico-Chemical Analysis and Organic Synthesis (*Practical*)	0+2
15	B.Sc. VII Sem (B.Sc. Chemistry Honours)	CHM-401	Molecular Symmetry and Molecular Vibrations	4+0
16		CHM-402	Quantum Chemistry-I	4+0
17		CHM-403	Main Group Elements	4+0
18		CHM-404	Organic Reaction Mechanism	4+0
19		CHM-405	Surface Chemistry, Purification and Identification of Materials (*Practical*)	0+4
20	B.Sc. VIII Sem (B.Sc. Chemistry Honours)	CHM-406	Analytical Chemistry	4+0
21		CHM-407	Thermodynamics and Electrochemistry	4+0
22		CHM-408	Transition Elements	4+0
23		CHM-409	Natural Products	4+0
24		CHM-410	Chemical Kinetics, Separation and Identification of Binary Inorganic/Organic Mixtures (*Practical*)	0+4

Maa Pateswari University, Balrampur

SUBJECT: CHEMISTRY

(Four Year Undergraduate Course Structure)

Purpose of the Program
The purpose of the undergraduate chemistry program is to equip students with essential knowledge and laboratory skills, preparing them for successful careers as professionals in diverse industries and research institutions.
Program Specific Outcomes
PSO1: Demonstrate a strong foundation in the fundamental principles and applications of contemporary chemical and scientific theories, encompassing Analytical, Inorganic, Organic, and Physical Chemistry. **PSO2:** Design and conduct scientific experiments, accurately record observations, and critically analyse experimental data to draw valid conclusions. **PSO3:** Apply problem-solving skills, critical thinking, and analytical reasoning to address complex scientific challenges. **PSO4:** Explore emerging areas of research in chemistry and related fields of science and technology. **PSO5:** Recognize the pivotal role of chemistry in society and uphold ethical principles in professional practice, including safe handling of chemicals, environmental responsibility, and awareness of key issues in energy, health, and medicine. **PSO6:** Explain and demonstrate how chemistry contributes to addressing social, economic, and environmental challenges. **PSO7:** Collaborate effectively as a member of an interdisciplinary team to solve scientific and technological problems.

Maa Pateswari University, Balrampur

MAA PATESWARI UNIVERSITY BALRAMPUR

B.Sc. I Year (CHEMISTRY)

Semester-I

(Four Year Undergraduate Course Structure)

CHM 101: Fundamentals of Chemistry	**Credit 4+0**

Course Outcomes:

This course will provide a broad foundation in chemistry that stresses scientific reasoning and analytical problem solving with a molecular perspective. Students will gain an understanding of

- Brief introduction of ancient Indian chemists.
- Basics of mathematical concepts of log, permutation and combination, differention and integration of some relevant functions.
- Molecular geometries, physical and chemical properties of the molecules.
- Current bonding models for simple inorganic and organic molecules to predict structures and important bonding parameters.
- The chapter Recapitulation of basics of organic chemistry gives the most primary and utmost important knowledge and concepts of organic Chemistry.
- This course gives a broader theoretical picture in multiple stages in an overall chemical reaction. It describes reactive intermediates, transition states and states of all the bonds broken and formed.
- The chapters Chemistry of alkanes and cycloalkanes gives the clear picture of singly bonded structure and geometry of the molecules.

Units	**Topics**	**Hours**
I	**Ancient Indian Chemists:** Contribution of Charaka, Sushruta and Nagarjuna in the development of chemistry in ancient India. **Mathematical Concepts:** Logarithmic relations, equation of straight line and slopes, tracing of curves, differentiation of simple functions like x, e^x , x^n, sin x, log x; maxima and minima, partial differentiation. Integration of some useful/relevant functions; Factorials	**5**
II	**Atomic Structure and Bonding Theories of Molecules:** Shapes of s, p and d orbitals, The valence bond theory (VBT) and its limitations, Concept of hybridization, hybrid orbitals and molecular geometry, Bent's rule, Valence shell electron pair repulsion (VSEPR) theory, shapes of the following simple molecules and ions containing lone pairs and bond pairs of electrons: H_2O, NH_3, PCl_5, SF_4, SF_6, ClF_3, I_3^-, ClF_2^- and SO_2^- and H_3O^+. Molecular orbital theory (MOT). Molecular orbital diagrams, bond orders of homonuclear and heteronuclear diatomic molecules and ions (N_2, O_2, C_2, B_2, F_2, CO, NO, and their ions), Hydrogen-bonding-Theory and Applications	**10**

III	**Periodic properties of Atoms:** Brief discussion of modern periodic table, factors affecting and variation trends of following properties in groups and periods. Effective nuclear charge, shielding or screening effect, Slater rules, Atomic and ionic radii, electronegativity, Pauling's/Allred Rochow's scales, Ionization enthalpy, electron gain enthalpy, polarizing power and polarizability	**10**
IV	**Gaseous state:** Basic characteristic of gases and associated laws, **Kinetic theories of gases**: Postulates of kinetic theory of gases, deviation from ideal behavior, van der Waals equation of state. **Critical phenomena:** PV isotherms of real gases, continuity of states, the isotherms of Van der Waals equation, relationship between critical constants and Van der Waals constants, the law of corresponding states, reduced equation of state. **Molecular Velocities:** Qualitative discussion of Maxwell's Distribution of molecular velocities (V_{mp}, V_{rms} and V_{avg}).	**10**
V	**Recapitulation of basics of Organic Chemistry:** Hybridization of organic molecules, bond parameters (bond lengths, bond angles and bond energy) and its variation with hybridization, localized and delocalized chemical bonding; **Electronic Displacements:** Inductive, electromeric, resonance/mesomeric effects, hyperconjugation and their applications in acidic and basic strength of simple organic molecules	**10**
VI	**Mechanism of Organic Reactions:** Arrow notations in chemistry, drawing electron movements with arrows, homolytic and heterolytic bond fission, **Types of reagents**: electrophiles and nucleophiles, **Types of organic reactions**-Addition, Elimination and Substitution reactions, Energy Profile of reactions. **Reactive intermediates** Carbocations, carbanions, free radicals, carbenes	**5**
VII	**Chemistry of Alkanes and Cycloalkanes** **A) Alkanes:** Classification of carbon atom in alkanes, General methods of preparation, physical and chemical properties of alkanes, Free radical substitutions: Halogenation -relative reactivity and selectivity **(B) Cycloalkanes:** Nomenclature, Baeyer's strain theory and its limitations. Chair, Boat and Twist boat forms of cyclohexane with energy diagrams, ring strain in small rings, theory of strain less rings. The case of cyclopropane ring, banana bonds.	**10**

Suggested Readings:

1. J.D. Lee, Concise Inorganic Chemistry, Pearson Education2010
2. Puri, Sharma and Kalia, Principles of Inorganic Chemistry, Milestone Publishers
3. Puri, Sharma and Pathania, Principles of Physical Chemistry, Vishal Publishing Co

4. P W Atkins, Atkins Physical Chemistry, Oxford Press
5. Morrison & Boyd, *Organic Chemistry*, *Dorling Kindersley* (India)Pvt. Ltd. (Pearson Education).
6. Clayden, Greeves, & Warren, *OrganicChemistry*,2nd edition, Oxford University Press,2012.
7. V. Subramanian. A Textbook of Environmental Chemistry, Dreamtech Press/Wiley
8. स्वामी सत्य प्रकाश सरस्वती, प्राचीन भारत मे रसायन का विकास, प्रकाशक: पुस्तकायन नयी दिल्ली

Note: For the promotion of Hindi language, course books published in Hindi may be prescribed by the University

Suggested online links:

1. http://heecontent.upsdc.gov.in/Home.aspx
2. https://nptel.ac.in/courses/104/106/104106096/
3. http://heecontent.upsdc.gov.in/Home.aspx
4. https://nptel.ac.in/courses/104/106/104106096/
5. https://nptel.ac.in/courses/104/103/104103071/#

Suggested Continuous Evaluation Methods: Students can be evaluated on the basis of score obtained in a mid-term exam, together with the performance of other activities which can include short exams, in-class or online tests, home assignments, group discussions or oral presentations, among others. **Or**

Assessment and presentation of Assignment	(10 marks)
04 tests (Objective): Max marks of each test = 10(average of all 04 tests)	(10 marks)
Overall performance throughout the semester, Discipline, participation in different activities)	**(**05 marks)

Course prerequisites: To study this course, a student must have had the chemistry in class 12th

Suggested equivalent online courses:……

Further Suggestions…..……..……

Maa Pateswari University, Balrampur

B.Sc. I Year (CHEMISTRY)

Semester-I Practical

(Four Year Undergraduate Course Structure)

CHM 102: Qualitative Analysis	**Credit 0+2**

Course outcomes:

Upon completion of this course the students will have the knowledge and skills to understand the laboratory methods and tests related to estimation of metals ions and estimation of acids and alkali contents in commercial products.

- Potability tests of water samples
- Estimation of metal ions in samples
- Estimation of alkali and acid contents in samples
- Estimation of inorganic salts and hydrated water in samples

Units	Topics
I	**Qualitative analysis of Inorganic mixture containing four radicals** $NH4^{+}$, Na^{+}, K^{+}, Mg^{++}, Ca^{++}, Sr^{++}, Ba^{++}, Zn^{++}, Mn^{++}, Ni^{++}, Co^{++}, Al^{+++}, Fe^{+++}, Cr^{+++}, Cu^{++}, Bi^{++}, Cd^{++}, As^{+++}, Sb^{+++}, Sn^{++}, Pb^{++}. CO_3^{2-}, NO_2^{-}, S^{2-}, SO_3^{2-}, SO_4^{2-}, F^{-}, Cl^{-}, Br^{-}, NO_3^{-}, CH_3COO^{-}.
II	**Estimation of Hardness of Water by EDTA Method**
III	**Crystallization and Determination of melting point with calibrated thermometer** (i) Benzoic Acid (ii) Acetanilide
IV	**Preparation of standards solutions by titration** Dilution 0.1M to 0.001M solutions, Mole concept and preparation of molar, formal, normal and molal solution.

Suggested Readings:

1. Mendham, J., Vogels Quantitative Chemical Analysis, Pearson
2. Harris, D. C. *Quantitative Chemical Analysis*. 6th Ed., Freeman (2007) Chapters 3-5.
3. Harris, D. C. *Exploring Chemical Analysis*, 9th Ed. New York, W.H. Freeman, 2016.
4. Khopkar, S.M. *Basic Concepts of Analytical Chemistry*. New Age International Publisher, 2009.
5. Skoog, D.A. Holler F.J. and Nieman, T.A. *Principles of Instrumental Analysis*, Cengage Learning India Edition

Suggestive digital platforms web links

1. https://www.labster.com/chemistry-virtual-labs/

2. https://www.vlab.co.in/broad-area-chemical-sciences
3. http://chemcollective.org/vlabs

Maa Pateswari University, Balrampur

B.Sc. I Year (CHEMISTRY)

Semester-II

(Four Year Undergraduate Course Structure)

CHM 103: Basic Organic Chemistry, Solid State and Chemistry of s and p-Block Elements	**Credit 4+0**

Course outcomes: This course will provide a broad foundation of –

- Unsaturated hydrocarbons.
- Basic understanding of stereochemistry of organic compounds
- Basic understanding of liquid and solid state
- Chemistry of s and p-block elements and noble gases.
- Brief introduction of food preservatives
- To introduce the contribution from Ancient Indian Chemists to modem science

Units	**Topics**	**Hours**
I	**Chemistry of Alkenes:** Methods of formation of alkenes, Reactions of alkene (i) addition of hydrogen, halogens, halogen acids, water and sulphuric acid and (ii) Hydroboration, epoxidation, ozonolysis and *bis*-hydroxylation.	**10**
II	**Chemistry of Alkynes:** Methods of formation of alkynes, Elementary treatment of mechanism of addition reactions of carbon-carbon triple bond- hydrogenation, halogenations, hydrohalogenation and hydration reactions.	**5**
III	**Stereochemistry:** Concept of isomerism, Types of isomerism. **Optical isomerism**: Concept of chirality, elements of symmetry, Optical isomerism of compounds containing one (lactic acid) and two asymmetric carbons (tartaric acid). Methods of racemization and resolution, (iii) **Geometrical isomerism**: Maleic & fumaric acid and methods for determination of their configurations. **Projection of organic molecules**: Wedge-Dash, Fischer, Sawhorse and Newman projection; **Relative and Absolute configuration**: D-L, R-S and E-Z nomenclatures, Conformations of ethane and *n*-butane, Conformation of cyclohexane and stability of monosubstituted cyclohexane.	**10**
IV	**Liquid State:** Intermolecular forces, structure of liquids (a qualitative description). Structural differences between solids, liquids and gases. Liquid crystals: Difference between liquid crystal, solid and liquid. Classification, structure of nematic and smectic and cholesteric phases. Thermography and seven segment cells.	**5**

V	**Solid State:** Definition of space lattice, Units cell and its types, Radius-Ratio rule, Laws of crystallography (i) Law of constancy of interfacial angles, (ii) Law of rationality of indices and (iii) Symmetry elements in crystals and law of symmetry, Miller Indices, X-ray diffraction by crystals. Derivation of Bragg's equation. Determination of crystal structure of NaCl and KCl.	**10**
VI	**Chemistry of s-Block Elements** Electronic configuration, general characteristic properties of alkali and alkaline earth metals; Anomalous behaviour of Li and Mg. Diagonal relationship between Li and Be, Mg and Al. General trend in properties of their hydrides, oxides and hydroxides.	**5**
VII	**Chemistry of p-Block Elements** Electronic configuration, general characteristic properties of p-block elements. Preparation, properties, structure, and applications of diborane, borazine, fullerenes, carbides, fluorocarbons, silicates (structural principles), tetra-sulphur tetra-nitride; classification and structures of interhalogens. Structures and properties oxyacids of phosphorus and sulphur. **Noble Gases** General characteristic properties of noble gases. Preparation, properties, structure, bonding and applications fluorides of xenon (XeF_2, XeF_4, and XeF_6). Structure and bonding of oxides of xenon (XeO_3 and XeO_4) and oxyfluorides of xenon ($XeOF_2$, $XeOF_4$, and XeO_2F_2).	**10**
VIII	**Food Preservatives and Additives:** Need for food preservation, **Natural vs. artificial preservatives**, Common food preservatives: Sodium benzoate, nitrates, citric acid, Sulphur dioxide, Adverse effects of overconsumption of food additives, Safety regulations and permissible limits (FSSAI, WHO guidelines)	**5**

Suggested Readings:

1. Finar, I. L. *Organic Chemistry* (*Volume 2)*, Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
2. Ball, D. W. *Physical Chemistry* Thomson Press, India (2007).
3. Castellan, G. W. *Physical Chemistry* 4th Ed. Narosa (2004).
4. Puri, Sharma and Kalia, *Principles of Inorganic Chemistry*, Milestone Publishers
5. Puri, Sharma and Pathania, *Principles of Physical Chemistry*, Vishal Publishing Co
6. Gem Mathew, G. D.; *Chemistry in Everyday Life*; Vishal Publishing Co

Maa Pateswari University, Balrampur

B.Sc. I Year (CHEMISTRY)

Semester-II Practical

(Four Year Undergraduate Course Structure)

CHM 104: Chemical Analysis	**Credit 0+2**

Course outcomes:

This course will provide basic qualitative and quantitative experimental knowledge of biomolecules such as carbohydrates, proteins, amino acids, nucleic acids drug molecules. Upon successful completion of this course students may get job opportunities in food, beverage, and pharmaceutical industries.

Units	Topics
I	Separation and identification of amino acids present in given mixture by paper chromatography and determination of Rf values
II	**Surface Tension and Viscosity** Determination of Surface Tension and Viscosity of liquid
III	**Preparation of Inorganic Compounds** Tetraamminecopper(II)sulphate *Bis*-(dimethylglyoximato)nickel(II) Mohr Salt
IV	**Configuration of Organic Compounds** Determination of E-Z & R-S configuration using Stick-ball model.

Suggested Readings:

1. Furniss, B.S.; Hannaford, A.J.; Smith, P.W.G.; Tatchell, A.R. *Practical Organic Chemistry, 5th Ed.*, Pearson (2012).
2. Mann, F.G. & Saunders, B.C. *Practical Organic Chemistry*, Pearson Education.
3. Ahluwalia, V.K. & Aggarwal, R. *Comprehensive Practical Organic Chemistry*, Universities Press
4. Cooper, T.G. *Tool of Biochemistry*. Wiley-Blackwell (1977).
5. Wilson, K. & Walker, J. *Practical Biochemistry*. Cambridge University Press (2009).
6. Varley, H., Gowenlock, A.H & Bell, M.: *Practical Clinical Biochemistry*, Heinemann,

Maa Pateswari University, Balrampur

B.Sc. II Year (CHEMISTRY)

Semester-III

(Four Year Undergraduate Course Structure)

CHM 201: Chemical Dynamics, Organic & Coordination Chemistry	**Credit 4+0**

Course Outcomes: Upon successful completion of this course students should be able to describe chemical kinetics, kinetic theories of gases, phase equilibrium, elementary knowledge of d-block elements and coordination chemistry.

Units	Topics	Hours
I	**Chemical Kinetics:** Rate of a reaction, molecularity and order of reaction, concentration dependence of rates, mathematical characteristic of simple chemical reactions zero order, first order, second order, pseudo-order, half-life and mean life. Determination of the order of reaction: differential method, method of integration, half-life method and isolation method. Theories of chemical kinetics: Effect of temperature on rate of reaction, Arrhenius equation, concept of activation energy. Simple collision theory based on hard sphere model, transition state theory (equilibrium hypothesis). Expression for the rate constant based on equilibrium constant and thermodynamic aspects (no derivation).	**10**
II	**Phase Equilibrium:** Statement and meaning of the terms-phase, component and degree of freedom, derivation of Gibbs phase rule, phase equilibria of one component system water, S, He and Diamond, graphite. Phase equilibria of two component systems Solid - liquid equilibria, simple eutectic systems. Pb-Ag system.	**8**
III	**Aromaticity and Chemistry of Arenes:** Aromatic, Antiaromatic and non-Aromatic compounds, Nomenclature of benzene derivatives, MO picture of benzene, Character of arenes, cyclic carbocations/carbanions. Electrophilic aromatic substitution - halogenation, nitration, sulphonation and Friedel- Craft's Alkylation with their mechanism, Directing effects of the groups	**7**
IV	**Chemistry of Alcohols:** Classification and nomenclature, Monohydric alcohols nomenclature, methods of formation by reduction of Aldehydes, Ketones, Carboxylic acids and Esters, Hydrogen bonding, Acidic nature, Differentiation among 1^{o}, 2^{o} and 3^{o} alcohols, Dihydric alcohols, Trihydric alcohols - nomenclature, methods of formation, chemical reactions of glycerol.	**10**
V	**Chemistry of Transition Elements** **Chemistry of Elements of First Transition Series** -Characteristic properties of d-block elements. Binary compounds (hydrides, carbides and oxides) of the elements of the first transition series and complexes with respect to relative stability of their oxidation states, coordination number and geometry. **Chemistry of Elements of Second and Third Transition Series-** General characteristics, comparative treatment of Zr/Hf, Nb/Ta, Mo/W in respect of ionic	**10**

	radii, oxidation states, magnetic behavior, spectral properties and stereochemistry.	
VI	**Coordination Chemistry:** Coordinate bonding, double complex salts, Werner's theory of coordination complexes classification of ligands, ambidentate ligands, chelates, coordination numbers, IUPAC nomenclature of coordination complexes (up to two metal centers), Isomerism in coordination compounds, constitutional and stereo isomerism, geometrical and optical isomerism in square planar and octahedral complexes.	**10**
VII	**Theories of Coordination Chemistry:** Metal- ligand bonding in transition metal complexes, limitations of valance bond theory, an elementary idea of crystal field theory, crystal field splitting in octahedral, tetrahedral and square planner complexes, factors affecting the crystal- field parameters.	**5**

Suggested Readings:

1. Alberty, R. A., *Physical Chemistry*, 4th edition Wiley Eastern Ltd,2001.
2. Atkins, PW, *The Elements of Physical Chemistry*, Oxford,1991
3. Cotton, F. A, Wilkinson, G and Gaus, P. L, *Basic Inorganic Chemistry*, 3rd Edition, Wiley 1995
4. Lee, J. D, *Concise Inorganic Chemistry* 4th EditionELBS,1977
5. Clayden, J., Greeves, N., Warren, S., *Organic Chemistry*, Second edition, Oxford University Press 2012.
6. Silverstein, R. M., Bassler, G. C., Morrill, T. C. *Spectrometric Identification of Organic Compounds*, John Wiley and Sons, INC, Fifth edition.
7. Pavia, D. L. *et al. Introduction to Spectroscopy*, 5th Ed. Cengage Learning India Ed.
8. Willard, H.H. *et al.*: *Instrumental Methods of Analysis*, 7th Ed. Wardsworth Publishing Company, Belmont, California, USA,1988.
9. Christian, G.D. *Analytical Chemistry*, 6th Ed. John Wiley & Sons, New York,2004.
10. Harris, D.C.: *Exploring Chemical Analysis*, 9th Ed. New York, W.H. Freeman,2016.
11. Khopkar, S.M. *Basic Concepts of Analytical Chemistry*. New Age International Publisher,2009.

Suggestive digital platforms web links

1. https://www.coursera.org/courses?query=chemistry&languages=en
2. https://www.mooc-list.com/tags/physical-chemistry
3. https://www.coursera.org/learn/physical-chemistry
4. https://ocw.mit.edu/courses/chemistry/5-61-physical-chemistry-fall-2017/
5. http://heecontent.upsdc.gov.in/Home.aspx

Maa Pateswari University, Balrampur

B.Sc. II Year (CHEMISTRY)

Semester-III Practical

(Four Year Undergraduate Course Structure)

CHM 202: Physical Analysis	**Credit 0+2**

Course Outcomes: Upon successful completion of this course students should be able to calibrate apparatus and prepare solutions of various concentrations, estimation of components through volumetric analysis; to perform dilatometric experiments: one and two component phase equilibrium experiments.

Units	Topics
I	**Identification of organic compounds** Identification of an organic compound through the functional group analysis, determination of melting point and preparation of suitable derivatives.
II	**Boiling point and Transition Temperature** 1. **Boiling Point:** Boiling point of common organic liquid compounds (any five): *n*-butyl alcohol, cyclohexanol, ethyl methyl ketone, cyclohexanone, acetylacetone, isobutyl methyl ketone, isobutyl alcohol, acetonitrile, benzaldehyde and acetophenone. [Boiling points of the chosen organic compounds should preferably be within 180°C]. 2. **Transition Temperature:** Determination of the transition temperature of the given substance by thermometric /dialometric method (e.g. $MnCl_2.4H_2O/SrBr_2.2H_2O$)
III	**Phase Equilibrium** 1. To study the effect of a solute (e.g. NaCl, succinic acid) on the critical solution temperature of two partially miscible liquids (e.g. phenol water system) and to determine the concentration of that solute in the given phenol-water system 2. To construct the phase diagram of two component (e.g. diphenylamine benzophenone) system by cooling-by-cooling curve method
IV	1. Kinetics of Dissolution of Mg ribbon in HCl 2. Determination of Heat of Neutralization of a. Strong Acid-Strong Base b. Strong Acid-Weak Base c. Weak Acid-Strong Base

Suggested Readings:

1. Skoog. D. A., West DM and Hollar, *Analytical Chemistry, An Introduction* 7th Edition, Sauders College

Suggestive digital platforms web links

1. https://www.labster.com/chemistry-virtual-labs/
2. https://www.vlab.co.in/broad-area-chemical-sciences
3. http://chemcollective.org/vlabs

Maa Pateswari University, Balrampur

B.Sc. II Year (CHEMISTRY)

Semester-IV

(Four Year Undergraduate Course Structure)

CHM 203: Quantum Mechanics, Organic Synthesis-A and Analytical Chemistry	**Credit 4+0**

Course Outcomes: Upon successful completion of this course students should be able to describe atomic structure, elementary quantum mechanics, wave function and its significance; Schrodinger wave equation and its applications; Molecular orbital theory, basic ideas Criteria for forming molecular orbital from atomic orbitals, Molecular Spectroscopy, Rotational Spectrum, vibrational Electronic Spectrum: photo chemistry and kinetics of photo chemical reaction

Analytical chemistry plays an enormous role in our society, such as in drug manufacturing, process control in industry, environmental monitoring, medical diagnostics, food production, and forensic surveys. It is also of great importance in different research areas. Analytical chemistry is a science that is directed towards creating new knowledge so that chemical analysis can be improved to respond to increasing or new demands.

- Students will be able to explore new areas of research in both chemistry and allied fields of science and technology.
- Students will be able to function as a member of an interdisciplinary problem-solving team.
- Students will be skilled in problem solving, critical thinking and analytical reasoning as applied to scientific problems
- Students will gain an understanding of how to determine the structure of organic molecules using IR spectroscopic technique
- To develop basic skills required for purification, solvent extraction, TLC and column chromatography

Units	Topics	Hours
I	**Elementary Quantum Mechanics**: Bohr's model of H atom. de-Broglie hypothesis. Heisenberg uncertainty principle, Schrödinger wave equation (time dependent and time independent) and its importance, physical interpretation of the wave function and probability distribution curves, Radial and angular wave functions, Schrödinger wave equation for H-atom, separation into three equations (without derivation), bonding wave function, concept of σ, σ*, π, π* molecular orbitals.	**10**
II	**Molecular Spectroscopy**: Introduction: Electromagnetic radiation, regions of the spectrum, basic features of different spectrometers, statement of the Born- Oppenheimer approximation, degrees of freedom **Rotational Spectrum**: Diatomic molecules. Energy levels of a rigid rotor (semi-classical principles), selection rules, spectral intensity, distribution using population distribution (Maxwell- Boltzmann distribution) determination of bond length, qualitative description of non-rigid rotor, isotope effect. **Vibrational Spectrum:** Infrared spectrum: Energy levels of simple harmonic	**10**

	oscillator, selection rules, pure vibrational spectrum, intensity, determination of force constant and qualitative relation of force constant and bond energies, effect of anharmonic motion and isotope on the spectrum, idea of vibrational frequencies of different functional groups. **Raman spectrum:** Concept of polarizability, pure rotational and pure vibrational, Raman spectra of diatomic molecules, selection rules.	
III	**Chemistry of Phenols:** Nomenclature, structure and bonding, preparation of phenols, physical properties and acidic character, Comparative acidic strengths of alcohols and phenols, resonance stabilization of phenoxide ion. Reactions of phenols electrophilic aromatic substitution, acylation and carboxylation.	**10**
IV	**Chemistry of Ethers and Epoxides**: Nomenclature of ethers and methods of their formation, physical properties, Chemical reactions cleavage and autoxidation, Synthesis of epoxides, Acid and base-catalyzed ring opening of epoxides,	**5**
V	**Volumetric Analysis:** General principle of acid-base titrations, precipitation titrations, oxidation-reduction titrations, iodimetry and complexometric titrations, use of EDTA for the determination of Ca^{2+} and Mg^{2+}, Hardness of water, types of EDTA titrations and metal ion indicators. **Gravimetric Analysis:** Precipitation from homogenous medium, purity of precipitates, coprecipitation, post-precipitation, washing and ignition of precipitates, contamination and their removal.	**10**
VI	**Errors and Evaluation** Definition of terms, mean and median, precision, standard deviation, relative standard deviation, accuracy- absolute error, types of error in experimental data determination (systematic), intermediate (or random) and gross, sources of errors and the effects upon the analytical results, methods for reporting analytical data, statistical evaluation and data -indeterminate errors, use of statistics	**5**
VII	**Separation Techniques: Solvent** extraction: Classification, principle and efficiency of the technique. Mechanism of extraction: extraction by solvation and chelation. Technique of extraction: batch, continuous and counter current extractions. Qualitative and quantitative aspects of solvent extraction: extraction of metal ions from aqueous solution, extraction of organic species from the aqueous and non- aqueous media. **Chromatography:** Classification, principle and efficiency of the technique. Mechanism of separation: adsorption, partition & ion exchange. Development of chromatograms: frontal, elution, and displacement methods.	**10**

Suggested Readings:

1. Alberty, R. A., *Physical Chemistry*,4th Edition Wiley Eastern Ltd ,2001.
2. Atkins, P. W., *The Elements of Physical Chemistry*, Oxford ,1991
3. Cotton, F. A., Wilkinson, G and Gaus, P. L, *Basic Inorganic Chemistry*,3rd Edition , Wiley 1995
4. Lee, J. D., *Concise Inorganic Chemistry* 4th Edition ELBS,1977
5. Clayden, J., Greeves, N., Warren, S., *Organic Chemistry*, Second edition, Oxford University Press 2012.
6. Silverstein, R. M., Bassler, G. C., Morrill, T. C. *Spectrometric Identification of Organic Compounds*, John

Wiley and Sons, INC, Fifth edition.
7. Pavia, D. L. *et al. Introduction to Spectroscopy*, 5th Ed. Cengage Learning India Ed.
8. Willard, H. H. *et al.*: *Instrumental Methods of Analysis*, 7th Ed. Wardsworth Publishing Company, Belmont,California, USA, 1988.
9. Christian, G.D. *Analytical Chemistry*, 6th Ed. John Wiley & Sons, New York, 2004.
10. Harris, D.C.: *Exploring Chemical Analysis*, 9th Ed. New York, W.H. Freeman, 2016.
11. Khopkar, S.M. *Basic Concepts of Analytical Chemistry*. New Age International Publisher, 2009.

Suggestive digital platforms web links

1. https://www.coursera.org/courses?query=chemistry&languages=en
2. https://www.mooc-list.com/tags/physical-chemistry
3. https://www.coursera.org/learn/physical-chemistry
4. https://ocw.mit.edu/courses/chemistry/5-61-physical-chemistry-fall-2017/
5. http://heecontent.upsdc.gov.in/Home.aspx
6. https://nptel.ac.in/courses/104/108/104108078/
7. https://nptel.ac.in/courses/104/108/104108124/
8. https://nptel.ac.in/courses/104/106/104106122/

Maa Pateswari University, Balrampur

B.Sc. II Year (CHEMISTRY)

Semester-IV Practical

(Four Year Undergraduate Course Structure)

CHM 204: Separation Technique and Volumetric Analysis	**Credit 0+2**

Course outcomes: Upon completion of this course, chemistry majors can employ critical thinking and scientific inquiry in the performance, design, interpretation, and documentation of laboratory experiments, at a level suitable to succeed at an entry-level position in chemical industry or a chemistry graduate program.

- Students will be able to explore new areas of research in both chemistry and allied fields of science and technology.
- Students will be able to function as a member of an interdisciplinary problem-solving team.
- Students will be skilled in problem solving, critical thinking and analytical reasoning as applied to scientific problems
- Students will gain an understanding of how to determine the structure of organic molecules using IR spectroscopic technique
- To develop basic skills required for purification, solvent extraction, TLC and column chromatography

Units	**Topics**
I	**Chromatographic Separations** Paper chromatographic separation of following metal ions: i. Ni (II) and Co (II) ii. Cu(II) and Cd(II)
II	Separation of a mixture of *o*-and *p*-nitrophenol or *o*-and *p*-aminophenol by thin layer Chromatography (TLC)
III	**Volumetric Exercises** I. Acid Base Titrations II. Estimation of Oxalic Acid by titrating with KMnO4 III. Estimation of Silver ions by Volhard's and Mohr's Method. IV. Redox titrations *e.g.* titration of ferrous ion with permanganate and dichromate using internal and external indicators. V. Estimation of hardness of water by EDTA.

Suggested Readings:

1. Mendham, J., *Quantitative Chemical Analysis* 6th Ed., Pearson,2009.
2. Willard, H. H. *et al.*: *Instrumental Methods of Analysis*, 7th Ed. Wardsworth Publishing Company, Belmont, California, USA,1988.
3. Christian, G. D., *Analytical Chemistry*, 6th Ed. John Wiley & Sons, New York, 2004.
4. Harris, D. C., *Exploring Chemical Analysis*,9th Ed. New York,W. H. Freeman,2016.
5. Khopkar, S. M., *Basic Concepts of Analytical Chemistry*. New Age International Publisher,2009.
6. Skoog, D. A., Holler F. J. and Nieman, T.A. *Principles of Instrumental Analysis*, Cengage Learning India Edition.
7. Mikes, O. & Chalmes, R. A., *Laboratory Handbook of Chromatographic &Allied Methods*, Elles Harwood Ltd. London.
8. Ditts, R. V., *Analytical Chemistry: Methods of separation*. Van Nostrand, New York,1974.

Maa Pateswari University, Balrampur

B.Sc. III Year (CHEMISTRY)

Semester-V

(Four Year Undergraduate Course Structure)

CHM 301: Photochemistry and Organic Synthesis-B	**Credit 4+0**

Course outcomes: Biomolecules are important for the functioning of living organisms. These molecules perform or trigger important biochemical reactions in living organisms. When studying biomolecules, one can understand the physiological function that regulates the proper growth and development of a human body. This course aims to introduce the students with basic of oxygen and halogen containing functional groups, experimental understanding of carbohydrates, amino acids, proteins, nucleic acids, and medicinal chemistry. Upon completion of this course students may get job opportUnitsies in food, beverage, and pharmaceutical industries. Students will gain an understanding of which are used as solvents and raw material for synthesis of drug and other pharmaceutically important compounds and synthetic dyes.

Units	Topics	Hours
I	**Physical Properties of Molecules:** Electric properties of molecules; Polarisation of a molecule in an electric field- The Clausius- Mossotti equation, The Debye equation, Dependence of Polarisation on frequency, Bond moments, Diploe moments and molecular structure, Group moments, Magnetic properties of molecules- Molecular interpretation of diamagnetism and paramagnetism measurement of magnetic susceptibility ferromagnetism and antiferromagnetism	5
II	**Photo Chemistry:** Interaction of radiation with matter, difference between thermal and photochemical processes. Laws of photochemistry: Grothus- Drapper law, Stark-Einstein law, Jablonski diagram depicting various processes occurring in the excited state, qualitative description of fluorescence, phosphorescence, non-radiative processes (internal conversion, intersystem crossing), quantum yield, photosensitized reactions – energy transfer processes (simple examples), kinetics of photochemical reaction.	7
III	**Chemistry of Organic Halides** Nomenclature and classes of alkyl halides, methods of formation, chemical reactions, Mechanisms of nucleophilic substitution reactions of alkyl halides, SN2 and SN1 reactions with energy profile diagrams; Polyhalogen compounds: Chloroform, carbon tetrachloride; Methods of formation of aryl halides, nuclear and side chain reactions; The addition-elimination and the elimination-addition mechanisms of nucleophilic aromatic substitution reactions; Relative reactivities of alkyl halides vs allyl, vinyl and aryl halides,	8

IV	**Chemistry of Carbohydrates**: Classification of carbohydrates, reducing and non-reducing sugars, General Properties of Glucose and Fructose, their open chain structure. Epimers, mutarotation and anomers. Mechanism of mutarotation Determination of configuration of Glucose (Fischer proof). Cyclic structure of glucose. Haworth projections. Cyclic structure of fructose. Inter conversions of sugars (ascending and descending of sugar series, conversion of aldoses to ketoses).	**10**
V	**Chemistry of Proteins:** Classification of amino acids, zwitter ion structure and Isoelectric point. Overview of primary, secondary, tertiary, and quaternary structure of proteins. Determination of primary structure of peptides, determination of N-terminal amino acid (by DNFB and Edman method) and C terminal amino, Synthesis of simple peptides (upto dipeptides) by N-protection & C-activating groups and Merrifield solid phase synthesis.	**10**
VI	**Chemistry of Nucleic Acids:** Constituents of Nucleic acids: Adenine, guanine, thymine, and Cytosine (Structure only), Nucleosides and nucleotides (nomenclature), Synthesis of nucleic acids, Structure of polynucleotides; Structure of DNA (Watson-Crick model) and RNA (types of RNA), Genetic Code, Biological roles of DNA and RNA: Replication, Transcription and Translation	**10**
VII	**Introductory Medicinal Chemistry:** Drug discovery, design, and development; Basic Retrosynthetic approach. Drug action-receptor theory. Structure activity relationships of drug molecules, binding role of OH group, $-NH_2$ group, double bond and aromatic ring.	**5**
VIII	**Synthetic Dyes:** Color and constitution (electronic Concept), Classification of dyes, Chemistry and synthesis of Methyl orange, Congo red, Malachite green	**5**

Suggested Readings:

1. Morrison, R. N.& Boyd, R. N. *Organic Chemistry*, Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
2. Sykes, P. *A guidebook to Mechanism in Organic Chemistry,* Pearson Education,2003.
3. Carey, F. A., Guiliano, R. M. *Organic Chemistry*, Eighth edition, McGraw Hill Education,2012.
4. Loudon, G. M. *Organic Chemistry*, Fourth edition, Oxford University Press,2008.
5. Clayden, J., Greeves, N. &Warren, S. *Organic Chemistry*,*2nd* edition, Oxford University Press, 2012.
6. Graham Solomons, T.W., Fryhle, C. B. *Organic Chemistry*, John Wiley & Sons, Inc.
7. Smith, J. G. *Organic Chemistry,* Tata McGraw-Hill Publishing Company Limited.
8. March, J. *Advanced Organic Chemistry,* Fourth edition, Wiley.

Maa Pateswari University, Balrampur

B.Sc. III Year (CHEMISTRY)

Semester-V

(Four Year Undergraduate Course Structure)

CHM302: Polymer, Coordination and Inner Transition Metal Chemistry	**Credit 4+0**

Course outcomes: This paper provides detailed knowledge of synthesis of various class of organic compounds and functional groups inter conversion. Organic synthesis is the most important branch of organic chemistry which provides jobs in production & QC departments related to chemicals, drugs, medicines, FMCG etc. industries.

Units	Topics	Hours
I	**Catalysis** General principles and properties of catalysts, homogenous catalysis (catalytic steps and examples) and heterogenous catalysis (catalytic steps and examples) and their industrial applications, Deactivation, or regeneration of catalysts. Phase transfer catalysts, application of zeolites as catalysts. Enzyme catalysis: Michaelis-Menten equation, Lineweaver-Burk plot, turn-over number.	**10**
II	**Chemistry of Lanthanides** Electronic structure, oxidation states and ionic radii and lanthanide contraction, complex formation, occurrence and isolation, ceric ammonium sulphate and its analytical uses.	**5**
III	**Chemistry of Actinides** Electronic configuration, oxidation states and magnetic properties, chemistry of separation of Np, Pu and Am from U.	**5**
IV	**Thermodynamic and kinetic aspects of metal complexes** A brief outline of thermodynamic stability of metal complexes and factors affecting the stability, stability constants of complexes and their determination, substitution reactions of square planar complexes.	**10**
V	**Inorganic Spectroscopy and Magnetism** **I.** Electronic spectra of Transition Metal Complexes, Types of electronic transitions, selection rules for d-d transitions, spectroscopic ground states, spectrochemical series, Orgel-energy level diagram for d^1 and d^9 states, discussion of the electronic spectrum of $[Ti(H_2O)_6]^{3+}$ and $[Cu(H_2O)_6]^{2+}$complex ion. **II.** Magnetic properties of Transition Metal Complexes, Types of magnetic behavior, magnetic susceptibility, methods of determining magnetic susceptibility, spin-only formula, L-S coupling, correlation of μ_s and μ_{eff} values, orbital contribution to magnetic moments, application of magnetic moment data for 3d-metal complexes. General description of Paramagnetism, diamagnetism and ferromagnetism	**10**

VI	**Metal Carbonyls and Nitrosyls** 18-electron rule, preparation, structure and nature of bonding in the mononuclear and dinuclear carbonyls and nitrosyls.	**10**
VII	**Introduction to Polymer** Monomers, Oligomers, Polymers and their characteristics, Classification of polymers: Natural synthetic, linear, cross linked and network; plastics, elastomers, fibers, Homopolymers and Co-polymers, Bonding in polymers: Primary and secondary bond forces in polymers; cohesive energy, and decomposition of polymers. Silicones and Phosphazenes, Silicones and phosphazenes as examples of inorganic polymers, nature of bonding in triphosphazenes.	**10**

Suggested Readings:

1. Lee, J. D. *Concise Inorganic Chemistry*, Pearson Education2010.
2. Cotton, F. A., Wilkinson, G and Gaus, P. L, *Basic Inorganic Chemistry*,3rd Edition, Wiley 1995
3. Puri, Sharma and Kalia, *Principles of Inorganic Chemistry*, Milestone Publishers

Maa Pateswari University, Balrampur

B.Sc. III Year (CHEMISTRY)

Semester-V Practical

(Four Year Undergraduate Course Structure)

CHM 303: Qualitative and Quantitative Analysis	**Credit 0+2**

Course outcomes:

Upon completion of this course the students will have the knowledge and skills to understand the laboratory methods and tests related to inorganic mixtures and organic compounds.

- Separation of organic compounds from mixture
- Elemental analysis in organic compounds
- Identification of functional group in organic compounds
- Identification of organic compound

Units	Topics
I	**Separation and Identification of Organic Mixture:** Analysis of an organic mixture containing two solid components using water, $NaHCO_3$, NaOH for separation and preparation of suitable derivatives
II	**Kinetics:** 1. To study the kinetics of reaction between acetone and iodine. 2. To determine the solubility of simple salt by evaporation method and to draw the solubility curve.
III	**Qualitative and quantitative analysis of carbohydrates:** 1. Separation of mixture of two sugars by ascending paper chromatography. 2. Differentiate between reducing and non-reducing sugar. 3. Synthesis of Osazones.
IV	**Determination and identification of Nucleic Acids** 1. Determination of nucleic acids 2. Extraction of DNA from onion/cauliflower

Suggested Readings:

1. Vogel, A. I., Tatchell, A. R., Furnis, B. S., Hannaford, A. J. & Smith, P. W. G., *Textbook of Practical Organic Chemistry*, Prentice-Hall, 5th Edition,1996.
2. Mann, F.G. & Saunders, B.C. *Practical Organic Chemistry* Orient-Longman,1960.
3. Harris, D. C. *Exploring Chemical Analysis*,9 Ed. New York, W. H. Freeman,2016.
4. Khopkar, S. M. *Basic Concepts of Analytical Chemistry*. New Age International Publisher,2009.

Maa Pateswari University, Balrampur

B.Sc. III Year (CHEMISTRY)

Semester-VI

(Four Year Undergraduate Course Structure)

CHM 304: Organic Synthesis C	**Credit 4+0**

Course outcomes: This paper provides detailed knowledge of synthesis of various class of organic compounds and functional groups inter conversion. Organic synthesis is the most important branch of organic chemistry which provides jobs in production & QC departments related to chemicals, drugs, medicines, FMCG etc. industries.

The study of natural products and heterocyclic compounds offers an excellent strategy toward identifying novel biological probes for several diseases. Historically, natural products have played an important role in the development of pharmaceutical drugs for several diseases including cancer and infection.

- It relates and gives an analytical aptitude for synthesizing various industrially important compounds.
- Learn the different types of alkaloids, & terpenes etc and their chemistry and medicinal importance.
- Explain the importance of natural compounds as lead molecules for new drug discovery.

Units	Topics	Hours
I	**Reagents in Organic Synthesis:** A detailed study of the following reagents in organic transformations, Oxidation with SeO_2, Jones Oxidation, PCC, PDC, $NaBH_4$, $LiAlH_4$, DIBAL-H	7
II	**Organometallic Compounds:** Organo magnesium compounds: The Grignard reagents, formation, structure and chemical reactions. Organolithium compounds: formation and chemical reactions.	7
III	**Chemistry of Aldehydes and ketones:** Nomenclature and structure of the carbonyl groups, synthesis of aldehydes and ketones with particular reference to the synthesis of aldehydes from acid chlorides, Physical properties. Mechanism of nucleophilic additions to carbonyl group with particular emphasis on benzoin, aldol, Perkin and Wittig reaction Oxidation of aldehydes, Cannizzaro reaction, MPV reduction, Clemmensen reduction, Wolff-Kishner reduction, An introduction to α, β –unsaturated aldehyde and ketones.	10
IV	**Carboxylic acids and their Functional Derivatives:** Nomenclature and classification of aliphatic and aromatic carboxylic acids. Preparation and reactions. Acidity (effect of substituents on acidity) and salt formation, Reactions: Mechanism of reduction, substitution in alkyl or aryl group, stereospecific addition to maleic and fumaric acids. Preparation and reactions of acid chlorides, acid anhydrides,	10

	amides and esters, acid and alkaline hydrolysis of esters, trans-esterification.	
V	**Organic Compounds of Nitrogen-** Preparation of nitroalkanes and nitroarenes, Chemical reactions of nitroalkanes. Mechanisms of nucleophilic substitution in nitroarenes and their reductions in acidic, neutral and alkaline media, Picric acid, Separation of a mixture of primary, secondary and tertiary amines. Structural features effecting basicity of amines. Gabriel- phthalimide reaction, Hofmann bromamide reaction. Reactions of amines, electrophilic aromatic substitution in arylamines, reactions of amines with nitrous acid.	10
VI	**Heterocyclic Chemistry** Molecular orbital picture and aromatic characteristics of pyrrole, furan, thiophene and pyridine, Methods of synthesis and chemical reactions with particular emphasis on the mechanism of electrophilic substitution, Mechanism of nucleophilic substitution reaction in pyridine derivatives, Comparison of basicity of pyridine, piperidine and pyrrole. Mechanism of electrophilic substitution reactions of indole, quinoline and isoquinoline.	**10**
VII	**Rearrangements** A detailed study of the following rearrangements: Pinacol-pinacolone, Benzil-Benzilic acid, and Fries rearrangement	**6**

Suggested Readings:

1. Morrison, R. N. & Boyd, R. N. *Organic Chemistry*, Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
2. Sykes, P. *A guidebook to Mechanism in Organic Chemistry*, Pearson Education,2003.
3. Carey, F. A., Guiliano, R. M. *Organic Chemistry*, Eighth edition, McGraw Hill Education,2012.
4. Loudon, G. M. *Organic Chemistry*, Fourth edition, Oxford University Press,2008.
5. Clayden, J., Greeves, N. &Warren, S. *Organic Chemistry*, 2nd edition, Oxford University Press, 2012.
6. Graham Solomons, T.W., Fryhle, C. B. *Organic Chemistry*, John Wiley & Sons, Inc.
7. Smith, J. G. *Organic Chemistry*, Tata McGraw-Hill Publishing Company Limited.
8. March, J. *Advanced Organic Chemistry*, Fourth edition, Wiley.
9. Acheson, R.M. *Introduction to the Chemistry of Heterocyclic compounds*, John Welly& Sons (1976).
10. Finar, I. L. *Organic Chemistry* (Volume 1), Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
11. Finar, I. L. *Organic Chemistry* (Volume 2: Stereochemistry and the Chemistry of Natural Products), Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
12. Singh, J.; Ali, S.M. & Singh, J. *Natural Product Chemistry*, Pragati Prakashan (2010).

Maa Pateswari University, Balrampur

B.Sc. III Year (CHEMISTRY)

Semester-VI

(Four Year Undergraduate Course Structure)

CHM 305: Chemical Energetics and Bioinorganic Chemistry	**Credit 4+0**

Course outcomes: Upon successful completion of this course students should be able to describe laws of thermodynamics and its applications, phase equilibria of one and two component system, electro chemistry, ionic equilibrium, applications of conductometric and potentiometric measurements.

Units	Topics	Hours
I	**Thermodynamics-I** **First Law of Thermodynamics:** Statement, definition of internal energy and enthalpy. Heat capacity, heat capacities at constant volume and pressure and their relationship. Joule's law Joule- Thomson coefficient and inversion temperature. **Thermochemistry:** Standard state, standard enthalpy of formation Hess's law of heat summation and its applications. Heat of reaction at constant pressure and at constant volume. Enthalpy of neutralization. Bond dissociation energy and its calculation from thermo-chemical data, Kirchhoff's equation.	15
II	**Thermodynamics II** Second Law of Thermodynamics, Need for the law, different statements of the law, Carnot cycle and its efficiency. Carnot theorem. Thermodynamic scale of temperature. Concept of Entropy, Entropy as a state function, entropy as a function of V & T, entropy as a function of P & T, Entropy change in ideal gases and mixing of gases. Gibbs and Helmholtz Functions Gibbs function (G) and Helmholtz function (A) as thermodynamic quantities. A & G as criteria for thermodynamic equilibrium and spontaneity, their advantage over entropy change,	15
III	**Electrochemistry** Specific conductance molar and equivalent conductance, measurement of equivalent conductance, variation of molar, equivalent and specific conductance with dilution. Migration of ions and Kohlrausch law, Arrhenius theory of electrolyte dissociation and its limitations. Weak and strong electrolytes. Ostwald's dilution law, its uses and limitations. Debye-Hückel-Onsager equation for strong electrolytes (elementary treatment only).	10
IV	**Colligative Properties-**Ideal and non-ideal solutions, methods of expressing concentrations of solutions, activity and activity coefficient. Dilute solution, colligative properties, Raoult's law, relative lowering of vapour pressure, molecular weight determination, Osmosis, law of osmotic pressure and its measurement, determination of molecular weight from osmotic pressure, Elevation of boiling point and depression of freezing, Thermodynamic derivation of relation between molecular weight and elevation in boiling point and depression	10

	in freezing point.	
V	**Bioinorganic Chemistry** Essential and trace elements in biological processes, metalloporphyrins with special reference to heamoglobin and myoglobin. Biological role of alkali and alkaline earth metal ions with special reference to Ca^{2+} and Mg^{2+}. Cu in plastocyanin and hemocyanin, Zn in carboxypeptidase and carbonic anhydrase.	**10**

Suggested Readings:

1. Foye, W. O., Lemke, T. L. & William, D. A.: *Principles of Medicinal Chemistry*, 4th Ed., B. I. Waverly Pvt. Ltd. New Delhi.
2. Peter Atkins & Julio De Paula, *Physical Chemistry* 9th Ed., Oxford University Press (2010).
3. Metz, C. R. *Physical Chemistry* 2nd Ed., Tata McGraw-Hill (2009). 4.
5. Ball, D. W. *Physical Chemistry* Thomson Press, India (2007).
6. Castellan, G. W. Physical Chemistry 4th Ed Narosa (2004).
7. Allen Bard, J Larry. Faulkner R, *Fundamentals of Electrochemical methods fundamentals and applications*, New York John, Wiley &sons ,2001
8. Arnikar, H. J. *Essentials of Nuclear Chemistry*, 4th Ed., New Age International, New Delhi, 1995.

Maa Pateswari University, Balrampur

B.Sc. III Year (CHEMISTRY)

Semester-VI Practical

(Four Year Undergraduate Course Structure)

CHM 306: Physico-Chemical Analysis and Organic Synthesis	**Credit 0+2**

Course Outcomes: Upon successful completion of this course students should be able to quantify the product obtained through gravimetric method; determination of R values and identification of organic compounds through paper and thin layer chromatography laboratory techniques: perform thermos-chemical reactions

Units	**Topics**
I	**Gravimetric Analysis** 1. Analysis of Cu as CuSCN, 2. Analysis of Ni as Ni(dimethylgloxime)
II	**Estimate the following metals gravimetrically:** 1. Barium as Barium sulphate 2. Zinc as Zinc Oxide 3. Iron as Iron Oxide 4. Chromium as Chromium Oxide 5. Lead as lead sulphate.
III	**Thermochemistry** 1. To determine the solubility of benzoic acid at different temperatures and to determine heat of the dissolution process. 2. To determine the enthalpy of neutralization of a weak acid/weak base versus strong base/strong acid and determine the enthalpy of ionization of the weak acid/weak base. 3. To determine the enthalpy of solution of solid calcium chloride and calculate the lattice energy of calcium chloride from its enthalpy data using Born-Haber cycle.
IV	Preparation of organic compounds (Single Step Synthesis) (i) *p*-Bromoacetanilide (ii) *p*-Nitro acetanilide (iii) Soap from line seed oil or coconut oil (iv) Esterification of Benzoic Acid from Ethanol/Methanol

Suggested Readings:

1. Skoog, D. A., West, D. M., Hollar, F. J., *Analytical Chemistry: An Introduction* 7th Edition, Sauders college publishing, Philadelphia (2010)
2. Larry Hargis, G *Analytical Chemistry: Principles and Techniques*, Englewood Cliffs, N. J.: Prentice Hall

Suggestive digital platforms web links

https://www.labster.com/chemistry-virtual-labs/

https://www.vlab.co.in/broad-area-chemical-sciences

https://chemcollective.org/vlabs

Maa Pateswari University, Balrampur

B.Sc. IV Year (CHEMISTRY)/ B.Sc. Chemistry Honours and Research

Semester-VII

(Four Year Undergraduate Course Structure)

CHM 401: Spectroscopy-I (Paper 1)	**Credit 4+0**

Objective: The objective of the course is to help students understand the theoretical aspects of various spectroscopic techniques like UV-Visible, IR, NMR and Mass, which in turn, will enhance their capability of interpreting the spectral data obtained from various techniques and use it for structural elucidation of organic compounds.

Outcome: Students acquire the knowledge of the instrumentation and principle involved in various advanced spectroscopic and will be able to interpret the spectral data for structural elucidation of organic compounds.

Units	Topics	Hours
I	**UV-Visible Spectroscopy:** Different type of electronic transitions, Lambert's Beer's law, Chromophores, Auxochromes, Solvent effect, Red-shift and blue-shift, Woodward's rule for conjugated cyclic and acyclic dienes and α, β – unsaturated carbonyl compounds, Absorption in aromatic compounds (substituted benzene, naphthalene and anthracene), Problems related UV-Visible Spectroscopy	**15**
II	**Infrared Spectroscopy:** Review of linear harmonic oscillator, Vibrational energies of diatomic molecules, Zero-point energy, Force constant and bond strength, Anharmonicity, Morse potential energy diagram, Vibration rotation spectroscopy, P, Q, R branches, Breakdown of Born-Oppenheimer approximation, Selection rules, Overtones, Hot Bands, Absorption by common functional groups, Brief description of IR and F.T.I.R. instruments, Problems related I.R. Spectroscopy	**15**
III	**Raman Spectroscopy:** Theories of Raman Effect, Conditions of Raman active Vibrations, Selection rules, Polarized and Depolarized Raman lines Study of: (Simple molecules such as SO_2, CO_2, N_2O and C_2H_2; (b) Hydrogen Bounding and (c) Metal ions in solution, Mutual exclusion principle, Problems related with Raman Spectra and its interpretation	**15**
IV	**Microwave spectroscopy:** Rotational Spectroscopy, Rotational spectra of diatomic molecules based on rigid rotator approximation, Determination of bond lengths and/or atomic masses from microwave data, Effect of isotopic substitution, Non-rigid rotator, Classification of polyatomic molecules, Energy levels and spectra of symmetric top molecules and asymmetric top molecules and applications	**15**

Recommended Books:

1. *Spectroscopy* by H. Kaur

2. *Molecular Spectroscopy* by Benwell

3. *Spectroscopy* by B.K. Sharma

4. *Spectroscopy of Organic Compounds* by P.S. Kalsi

5. *Vibrational Spectroscopy: Theory and Applications* by D.N. Sathyanarayana

Maa Pateswari University, Balrampur

B.Sc. IV Year (CHEMISTRY)/ B.Sc. Chemistry Honours and Research

Semester-VII

(Four Year Undergraduate Course Structure)

CHM 402: Physical Chemistry (Chemical Kinetics and Classical Thermodynamics) (Paper 2)	**Credit 4+0**

Course Objectives: The objective of this course is to provide students a new and advance understanding of Transition state theory, Limitation of Lindemann theory, Hinshelwood treatment, RRK theory, salt effects, RRKM theory and advances made by Slater. It also gives knowledge of collision cross-section, Inter- molecular potential, potential energy surfaces, elastic molecular collisions, general features of fast reaction and their measurement technique. provide comprehensive and rigorous treatment of classical thermodynamics, thermodynamics relations. Explain the concept of partial molar properties fugacity and activity. It provides knowledge of entropy production, irreversible process and Onsager's reciprocity.

Course Outcome: After successful completion of this course

Students will be able to understand the collision theory and theory of absolute reaction rates. Statistical treatment of unimolecular reaction including Lindemann theory, Hinshelwood treatment, RRK theory (salient features and limitations) RRKM theory and advances made by Slater.
Students will be able to understand fast reaction: Flow system, Relaxation methods, Flash photolysis
Students will acquire an ability to learn Collision cross-section, Inter- molecular potential, potential energy surfaces and elastic molecular collisions.
Students will be able to understand various thermodynamic relationships, the concept of free energy and partial molar quantities, fugacity, activity and activity coefficients and determination, third law of thermodynamics
Students will be able to understand thermodynamic criteria in non-equilibrium state, entropy production and their applications.

Units	**Topics**	**Hours**
I	**Theories of Reaction Rates:** Collision Theory of reaction rates, steric factor. Arrhenius equation and collision theory. Theory of absolute reaction rates. Thermodynamic formulation of reaction rates, comparison of Eyring equation and Arrhenius equations. Comparison of transition state theory and collision theory. Lindemann's mechanism of unimolecular gaseous reaction. Hinshelwood mechanism, RRK theory and RRKM theory, ionic reactions, salt effects (primary and secondary)	**15**
II	**Chemical Dynamics:** Dynamic chain reaction, H_2-Br_2, decomposition of ethane and acetaldehyde. Photochemical combination of H_2-Br_2, and H_2-Cl_2 reactions. Oscillatory chemical reactions. Kinetics of enzyme reactions (Michaelis Menten Equation, Lineweaver-Burk Plot). General features of fast reactions, study of fast reactions; by flow method, relaxation method, flash photolysis and magnetic resonance method.	**15**

III	**Some Important Thermodynamic Relationships:** The Joule Thomson's effect, The Gibbs- Helmholtz equation and its application, The Clausius -Clapeyron equation, The Maxwell's relations. **Partial molar Properties:** Partial molar quantities, (partial molar volume and partial molar Gibbs energy), Chemical potential and variation of chemical potential with temperature and pressure, The Gibbs Duhem equation and its applications. **Fugacity and Activity:** Fugacity, variation of fugacity with temperature and pressure, Activity and the activity coefficient.	**15**
IV	**Third law Thermodynamics:** The third law, Nernst heat theorem, application of third law, The residual entropy. Thermodynamics of Irreversible Processes: Entropy production in irreversible processes, Entropy equation for heat flow, relation between fluxes and forces, non- equilibrium stationary states, Linear phenomenological equations, Onsager's reciprocity relation, non –linear thermodynamic treatment of electro- kinetic phenomena, thermo- osmosis and reverse osmosis.	**15**

Books Recommended:

1. K. J. Laidler, *Chemical Kinetics*, 3rd edition (1987), Harper & Row
2. I.N. Levine, *Physical Chemistry*, 5th Edition (2002), Tata McGraw Hill Pub. Co. Ltd., New Delhi.
3. *Thermodynamics for Chemists* by S. Glasstone.
4. *An Introduction of Chemical Thermodynamics* by R.P. Rastogi and R.R. Mishra.
5. *Comprehensive Physical Chemistry* by N.B. Singh, S.S. Das and N.S. Gajbhiye, New Age International Publishers.
6. P.W. Atkins, *Physical Chemistry*, Oxford University Press, New York.

Maa Pateswari University, Balrampur

B.Sc. IV Year (CHEMISTRY)/ B.Sc. Chemistry Honours and Research

Semester-VII

(Four Year Undergraduate Course Structure)

CHM 403: Inorganic Chemistry (Chemistry of Main Group Elements) (Paper 3)	**Credit 4+0**

Course Objectives:

1. Understand and apply stereochemical principles to predict the geometry of main group element compounds using VSEPR theory.
2. Analyze molecular shapes using Walsh diagrams and evaluate the factors affecting the stereochemistry of molecules and ions.
3. Explore the nature and implications of dπ–pπ bonding, Bent's rules, and hybridization energetics in main group compounds.
4. Investigate the synthesis, structure, bonding, and industrial relevance of polyether complexes, polyphosphazenes, thiazyl compounds, and tetrasulphur dinitride.
5. Examine the structural and bonding features of boranes, carboranes, and related anionic species.
6. Study the synthesis, bonding, and structural diversity of carbides, polyanions, and silicates including their classification.

Course Outcome:

1. Students will able to Apply VSEPR theory and steric principles to predict and explain the shapes of molecules and ions with 2–7 electron pairs in the valence shell.
2. Interpret and construct Walsh diagrams to rationalize geometry changes in triatomic and penta-atomic molecules.
3. Explain the formation and importance of dπ–pπ bonds and apply Bent's rule to rationalize hybridization patterns and molecular stability.
4. Describe the preparation methods, structural characteristics, and technical applications of polyether complexes, polyphosphazenes, thiazyl polymers, and S_4N_2 compounds.
5. Analyze the bonding and structural diversity in boranes, carboranes, and their anions using Wade's rules and molecular orbital theory.
6. Classify and describe the structures of silicates, and evaluate the synthesis and bonding in carbides and polyanions of heavier main group elements like Ge, Sn, Pb, Sb, Bi, and Hg.

Units	Topics	Hours
I	**Stereochemistry of Bonding Among Main Group Elements:** VSEPR theory, stereochemical rules and explanation of shapes of molecules and ions of non-transition elements with 2-7 valence shell electron pairs. Walsh diagram (tri- and penta-atomic molecules) dπ-pπ bonds, Bent's rules. Energetics of hybridization	**15**
II	**Compounds of Main Group Elements:** Preparation Structure Bonding and Technical application of Polyether complexes of alkali and alkaline earth metals; Polyphosphazenes and Thiazyl & its polymers, tetrasulphur dinitride.	**15**
III	**Structure and Bonding in ions of Some Main Group Elements:** Structure and bonding in borane anions, higher boranes, carboranes.	**15**

IV	**Carbides, Polyanions &Silicates:** Synthesis and structure of carbides & polyanions of Ge, Sn, Pb, Sb, Bi and Hg. Classification and structures of silicates.	**15**

Books Recommended:

1. *Advanced Inorganic Chemistry*, 6th Edition F. A. Cotton and G. Wilkinson.
2. *Principles of Structure and Reactivity* 4th Edition J. E. Huheey, E. A. Keiter and R. L. Keiter
3. *Chemistry of Elements* N. N. Greenwood and A. Ernshaw
4. *Organometallic Chemistry: A Unified Approach* R. C. Mehrotra and A. K. Singh

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Semester-VII

(Four Year Undergraduate Course Structure)

CHM 404: Organic Chemistry (Organic Reaction Mechanism) (Paper 4)	**Credit 4+0**

Objective: Primary aim of this course is to develop interest and skill for generating mechanistic path for organic transformations in the students. The focus of this course is to give the detailed insight of organic reaction mechanism and to understand the physical chemistry of organic reactions along with the nucleophilic substitution reaction, elimination reaction & Addition on Carbon-Carbon double bond.

Outcome: After completion of the course students will understand the mechanistic pathways of the various organic reactions. Students will become competent to predict the chemo-, regio- and stereoselective outcome of such reactions.

Units	Topics	Hours
I	**Determination of Organic Reaction Mechanism:** Potential energy diagram, Transition states and intermediates, Hammond's Postulate, Methods of determination of organic reaction mechanism, Kinetic isotopic effect and its importance in the determination of reaction mechanism, The Hammett equation and linear free energy relationship, substituent and reaction constants	**15**
II	**Substitution Reaction:** Aliphatic Nucleophilic Substitution at Saturated Carbon Atom: Mechanism and stereochemistry of SN^1, SN^2, and SN^i reactions. Role of structure of substrate, nucleophile, leaving group and solvent on SN reactions, nucleophilic substitution in bridged systems, Neighbouring Group Participation: Evidence for NGP, Participation by phenyl group, π and σ bonds, and Anchimeric Assistance.	**15**
III	**Elimination Reaction:** Mechanism and Stereochemistry of E1, E2 and E1cb elimination, factors affecting E1, E2 and E1cb reactions, orientation (Saytzeff and Hofmann Rule), Pyrolytic (syn) elimination (Chugaev and Hoffman elimination), Competition between substitution and elimination reactions, Peterson Elimination, Julia Olefination	**15**
IV	**Addition on Carbon-Carbon double bond:** Mechanism and Stereochemistry of addition of halogen (X_2), Halogen acids (HX) to alkenes and its regioselectivity, 1,2-Bishydroxylation, Epoxidation, Hydroboration-Oxidation and Oxymercuration-Demercuration **Addition to Carbon-Oxygen double bond:** Aldol Condensation, Stobbe Condensation, Cannizaro Reaction, Benzoin condensation. **Addition on Conjugated Alkene:** Addition of halogens on butadiene, Michael Addition	**15**

Recommended Books

1. Advance Organic Chemistry–Structure and Mechanism, J. March, John Wiley

2.	Advanced Organic Chemistry-F. A. Carey and R. J. Sundberg A
3.	Advanced Organic Chemistry-F. A. Carey and R. J. Sundberg B
4.	Modern Methods of Organic Synthesis-W. Carruthers & I. Coldham
5.	Modern Organic Synthesis-Zweifel & Nantz

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B.Sc. IV Year (CHEMISTRY)/ B.Sc. Chemistry Honours and Research

Semester-VII

(Four Year Undergraduate Course Structure)

CHM 405: Surface Chemistry, Purification and Identification of Materials (*Practical*) (Paper 5)	**Credit 0+4**

Objective: To provide basic understanding of the principles and processes by which chemical analysis is being done.

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

- Determine solubility, heat of solution, distribution coefficient, adsorption isotherms, and order of chemical reactions
- Qualitatively analyse of an inorganic mixture
- Separate the metal ions using chromatographic techniques
- Separate and analyse the components of binary organic mixtures
- Determine equivalent weight of organic acids

Unit	Topic
I	**Physical Chemistry:** 1. Determine the solubility of benzoic acid in water at different temperatures and calculate the heat of solution. 2. Determine the distribution coefficient of benzoic acid between benzene and water. 3. Determine the distribution coefficient of acetic acid between benzene and water. 4. Determine the distribution coefficient of iodine between carbon tetra chloride and water. 5. Study the adsorption of acetic acid on charcoal and draw the Freundlich isotherm. 6. Show that the order of reaction between acetone and iodine is zero with respect to iodine.
II	**Inorganic Chemistry:** 1. Qualitative analysis of an inorganic mixture of seven radicals including Tl, W, Se, Te, V, Be, U, Ti, Zr, Th, Ce and Li, in addition to the radicals prescribed for the B.Sc. Course. Semi micro analysis is to be done. 2. Chromatographic separation of metal ions given in any one of the following combinations: (a) Pb^{2+}, Ag^{+}, Hg^{2+} (b) Co^{2+}, Ni^{2+}, Cu^{2+} (c) Fe^{3+}, Cr^{3+}, Al^{3+} (d) Ba^{2+}, Sr^{2+}, Ca^{2+}

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III	**Organic Chemistry:** 1. Analysis of primary binary organic mixture (liquid-liquid, liquid-solid, solid-solid). 2. Determination of equivalent weight of organic acids by direct titration method.

Suggested Readings:

1. Skoog, D. A., West, D. M., Hollar, F. J., *Analytical Chemistry: An Introduction* 7th Edition, Sauders college publishing, Philadelphia (2010)
2. Larry Hargis, G *Analytical Chemistry: Principles and Techniques,* Englewood Cliffs, N. J.: Prentice Hall

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Semester-VIII

(Four Year Undergraduate Course Structure)

CHM 406: Analytical Chemistry (Paper 1)	**Credit 4+0**

Objective: To provide basic understanding of the principles, instrumentation and application of chemical analysis techniques.

Outcome: On completion of the course, students acquire knowledge to select proper techniques and instrumentation for particular sample analysis.

Units	Topics	Hours
I	**Electroanalytical Techniques:** (a) Conductometric: Discussion of the nature of the curves of acid-base (including mixtures of acids), precipitation and complexometric titrations. (b) Potentiometric: different types of electrodes, discussion of nature of the curves for oxidation- reduction and acid-base titrations, comparison with the conductometric method. (c) Voltammetry, Cyclic voltammetry (d) Polarography: Dropping mercury electrons and its advantages, polarographically active species, concept of residual, diffusion and limiting current of half-wave potential, Ilkovic equation and factors affecting diffusion current.	15
II	**Thermo-analytical Methods:** (a) Thermo-gravimetry: apparatus, factors affecting TGA, interpretation of TG curves of $CaC_2O_4.H_2O$ and $MgC_2O_4.2H_2O$ (b) Differential Thermal Analysis: Apparatus, factors affecting DTA curves with Special reference to heating rate, Particle size and packing, measurement of heat of transition, heat of reaction and heat of dehydration of salts of metal hydrates.	15
III	**Radiochemical methods:** (a) Isotope Method (b) Inverse Isotopic Dilution (c) Neutron activation technique.	15
IV	**Chromatographic Method:** (a) Gas Chromatography: GLC and GC (b) HPLC	15

Recommended Books

1. Fundamentals of analytical chemistry, D.A. Skoog, D.M. West and F.J. Holler
2. Quantitative inorganic analysis, A.I. Vogel

3.	Instrumental Methods of Chemical Analysis, B.K. Sharma
4.	Instrumental Methods of Chemical Analysis, H. Kaur
5.	Analytical Chemistry, Gary D. Christian

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Semester-VIII

(Four Year Undergraduate Course Structure)

CHM 407: Physical Chemistry (Quantum Mechanics and Surface Chemistry) (Paper 2)	**Credit 4+0**

Course Objectives:

The objective of this course is to provide students a new and advance understanding into quantum mechanics and surface chemistry

Course Outcome:

1. After successful completion of the course, the student will be able to:
2. solve basic quantum mechanical problems using Schrödinger equation (particle in a box, harmonic oscillator, rigid rotator and hydrogen atom
3. Interpret the principles of quantum chemistry in the context of atomic and molecular structure.
4. Interpret the approximate methods to solve the molecular problems
5. Describe the concepts of surface chemistry including adsorption and colloids.
6. Analyse adsorption isotherms and interpret experimental surface phenomena data.

Units	Topics	Hours
I	**Basic principles of quantum mechanics:** Postulates; operator algebra; exactly-solvable systems: particle-in-a-box, harmonic oscillator, rigid rotator and the hydrogen atom, including shapes of atomic orbitals; orbital and spin angular momenta; tunnelling.	**15**
II	**Approximate methods:** The variation theorem, linear variation principle. Perturbation theory (first order and nondegenerate). Simple application of variation method in perturbation theory. **Many –Electron Atoms,** Antisymmetry and Slater determinant for the wave function of ground state of multielectron atom, Self consistent field approximation (Hartree's Theory).	**15**
III	**Surface chemistry:** Adsorption Surface tension, capillary action, pressure difference across curved surface (Laplace equation), vapor pressure of droplets (Kelvin equation), Gibbs adsorption isotherm, estimation surface area (BET equation), and surface film of liquids (electro –kinetic phenomenon) catalytic activity at surface.	**15**
IV	**Micelles:** Surface active agent, classification of surface-active agent, micellization, hydrophobic interaction, critical micellar concentration (CMC), factors affecting the CMC of surfactant, counter ion binding to micelles, thermodynamics of micellization – phase separation and moss action models, solubilization, micro emulsion, reverse micelles.	**15**

Books Recommended:

1. *Quantum Chemistry* by Donald A. MacQuarrie
2. *Molecular Quantum Mechanics* by P.W. Atkins and R.S. Friedman
3. *Quantum Chemistry* by R. K. Prasad

4. *Introductory Quantum Chemistry* by A. K. Chandra
5. *Quantum Chemistry* by Ira N. Levine
6. *Advance Physical Chemistry* (Vol-1,2,3,4), K.L. Kapoor, MacMillan
7. *Advance Physical Chemistry*; Puri, Sharma, Pathania,

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Semester-VIII

(Four Year Undergraduate Course Structure)

CHM 408: Inorganic Chemistry (Chemistry of Transition Metals) (Paper 3)	**Credit 4+0**

Objective: The objective of this course is to

1. Understand the chemistry of transition metal-carbon multiple bonds with emphasis on metal carbenes and carbynes, including their synthesis, bonding, and structural aspects.
2. Examine the kinetics and mechanisms of ligand substitution reactions in coordination complexes, particularly in octahedral Co(III) and square planar Pt(II) systems.
3. Analyze stereoisomerism in six-coordinate octahedral complexes and understand stereochemical rearrangements and racemization mechanisms.
4. Explore the theories and principles governing metal-ligand equilibria in solution, including formation constants and their experimental determination.
5. Apply both qualitative and quantitative methods to evaluate the thermodynamic stability of metal complexes.

Course Outcome: Students will able to

1. Explain the structural and bonding characteristics of low-valent transition metal carbenes and carbynes, and outline their methods of synthesis.
2. Analyze the kinetics and mechanisms of ligand substitution reactions in Co(III) and Pt(II) complexes using associative and dissociative pathways.
3. Identify and predict the number and types of stereoisomers in octahedral complexes, including those with mono-, bi-, and polydentate ligands.
4. Describe and distinguish between stereochemical rearrangement mechanisms such as Bailar and Ray–Dutta twists and explain racemization processes in tris(chelate) complexes.
5. Define stepwise and overall formation constants, and analyze the factors influencing complex stability based on the properties of metal ions and ligands.
6. Determine stability constants of metal-ligand complexes using pH-metric and spectroscopic methods and interpret the results in terms of coordination chemistry principles

Units	**Topics**	**Hours**
I	**Compounds of Transition Metal-Carbon Multiple Bond:** Carbenes and Carbynes: Low valent carbenes and carbines, synthesis, nature of bond and Structural Characteristics.	**15**
II	**Kinetics and mechanism of substitution reactions** in octahedral Co (III) and square planar Pt (II) complexes.	**15**
III	**Stereoisomerisms** in six coordinate octahedral complexes (Ma_3bcd, Ma_2bcde, Mabcdef and complexes containing bi- and ter -dentate ligands, intermolecular and intramolecular rearrangements (Bailar and Ray-Dutt Twist) Mechanism of	**15**

	racemization in tris (chelate) octahedral complexes, methods of resolution of optical isomers.	
IV	**Metal Ligand Equilibria in Solution:** Step wise and overall formation constants and their relations, Factors affecting the stability of metal complexes with reference to the nature of metal ions and ligands, determination of stability constants by pH-metric and spectroscopic methods.	**15**

Books Recommended:

1. *Inorganic Chemistry*, 4th Edition, Principles of Structure and Relativity by J.E. Huheey, E.A. Keiter and R.L. Keiter, 1993
2. *Chemistry of XElements* by N.N. Greenwood and A. Ernshaw, Butterworths, 1997
3. *Mechanism of Inorganic Reactions: A Study of Metal Complexes in Solution* by F. Bosolo and R.G. Pearson

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Semester-VIII

(Four Year Undergraduate Course Structure)

CHM 409: Organic Chemistry (Stereochemistry and Pericyclic Reactions) (Paper 4)	**Credit 4+0**

Objective: This course is framed to provide an in depth understanding of some important aspects of Stereochemistry, pericyclic reactions, Stereochemistry and reactivity of cyclohexane and asymmetric synthesis.

Outcome: On the completion of the course students will have the understanding of basics of organic Photochemistry and Pericyclic reactions. Various theories/rules governing these pericyclic reactions will help them to predict the products with stereochemistry involved in these reactions.

Units	Topics	Hours
I	**Stereochemistry:** Elements of symmetry, chirality, molecules with more than one chiral center, threo and erythro isomers, Configurational projections (Wedge-dash, Fischer, Newmann and Saw-Horse projections), Interconversion of different projections, CIP rule and R/S nomenclature, **Principle of axial and planar chirality:** optical isomerism of biphenyl, allenes, spiranes, cyclophane, ANSA compounds optical activity due to intramolecular overcrowding, absolute configuration, **Topicity and Prostereoisomerism:** Introduction, Homotopic, enantiotopic and diastereotopic atoms, groups and faces, Nomenclature and symbols	**15**
II	**Asymmetric synthesis:** Racemic mixture, Enantiomeric excess and optical purity, stereoselectivity (enantioselectivity and diastereoselectivity) and stereospecificity, Diastereoselective aldol condensation with special emphasis on Cram's rule, Felkin-Anh Model and Zimmerman-Traxler Model **Asymmetric synthesis:** Principles of asymmetric synthesis, Asymmetric synthesis involving chiral auxiliary (Evans Auxiliary), chiral reagent and chiral catalysis example: CBS reagent, Sharpless Asymmetric epoxidation,	**15**
III	**Stereochemistry and reactivity of cyclohexane and its derivatives:** Configuration, conformation and stability of mono and di-substituted cyclohexane and cyclohexanones, Stereoisomerism (cis-trans and chirality) of disubstituted cyclohexanes. Effect of conformation on Reactivity of substituted cyclohexane	**15**
IV	**Pericyclic reactions:** Introduction, classification and characteristics, Conservation of Molecular orbital symmetry, Use of correlation diagrams: FMO approach to study electrocyclic reactions of linear conjugated diene, triene and allyl systems., Cycloaddition reactions involving [2+2] and [4+2] systems., Sigmatropic rearrangements ([1,3], [1,5] and [3,3]), Claisen, Cope, and aza-Cope rearrangements, Wolff Rearrangement, Wittig Rearrangement, Group transfer reactions such as Conia-ene reaction	**15**

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Recommended Books

1. *Pericyclic Reaction and Organic Photochemistry* BY Dr. Vinay Prabha Sharma, Rakesh Kumar
2. *Organic Synthesis* BY Dr. Jagdamba Singh, Dr. L.O.S. Yadav
3. *Stereochemistry* By P. S. Kalsi
4. *Stereochemistry* by D Nasipuri

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Semester-VIII

(Four Year Undergraduate Course Structure)

CHM 410: Chemical Kinetics, Separation and Identification of Binary Inorganic/Organic Mixtures (*Practical*) **(Paper 5)**	**Credit 0+4**

Objective: To provide basic understanding of the principles and processes by which chemical analysis is being done.

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

- Determine solubility, heat of solution, and rate constant of chemical reactions
- Perform conductometric titrations
- Perform Gravimetric and volumetric (Quantitative) analysis of an inorganic mixture
- Prepare of simple organic compounds
- Purify of organic compounds

Unit	Topic
I	**Physical Chemistry:** 1. Draw the solubility curve for water-acetic acid- chloroform system. 2. Determine the rate constant of the acid-catalyzed hydrolysis of ethyl acetate at laboratory temperature. 3. Determine the rate of constant of the hydrolysis of ethyl acetate by sodium hydroxide at laboratory temperature. 4. Carry out the conductometric titration between the strong acid and strong alkali. 5. Determine the dimerization constant of benzoic acid in benzene medium by partition method. 6. Determine the solubility of salicylic acid in water at different temperatures and calculate the heat of solution.
II	**Inorganic Chemistry:** Either both gravimetric and one volumetric estimation of two metal ions from following mixtures: a) Cu^{2+} and Ni^{2+} b) Cu^{2+} and Zn^{2+} c) Ni^{2+} and Zn^{2+} d) Cu^{2+} and Ba^{2+} e) Cu^{2+} and Ag^{+} f) Fe^{2+} and Ag^{+} **g)** Ba^{2+} and Ag^{+}
III	**Organic Chemistry:** 1. Preparation of organic compounds involving two stages, Emphasis should be given in the following Processes:

	2. Purification, distillation under reduced pressure, steam distillation, and fractional crystallization

Suggested Readings:

1. Mendham, J. Vogel's *Quantitative Chemical Analysis*, Pearson, 2009.
2. Harris, D. C. *Quantitative Chemical Analysis*. 6th Ed., Freeman (2007) Chapters 3-5.
3. Harris, D.C. *Exploring Chemical Analysis*, 9th Ed. New York, W.H. Freeman, 2016.
4. Khopkar, S.M. *Basic Concepts of Analytical Chemistry*. New Age International Publisher, 2009.
5. Skoog, D.A. Holler F.J. and Nieman, T.A. *Principles of Instrumental Analysis*, Cengage Learning India Edition