DEEN DAYAL UPADHYAYA GORAKHPUR UNIVERSITY

GORAKHPUR

FOUR YEAR

B. Sc. CHEMISTRY Programme

(B.Sc. Chemistry- Honours and Research Programme)

Syllabus

(For the Academic Session-2024 onwards)

Appendix-A (Four Year UG Programme Framework)

Year	Semester	MAJOR-1 [Subject-1] From Same Faculty	MAJOR-2 [Subjec:-2] From Same Faculty	MINOR [Subject-3] From Same/ others Faculty	SEC Skill Enhancement Course/ vocational	AEC Ability Enhancement Courses/ CoCurricular	Research Project/ Dissertation/ Internship/ Field work/ survey	Total Credits	Degree and Credits	
1	I	Th (6) OR Th (4)+ Prac (2)	Th (6) OR Th (4)+ Prac (2)	Th (6) OR Th (4)+ Prac (2)	S.E.C.-I (3 Credits)	AEC-1 (2 Credits)		23	Certificate in Faculty (46 Credits)	
	II	Th (6) OR Th (4)+ Prac (2)	Th (6)or Th (4)+ Prac (2)	Th (6) OR Th (4)+ Prac (2)	S.E.C.-2 (3 Credits)	AEC-2 (2 Credits)		23		Exit Option 1
2	III	Th (6) OR Th (4)+ Prac (2)	Th (6)or Th (4)+ Prac (2)	Th (6) OR Th (4)+ Prac (2)	S.E.C.-3 (3 Credits)	AEC-3 (2 Credits)		23	Diploma in Faculty (92 Credits)	
	IV	Th (6) OR Th (4)+ Prac (2)	Th (6) OR Th (4)+ Prac (2)	Th (6) OR Th (4)+ Prac (2)		AEC-4 (2 Credits)	Any one (3 Credits)	23		Exit Option 2
3	V	Th (2x5) OR Th (2x4) + Prac (2)	Th (2x5) OR Th(2x4) + Frac (2)					20	UG Degree (132 Credits)	
	VI	Th (2x5) OR Th (2x4) + Prac (2)	Th (2x5) OR Th (2x4) + Prac (2)					20		
4	VII	Th (5x4) OR Th (4x4)+ Prac(4)						20	UG Honors (172 Credits)	
	VIII	Th (5x4) OR Th (4x4)+ Prac (4)						20		
OR		For Students who secured 75% Marks in First Six Semesters								
4	VII	Th (5x4) OR Th (4x4)+ Prac(4)						20	UG Honors with Research (172 Credits)	
	VIII	Th (2x4)					Research Project (12 Credits)	20		

B.Sc. Chemistry

B.Sc. I Semester

Paper No.	Paper Name	No. of Credits
CHE-101F	Fundamentals of Chemistry	4+0
CHE-102F	Qualitative Analysis	0+2
SECC-01F	Laboratory tools and techniques	3+0
AECC-01F	Academic writing	2+0

B.Sc. II Semester

Paper No.	Paper Name	No. of Credits
CHE-103F	Basic organic chemistry, solid state and chemistry of s and p-block elements	4+0
CHE-104F	Chemical Analysis	0+2
SECC-02F	Industrial Processes	3+0
AECC-02F	Personality Development and Leadership	2+0

B.Sc. III Semester

Paper No.	Paper Name	No. of Credits
CHE-201F	Chemical Dynamics, Organic & Coordination Chemistry	4+0
CHE-202F	Physical Analysis	0+2
SECC-03F	Environmental studies and Computer application	3+0
AECC-03F	Industrial Waste Management	2+0

B.Sc. IV Semester

Paper No.	Paper Name	No. of Credits
CHE-203F	Quantum Mechanics & Organic Synthesis-A	4+0
CHE-204F	Separation Technique and Volumetric Analysis	0+2
CHE-205F	Research Project	3+0
AECC-04F	Occupational Health Management	2+0

B.Sc. V Semester

Paper No.	Paper Name	No. of Credits
CHE-301F	Analytical Techniques and Organic Synthesis-B	4+0
CHE-302F	Polymer, Coordination and Inner Transition Metal Chemistry	4+0
CHE-303F	Qualitative and Quantitative Analysis	0+2

B.Sc. VI Semester (B.Sc. Chemistry)

Paper No.	Paper Name	No. of Credits
CHE-304F	Organic Synthesis-C	4+0
CHE-305F	Chemical Energetics & Bioinorganic Chemistry	4+0
CHE-306F	Physico-Chemical Analysis and Organic Synthesis	0+2

B.Sc. VII Semester
(B.Sc. Chemistry Honours) and (B.Sc. Chemistry Research)

Paper No.	Paper Name	No. of Credits
CHE-401F	Molecular Symmetry and Molecular Vibrations	4+0
CHE-402F	Quantum Chemistry-I	4+0
CHE-403F	Main Group Elements	4+0
CHE-404F	Organic Reaction Mechanism	4+0
CHE-405F	Surface Chemistry, purification and identification of materials	0+4

B.Sc. VIII Semester (B.Sc. Chemistry Honours)

Paper No.	Paper Name	No. of Credits
CHE-406F	Analytical Chemistry	4+0
CHE-407F	Thermodynamics and Electrochemistry	4+0
CHE-408F	Transition Elements	4+0
CHE-409F	Natural Products	4+0
CHE-410F	Chemical Kinetics, separation and identification of binary inorganic / organic materials	0+4

B.Sc. VIII Semester (B.Sc. Chemistry Research)

Paper No.	Paper Name	No. of Credits
CHE-406F	Analytical Chemistry	4+0
CHE-411F	Chemical Techniques	4+0
CHE-412F	Research Project	0+12

SUBJECT: CHEMISTRY

(Four Year Undergraduate Course Structure)

Purpose of the Program

The purpose of the undergraduate chemistry program is to provide the key knowledge based and laboratory resources to prepare students for career as professionals in various industries and research institutions.

Program Specific Outcomes

PS01. Students will have a firm foundation in the fundamentals and application of current chemical and scientific theories including those in analytical, Inorganic, Organic and Physical Chemistries.

PS02. Students will be able to design and carry out scientific experiments as well as accurately record and analyze the results of such experiments.

PS03. Students will be skilled in problem solving, critical thinking and analytical reasoning as applied to scientific problems.

PS04. Students will be able to explore new areas of research in both chemistry and allied fields of science and technology.

PS05. Students will appreciate the central role of chemistry in our society and use this as a basis for ethical behavior in issues facing chemists including an understanding of safe handling of chemicals, environmental issues and key issues facing our society in energy, health, and medicine.

PS06. Students will be able to explain why chemistry is an integral activity for addressing social, economic, and environmental problems.

PS07. Students will be able to function as a member of an interdisciplinary problem-solving team.

B.Sc. I Year (CHEMISTRY)

Semester-I

(Four Year Undergraduate Course Structure)

CHE 101F: 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

- 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.

Unit	**Topics**
I	**Atomic Structure:** Quantum numbers. shapes of s, p and d orbitals. Pauli's exclusion principle. Hund's rule of maximum multiplicity. Aufbau principle. Variation of orbital energies with atomic number and energy level diagram.
II	**Bonding theories of Molecules:** The valence bond theory (VBT) and it's limitations, Concept of hybridization, hybrid orbitals and molecular geometry, Bents rule, Valence shell electron pair repulsion theory (VSEPR), shapes of simple molecules and ions. Molecular orbital theory (MOT). Molecular orbital diagrams, bond orders of homonuclear and heteronuclear diatomic molecules and ions.
	Dipole Moment and Weak Chemical Forces- hydrogen bonding, Van der Waals forces

III	**Periodic properties of Atoms:** Brief discussion, 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.
IV	**Kinetic theories of gases Gaseous State:** 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.
V	**Recapitulation of basics of Organic Chemistry:** Hybridization, bond lengths and bond angles, bond energy, localized and delocalized chemical bonding, hyperconjugation; Electronic Displacements: Inductive, electromeric, resonance mesomeric effects and their applications
VI	**Mechanism of Organic Reactions:** Curved arrow notation, drawing electron movements with allows, half-headed and double-headed arrows, homolytic and heterolytic bond fission, Types of reagents electrophiles and nucleophiles, Types of organic reactions, Energy considerations. Reactive intermediates Carbocations, carbanions, free radicals, Assigning formal charges on intermediates and other ionic species.
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, methods of formation, chemical reactions, 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.

Suggested Readings:

1. Lee, J.D. Concise Inorganic Chemistry, Pearson Education2010
2. Huheey, J.E., Keiter, E.A., Keiter, R. L., Medhi, O.K. Inorganic Chemistry, Principles of Structure and Reactivity, Pearson Education 2006.
3. Shriver, D.D. & P. Atkins, *Inorganic Chemistry 2nd Ed.,* Oxford University Press,1994.
4. Morrison,R.N.&Boyd,R.N.*OrganicChemistry*,DorlingKindersley(India)Pvt.Ltd.(PearsonEducation).
5. Carey, F. A., Guiliano, R. M.*Organic Chemistry*, Eighth edition, McGraw Hill Education,2012.
6. Clayden,J.,Greeves,N.&Warren,S.*OrganicChemistry,* 2nd edition,OxfordUniversityPress,2012.
7. Graham Solomons, T.W., Fryhle, C. B. *Organic Chemistry,* John Wiley & Sons,Inc.
8. Chaube D. K. *et al, A Textbook of fundamental chemistry*, The Krishna Publications.

B.Sc. I Year (CHEMISTRY)
Semester-I Practical
(Four Year Undergraduate Course Structure)

CHE 102F: 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

Unit	**Topics**
I	**Crystallisation and Determination of melting point** (i) Benzoic Acid (ii) Acetanilide
II	**Qualitative analysis of Inorganic mixture containing four radicals** NH_4^+, 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^-.
III	**Calibration of thermometer, pipettes, burettes and other glasswares.**
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 Qauntitative Chemical Analysis, Pearson
2. Harris, D. C. Quantitative Chemical Analysis. 6th Ed., Freeman (2007) Chapters3-5.
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
6. Chaube D. K. *et al, Practical Chemistry*, The Krishna Publications.

B.Sc. I Year (CHEMISTRY) Semester-II (Four Year Undergraduate Course Structure)	
CHE 103F: 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
- Chemistry of p-block elements and noble gases.

Unit	Topics
I	**Chemistry of Alkenes:** Methods of formation of alkenes, Elementary treatment of mechanism of (i) addition of hydrogen, halogens, halogen acids, water and sulphuric acid and (ii) Hydroboration, epoxidation, ozonolysis and hydroxylation.
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.
III	**Stereochemistry:** Concept of isomerism, Types of isomerism. (i) Optical isomerism: (a) Concept of chirality, elements of symmetry (b) Optical isomerism of compounds containing one (lactic acid) and two asymmetric carbons (tartaric acid). (ii) Methods of racemization and resolution, relative and absolute configuration. (iii) Geometrical isomerism: Maleic and fumaric acid, and methods for their configurations. (iv) Sawhorse and Newman's projection formula; R-S, D-L and E-Z nomenclatures. (v) Conformations of ethane and n-butane
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 cholesterol phases. Thermography and seven segment cell.
V	**General studies of s block elements :** Group wise discussion of s-block element with respect to electronic configuration, ionisation potential, electron affinity, electronegativity, atomic and ionic radii and their oxidation states. General trend of their compounds.
VI	**Solid State:** Definition of space lattice, unit cell. 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 .X-ray diffraction by crystals. Derivation of
	Bragg equation. Determination of crystal structure of NaCl and KCl.

VII	**p-Block Elements**: Comparative study (including diagonal relationship) of groups 13-17 elements, compounds like hydrides, oxides, oxyacids and halides of group 13-16, hydrides of boron-diborane and higher boranes, borazine, borohydrides, fullerenes, carbides, fluorocarbons, silicates (structural principle), tetrasulphur tetra nitride, basic properties of halogens, interhalogens and polyhalides. **Chemistry of Noble Gasses**: Chemical properties of the noble gases, chemistry of xenon, structure and bonding in xenon compounds.

Suggested Readings:

1. Davis,B.G.,Fairbanks,A.J.,*CarbohydrateChemistry*,OxfordChemistryPrimer,OxfordUniversityPress.
2. Finar, I. L. *Organic Chemistry* (*Volume 2)*, Dorling Kindersley (India) Pvt. Ltd.(PearsonEducation).
3. Nelson, D. L. & Cox, M. M. *Lehninger's Principles of Biochemistry7th Ed.*, W. H.Freeman.
4. Ball, D. W. Physical Chemistry Thomson Press, India(2007).
8. Castellan, G. W. Physical Chemistry 4th Ed. Narosa(2004).
9. R.B. Seymour & C.E. Carraher: *Polymer Chemistry: An Introduction*, Marcel Dekker, Inc. New York, 1981.
10. G.Odian:*PrinciplesofPolymerization*,4thEd.Wiley,2004.
11. F.W.Billmeyer:*TextbookofPolymerScience*,2ndEd.WileyInterscience,1971.
12. P. Ghosh: Polymer Science & Technology, Tata McGraw-Hill Education,1991

B.Sc. I Year (CHEMISTRY)
Semester-II Practical
(Four Year Undergraduate Course Structure)

CHE 104F: 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.

Unit	**Topics**
I	Separation and identification of amino acids present in given mixture by paper chromatography, reporting the R_f value.
II	**Surface Tension and Viscosity** 1.Determination of surface tension of pure liquid or solution 2.Determination of viscosity of liquid pure liquid or solution
III	**Preparation of Organic Compounds** (i) Picrates (ii) Acetanilide (iii) 2,4,6 tribromoaniline
IV	**Identification of organic compounds** Identification of an organic compound through the functional group analysis, determination of melting point and preparation of suitable derivatives.

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,* PearsonEducation.
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,

B.Sc. II Year (CHEMISTRY) Semester-III (Four Year Undergraduate Course Structure)	
CHE 201F: 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 equilibirium, lementary knowledge of d-block elements and coordination chemistry.

Unit	Topics
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, halflife 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).
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. Pb-Ag systems.
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
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.

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 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.
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 7 in octahedral, tetrahedral and square planner complexes, factors affecting the crystal-field parameters.

Suggested Readings:

1. Alberty,R A, Physical Chemistry,4 theditionWiley Eastern Ltd,2001.
2. Atkins,PW,the elements of physical chemistry,Oxford,1991
3. Barrow,G .M,International student Edition .McGraw Hill,McGraw-Hill,1973.
4. Cotton,F.A, Wilkinson,G and Gaus,P. L ,Basic Inorganic Chemistry,3rd Edition ,Wiley1995
5. Lee,J.D, Concise Inorganic Chemistry 4th EditionELBS,1977
6. Clayden,J.,Greeves,N.,Warren,S.,*OrganicChemistry*,Secondedition,OxfordUniversityPress2012.
7. Silverstein, R. M., Bassler, G. C., Morrill, T. C. *Spectrometric Identification of Organic Compounds*, John Wiley and Sons, INC, Fifthedition.
8. Pavia, D. L. *et al*. *Introduction to Spectroscopy*, 5th Ed. Cengage Learning IndiaEd.
9. Willard, H.H. *et al.*: *Instrumental Methods of Analysis*, 7th Ed. Wardsworth Publishing Company, Belmont, California, USA,1988.
10. Christian, G.D. *Analytical Chemistry*, 6th Ed. John Wiley & Sons, New York,2004.
11. Harris, D.C.: *Exploring Chemical Analysis*, 9th Ed. New York, W.H. Freeman,2016.
12. 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

B.Sc. II Year (CHEMISTRY)
Semester-III Practical
(Four Year Undergraduate Course Structure)

CHE 202F: 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.

Unit	Topics
I	**Surface Tension and Viscosity** 1. Determination of surface tension of pure liquid or solution 2. Determination of viscosity of liquid pure liquid or solution
II	**Boiling point and Transition Temperature** 1. Boiling point of common organic liquid compounds **ANY FIVE:** *n* butylalcohol, 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 180^0C]. 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 neutralisation of (i) Strong Acid-Strong Base (ii) Strong Acid-Weak Base (iii) Weak Acid-Strong Base

Suggested Readings:

1. Skoog. D. A., West DM and Hollar
2. 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, http://chemcollective.org/vlabs

B.Sc. II Year (CHEMISTRY)
Semester-IV
(Four Year Undergraduate Course Structure)

CHE 203F: Quantum Mechanics and Organic Synthesis-A	**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

Unit	Topics
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*
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 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.
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,
V	**A. 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. **B. Gravimetric Analysis** Precipitation from homogenous medium, purity of precipitates, coprecipitation, post-precipitation, washing and ignition of precipitates, contamination and their removal.
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
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.

Suggested Readings:

13. Alberty,R A, Physical Chemistry,4 theditionWiley Eastern Ltd,2001.
14. Atkins,PW,the elements of physical chemistry,Oxford,1991
15. Barrow,G .M,International student Edition .McGraw Hill,McGraw-Hill,1973.
16. Cotton,F.A, Wilkinson,G and Gaus,P. L ,Basic Inorganic Chemistry,3rd Edition ,Wiley1995
17. Lee,J.D, Concise Inorganic Chemistry 4th EditionELBS,1977
18. Clayden,J.,Greeves,N.,Warren,S.,*OrganicChemistry,*Secondedition,OxfordUniversityPress2012.
19. Silverstein, R. M., Bassler, G. C., Morrill, T. C. *Spectrometric Identification of Organic Compounds*, John Wiley and Sons, INC, Fifthedition.
20. Pavia, D. L. *et al. Introduction to Spectroscopy,* 5th Ed. Cengage Learning IndiaEd.
21. Willard, H.H. *et al.*: *Instrumental Methods of Analysis*, 7th Ed. Wardsworth Publishing Company, Belmont, California, USA,1988.
22. Christian, G.D. *Analytical Chemistry*, 6th Ed. John Wiley & Sons, New York,2004.
23. Harris, D.C.: *Exploring Chemical Analysis*, 9th Ed. New York, W.H. Freeman,2016.
24. Khopkar, S.M. *Basic Concepts of Analytical Chemistry*. New Age International Publisher,2009.

Suggestive digital platforms web links

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

B.Sc. II Year (CHEMISTRY)
Semester-IV Practical
(Four Year Undergraduate Course Structure)

CHE 204F: 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

Unit	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.AnalyticalChemistry,6thEd.JohnWiley&Sons,NewYork,2004.
4. Harris,D.C.ExploringChemicalAnalysis,9thEd.NewYork,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 &AlliedMethods, Elles Harwood Ltd.London.
8. Ditts, R.V. Analytical Chemistry: Methods of separation. Van Nostrand, New York,1974.

B.Sc. III Year (CHEMISTRY) Semester-V (Four Year Undergraduate Course Structure)	
CHE 301F: Analytical Techniques 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 opportunities 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.

Unit	Topics
I	**UV-Visible Spectroscopy :** Origin of spectra, interaction of radiation with matter, fundamental laws of spectroscopy and selection rules, types of electronic transitions, λmax, chromophore and auxochromes, nBathochromic and Hypsochromic shifts, Intensity of absorption, application of Woodward Rules for calculation of λmax for the conjugated dienes, alicyclic, homoannualar and heteroannular; extended conjugated systems, distinction between cis and trans isomers.
II	**Infrared Spectroscopy:** **IR Spectroscopy**: Fundamental and non-fundamental molecular vibrations; Hooke's law, selection rule, IR absorption positions of various functional groups; Effect of H-bonding, conjugation, resonance and ring size on IR absorptions; Fingerprint region and its significance, application in functional group analysis and and interpretation of I.R. spectra of simple organic compounds.
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; Polyhalogencompounds : 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,

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).
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.
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
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.
VIII	**Synthetic Dyes:** Color and constitution (electronic Concept), Classification of dyes, Chemistry and synthesis of Methyl orange, Congo red, Malachite green

Suggested Readings:

1. Morrison,R.N.&Boyd,R.N.*OrganicChemistry*,DorlingKindersley(India)Pvt.Ltd.(PearsonEducation).
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, OxfordUniversity 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 CompanyLimited.
8. March, J. *Advanced Organic Chemistry*, Fourth edition, Wiley.\

B.Sc. III Year (CHEMISTRY)

Semester-V

(Four Year Undergraduate Course Structure)

CHE 302F: 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.

Unit	Topics
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-Burkplot, turn-over number.
II	**Chemistry of Lanthanides** Electronic structure, oxidation states and ionic radii and lanthanide contraction, complex formation, occurrence and isolation, ceric ammonium sulphate and its analyticaluses.
III	**Chemistry of Actinides** Electronic configuration, oxidation states and magnetic properties, chemistry of separation of Np, Pu and Am from U.
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.

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 d1 and d9 states, discussion of the electronic spectrum of $[Ti(H2O)_6]$ 3+ and $[Cu(H_2O)_6]^{2+}$complex ion. **II.** Magnetic properties of transition metal complexes, types of magnetic behaviour, 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 magnetic properties : Paramagnetism, diamagnetism, ferromagnetism and magnetic susceptibility.
VI	**Metal Carbonyls and Nitrosyls** 18-electron rule, preparation, structure and nature of bonding in the mononuclear and dinuclear carbonyls and nitrosyls.
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.

Suggested Readings:

1. Morrison,R.N.&Boyd,R.N.*OrganicChemistry*,DorlingKindersley(India)Pvt.Ltd.(PearsonEducation).
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, OxfordUniversity Press, 2012.
6. Smith, J. G. *Organic Chemistry*, Tata McGraw-Hill Publishing CompanyLimited.
7. March,J.*AdvancedOrganicChemistry*,Fourthedition,Wiley.
8. Lee,J.D.ConciseInorganicChemistry,PearsonEducation2010.

B.Sc. III Year (CHEMISTRY)
Semester-V Practical
(Four Year Undergraduate Course Structure)

CHE 303F: 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

Unit	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	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. 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.*ExploringChemicalAnalysis*,9th Ed.NewYork,W.H.Freeman,2016.
4. Khopkar, S.M. *Basic Concepts of Analytical Chemistry*. New Age International Publisher,2009.

B.Sc. III Year (CHEMISTRY)
Semester-VI
(Four Year Undergraduate Course Structure)

CHE 304F: 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.

Unit	Topics
I	**Reagents in Organic Synthesis** A detailed study of the following reagents in organic transformations, Oxidation with SeO2, Jones Oxidation, PCC, PDC, NaBH4, LiAlH4, DIBAL-H
II	**Organometallic Compounds-** Organomagnesium compounds: the Grignard reagents, formation, structure and chemical reactions. Organolithium compounds: formation and chemical reactions.
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 nucleophillic additions to carbonyl group with particular emphasis on benzoin, aldol, Perkin and Wittig reaction Oxidation of aldehydes, Cannizzaro reaction, ~~MPV~~, Clemmensen, Wolff-Kishner, An introduction to a,b –unsaturated aldehyde and ketones.
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, 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.
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 electrophilc substitution reactions of indole, quinoline and isoquinoline.
VII	**Rearrangements** A detailed study of the following rearrangements: Pinacol-pinacolone, Benzil Benzilic acid, and Fries rearrangement

Suggested Readings:

1. Morrison,R.N.&Boyd,R.N.*OrganicChemistry*,DorlingKindersley(India)Pvt.Ltd.(PearsonEducation).
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, OxfordUniversity 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 CompanyLimited.
8. March, J. *Advanced Organic Chemistry*, Fourth edition,Wiley.
9. Acheson, R.M. Introduction to the Chemistry ofHeterocyclic 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 ofNatural
12. Products), Dorling Kindersley (India) Pvt. Ltd. (PearsonEducation).
13. Singh, J.; Ali, S.M. & Singh, J. Natural Product Chemistry, Pragati Prakashan(2010).

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Suggested online links:

http://heecontent.upsdc.gov.in/Home.aspx

B.Sc. III Year (CHEMISTRY) Semester-VI (Four Year Undergraduate Course Structure)	
CHE 305F: 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 conductivity and potentiometric measurements

Unit	Topics
I	**Thermodynamics-1 :** **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.
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 Helmhotz function (A) as thermodynamic quantities. A & G as criteria for thermodynamic equilibrium and spontaneity, their advantage over entropy change,
III	**Electrochemistry**: specific conductance molar and equivalent conductance, measurement of equivalent conductance, variation ofmolar,equivalent and specific conductances 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 .

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 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.

Suggested Readings:

1. Foye, W.O., Lemke, T.L. & William, D.A.: Principles of Medicinal Chemistry, 4th ed., B..I. Waverly Pvt. Ltd. NewDelhi.
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.PhysicalChemistryThomsonPress,India(2007).
6. Castellan,G.W.PhysicalChemistry4thEdn.Narosa(2004).
7. Allen Bard ,JLarry . Faulkner R ,Fundamentals of Electrochemical methods fundamentals and applications,newYork John ,Wiley &sons ,2001
8. H. J. Arnikar, *Essentials of Nuclear Chemistry*, 4th ed., New Age International, NewDelhi, 1995.

B.Sc. III Year (CHEMISTRY)
Semester-VI Practical
(Four Year Undergraduate Course Structure)

CHE 306F: 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 thermo chemical reactions

Unit	**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-Habercycle.
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. Skkog DA, West DM Hollar, FJ, Analytical Chemistry: An Introduction 7th Edition, Sauders college publishing, Philadelphia (2010)
2. Larry Hargis, G Analytical Chemistry: Principles and Techniques

Suggestive digital platforms web links

4. https://www.labster.com/chemistry-virtual-labs/
5. https://www.vlab.co.in/broad-area-chemical-sciences
6. http://chemcollective.org/vlabs

B.Sc. Chemistry Honours and Research
Semester-VII

CHE 401F :Molecular Symmetry and Molecular Vibrations

(4+0 Credits)

Course Objectives: Symmetry strictly defines relations between molecular spectra and molecular structure. This paper focuses on the mathematical tools which are necessary to apply symmetry concepts to vibrational spectroscopy.

Unit-1

Symmetry elements and symmetry operations with special reference to water and ethane.

Classification of molecules/ ions based on their symmetry properties.

Unit-2

Derivation of matrices for rotation, reflection, rotation-reflection and inversion operations, Symmetry point groups applied to all type of molecules (C_{nh}, D_{nh}, C_{nv}, T_d, O_h and I_h).

Unit-3

Group multiplication basis, matrix representation, character of an operation, orthogonality, character tables, reducible and irreducible representations, groups, subgroups and classes.

Unit-4

Symmetry of normal vibrations, determination of normal modes by internal and Cartesian coordinates methods, mixing of internal coordinates in normal modes, selection rules for IR and Raman spectroscopy.

Unit-5

Normal coordinate analysis of water and ammonia molecules and their infrared and Raman spectral activity.

Books Recommended:

1. D.M. Bishop, "Group theory and Chemistry" Dover Publications.
2. F.A. Cotton, "Chemical Applications of Group Theory", John Wiley, 1971.
3. M. Hamaresh, "Group theory and its Applications to Physical Problems" Addison- Wisley
4. McWeeny, "Symmetry - An Introduction to Group Theory", Pergamon Press.
5. Lowell H. Hall "Group Theory and Symmetry in Chemistry", McGraw Hill Book Company, New York, 1969
6. K.VeeraReddy,"Symmetry and Spectroscopy of Molecules", New Age International Limited Publisher, New Delhi.

Course Outcomes:

CO 1: Symmetry elements and symmetry operations covers a wide area of research in theoretical chemistry.

CO 2: Understanding of symmetry of normal vibrations, determination of normal modes, mixing of internal coordinates and normal coordinate analysis of molecules develops the basis of experimental infra red and Raman spectroscopic analysis of molecules and their theoretical calculations via computational programmes.

CHE 402F : Quantum Chemistry I

(4+0 Credits)

Course Objectives: The objective of the course is to know the application of quantum mechanics in physical models and experiments of chemical systems. It is also called molecular quantum mechanics.

Unit-1

Fundamental Concepts:

- **a.** Operators and algebra of operators, commutators, Linear operators, Vector operators, Laplacian operators, Hermitian operators, Concept of normalization and orthogonality in wave function.
- **b.** Postulates of quantum mechanics.
- **c.** Schrodinger equation and particle in one dimensional and three-dimensional box and degeneracy of states.

Unit-2

Quantum mechanical treatment:

a. Quantum mechanical treatment of a harmonic oscillator, One dimensional Harmonic oscillator (Classical and quantum mechanical treatments), Energy levels of harmonic and an-harmonic oscillators.
b. Quantum mechanical treatment of a rigid rotor
c. Rigid rotor model of a diatomic molecule, Energy levels of a rigid rotor, Rigid rotor selection rule, A non rigid rotor.

Unit 3

Schrodinger equation for H atom:

Transformation of coordinates, Separation of Variables, φ,θ and R equations and theirsolutions, Spherical harmonics.

Unit 4

Many –Electron Atoms:

Antisymmetry and Slater determinant for the wave function of ground state of multielectron atom, Self consistent field approximation (Hartree's Theory).

Unit 5

Approximation methods:

The variation method, Perturbation method and First order Perturbation theory.

Reference Books:

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. Physical Chemistry by T. Engel and P. Reid

Course Outcomes:

CO 1: Students will be able to grasp fundamental concepts of operators, algebra of operators and quantum mechanical and Schrodinger wave equations for single and multi electron systems.

CO 2: Real analysis covers a wide area of research in computational chemistry. This course is useful in various completive exams like CSIR-NET, IAS, PCS.

CHE 403F: Main Group Elements

(4+0 Credits)

Course Objectives: The paper of main group elements is introduced to M.Sc. classes for the study of s and p block elements of the periodic table. The core objective of this paper is to prepare the students to understand and correlate preparation, structure, bonding and properties of s and p block elements.

Unit-1

Stereochemistry of Bonding in Main Group Components:

dπ – pπ bonds, Bents rule, Energetics of hybridization

Unit-2

Preparation, Structure, Bonding and Technical Applications of,

a. Polyether complexes of alkali and alkaline earth metals
b. Polyphasphazenes
c. Thiazyl and its polymers, tetrasulfurdinitride.

Unit-3

a. Structure and bonding of Borane anions
b. Classification and structures of Silicates

Unit-4

Synthesis and structure of:

a. Carbides
b. Polyions of Ge, Sn, Pb, Sb, Bi and Hg

Unit-5

a. Definition and classification of organometallic compounds on the basis of hapticity and polarity of metal-carbon bond
b. Preparation, Properties, Structure and Applications of**a**lkyl and aryls of Lithium, Beryllium, Aluminum, Mercury and Tin.

Reference Books:

1. Advance Inorganic Chemistry, 6th Edition, Cotton and Wilkinson
2. Inorganic Chemistry, 4th Edition, Principles of Structure and Reactivity by J.F. Huheey, E.A. Keiter and R.L. Keiter, 1993

3. Chemistry of Elements by N.N. Greenwood and A. Ernshaw, Butterworths 1997
4. Organometallic Chemistry: A Unified Approach by R.C. Mehrotra and A.K. Singh
5. Comprehensive Coordination Chemistry Vol.3 by G. Wilkinson, R.D. Gillard, And J.A. McCleverty, Pergamon Press 1987.

Course Outcomes:

CO 1. Students will be able to demonstrate an intuitive understanding ofcorrelation between electronic configuration and bonding properties of elements.

CO 2. Chemistry of main group elements covers a wide area of research in inorganic chemistry.

CHE 404F:Organic Reaction Mechanism

(4+0 Credits)

Course Objectives:

1. Train students to graspbasics of organic reactions- step by step sequence of elementary reactions by which overall chemical change occurs.
2. To understand principles of organic reaction mechanism, substitution, elimination, homo- and hetero bond addition reactions.
3. To prepare the students for further research in organic chemistry.

Unit-1

Basic principle of organic reaction mechanism:

Potential energy diagram, methods of determination of organic reaction mechanism and their applications, kinetic isotopic effect and its importance in determination of reaction mechanism.

Unit-2

Substitution Reactions:

a. **Aromatic electrophilic substitution:** General view, energy profile diagram, arenium ion mechanism (ArSE) of different aromatic electrophilic substitution reactions, ipso-substitution and ortho/ para ratio.

b. **Aromatic nucleophilic substitution:** (ArSN) Addition- elimination and elimination- addition (benzyne) mechanisms,

c. **Aliphatic nucleophilic substitution:** Mechanism and stereochemistry of S_N1, S_N2, S_N' and S_N^i reactions, role of substrate's. Nuleophilic substitution at bridged head carbon atom.

d. **Neighouring group participation (NPG):** Evidence for NGP,participation of sigma., Pi- bonds, halogen, N-atoms and phenyl ring.

Unit-3

Elimination reaction:

E_1, E_2 and E_1cb mechanisms, orientation (Saytzef's and Hoffmann eliminations), pyrolytic (syn) elimination, stereochemistry of E_2 reaction, factors affecting E_1, E_2 and E_1cb reactions, Competition between substitution and elimination reactions.

Unit-4

C=C Bond Addition :

Mechanism and stereochemistry of addition of halogen and halogen acids to alkenes,1,2-hydroxylation, oxymercuration-demercuration, Corey epoxidation and cyclopropanation, Simmon-Smith cyclopropanation and Sharpless asymmetric epoxidation (SAE).

Unit-5

C-Hetero multiple Bond addition:

Mechanism of hydrolysis of ester and amide. Crame's rule. Condensationreaction involving Cannizzaro, Claisenand Knovenagel.

Reference Books:

1. Advanced Organic Chemistry Part. A &B By F. A. Carey and R. J. Sundberg, Plenum Publisher , New York, 2007.
2. Advanced Organic Chemistry By J. March, 2007.
3. Organic chemistry By J. Clayden, N. Greeves, S. Warren and P. Wothers, Oxford University Press , New York, 2001.

Course Outcomes: Organic reaction mechanism is the backbone of classical and applied organic chemistry.

Semester-VII (Practical)

CHE 405F: Surface Chemistry, purification and identification of materials

(0+4 Credits)

Physical Chemistry exercises:

1. Determination of the solubility of benzoic acid in water at different temperatures and calculate the heat of solution
2. Determinationof the distribution coefficient of benzoic acid between benzene and water
3. Determinationof the distribution coefficient of acetic acid between benzene and water
4. Determination of the distribution coefficient of iodine between carbon tetrachloride and water
5. Study the adsorption of acetic acid on charcoal and draw the Freundlich isotherm

Inorganic Chemistry exercises:

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

Organic Chemistry exercises:

Preparation of organic compounds involving two stages. Emphasis should be given in the following processes:

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

B.Sc. Chemistry Honours

Semester-VIII

CHE 406F: Analytical Chemistry

(4+0 Credits)

Course Objectives:

1. To study concepts and theories behind basic methods and techniques used in analytical chemistry. This theory can be used to solve many rigorous problems of universe.
2. To prepare the students for further research in analytical methods of chemistry.

Unit-1

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 the nature of the curves for oxidation-reduction and acid-base titrations, comparision with the conductometric method
c. **Voltammetry:** Cyclic voltammetry
d. **Polarography:** Dropping mercury electrode and its advantages, polarographically active species, concept of residual, diffusion and limiting current of half wave potential, Ilkovic equation and factors affecting diffusion current

Unit-2

Thermoanalytical Methods:

a. **Thermogravimetry:** Apparatus, factors affecting TG, Interpretation of TG curves of $CaC_2O_4.H_2O$ and $MgC_2O_4.2H_2O$
b. **Differential Thermal Analysis and Differential Scanning Calorimetry:** Apparatus, factors affecting DTA and DSC 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 and metal hydrates.

Unit-3

Radiochemical Methods

a. Isotope method

b. Inverse isotopic dilution

c. Neutron activation technique

Unit-4

Chromatographic Method:

a. **Gas Chromatography:** GLC and GSC

b. HPLC

Unit-5

Spectral Methods:

a. Nephelometry

b. Turbidimetry

c. Flame Photometry

Reference Books:

1. Fundamentals of Analytical Chemistry: D.A. Skoog, D.M. West and F.J. Holler, 1992, 6e
2. Quantitative Inorganic Analysis, A.I. Vogel, 2012, 7e
3. Instrumental Methods of Chemical Analysis: B.K. Sharma, 2011
4. Instrumental Methods of Chemical Analysis: H. Kaur, 2016, 12 e
5. Analytical Chemistry, Gary D. Christian, 2007, 6e
6. Instrumental Methods of Analysis: H.H. Willard, L.L. Merrit, Jr. J.A. Dean, 1974, 5e

Course Outcomes:

After studying this course the student will be able to,

CO 1. Understand the basic of this course and think & develop new ideas and concepts in analytical chemistry

CO 2. Know about electroanayltical, thermoanalytical, radiochemical, chromatographic and spectral techniques.

CHE 407F: Thermodynamics and Electrochemistry

(4+0 Credits)

Course Objectives: The main objective of the course is to provide fundamentalconcepts of thermodynamics effects and relationships. The course is to give knowledge of comprehensive and rigorous treatment of classical thermodynamics, thermodynamics relations. Explain the concept of partial molar properties fugacity and activity. The course is designed to give an insight of phenomena of electrolytic conductance, reactions in solutions, basic principles of electrical phenomena are important for interfaces and electrode processes.

Unit 1

a. **Some important thermodynamic effects and relationships :**

The Joule Thomson's effect, The Gibbs Helmoltz equation and its application, The ClausiusClapeyron equation, The Maxwell's relation.

b. **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

c. **Fugacity and Activity**

Fugacity, variation of fugacity with temperature and pressure, Activity and the activity coefficient.

Unit 2

The Third law Thermodynamics:

The third law, Nernst heat theorem, application of third law, The residual entropy.

Unit 3

Electrolytic Conductance of strong electrolytes:

Debye-Falkenhagen effects, Wein effects the ionic association, effect of ionic strength on rate of ionic reactions.

Unit 4

Electrical phenomena at interface:

The electrical double layer, electrokinetic phenomena, quantitative treatment of electro osmosis, Electrophoresis and streaming potential.

Unit 5

Electrode processes:

Dissolution and deposition potential, decomposition potential and its determination, Concentration Polarization and over voltage(hydrogen overvoltage and oxygen overvoltage), The Limiting current density.

Reference Books:

1. Thermodynamics for Chemists by S.Glasstone.
2. An Introduction of Chemical Thermodynamics by R.P.Rastogi and R.R.Mishra.
3. Thermodynamics by K.S.Pitzer
4. Electrochemistry by S.Glasstone
5. Electrochemistry by Potter
6. Modern Electrochemistry by Bockris Reddy VoL I&II
7. Comprehensive Physical Chemistry byN.B. Singh,S.S. Das and N.S. Gajbhiye, New Age International Publishers.

Course Outcomes:

CO 1. To understand various thermodynamic relationship, the concept of free energy and partial molar quantities, activity and activity coefficients and determination.

CO 2. To understand the phenomena of electrolytic conductance. Reactions in solutions.

CO 3. To understand electrical phenomena at interfaces and electrode processes.

CO 4. To understand application of electrochemistry in electrolytic processes.

CHE 408F: Transition Elements

(4+0 Credits)

Course Objectives:

1. Train students to grasp fundamental chemistry of transition metal elements- group of element whose atom has a partially filled *d* sub-shell.
2. To understand principles of structure, stereochemistry, kinetics and mechanism of transition metal elements.
3. To prepare the students for further research in transition metal chemistry.

Unit-1

Structures of 2 to 8 Coordinate Metal Complexes:

Cation-anion ratio in various polyhedral, Hybrid orbitals and preferred conditions of formation of the complexes of following geometries :

C.N.2 - Linear

C.N.3 - Trigonal planar, Trigonal pyramidal

C.N.4 - Tetrahedral, Square planar

C.N.5 - Trigonal bipyramidal, Square pyramidal, pentagonal.

C.N.6 - Octahedral, Trigonal prism

C.N.7 - Pentagonal bipyramidal, Capped octahedral, Capped trigonal prism.

C.N.8 - Cubic, Tetragonal antiprismatic, Dodecahedral, Hexagonal bipyramidal, and Bicapped trigonal prism,

Stereochemical non-rigidity in four to eight coordinate Complexes.

Unit-2

Stereoisomerism in six coordinate octahedral complexes (Ma3bcd, Ma2bcde, Mabcdef and complexes containing bi-and ter- dentate ligands, Intermolecular and intramolecular rearrangements (Bailar and Ray Dutta twist only), mechanism of racemisation in tris (chelate) octahedral complexes, Methods of resolution of optical isomers.

Unit-3

Kinetics and mechanism of substitution reactions in octahedral Co (III) and square planar Pt (II) complexes.

Unit-4

Mechanism of one electron transfer reactions (inner and outer sphere mechanisms), Factors affecting the rates of direct electron transfer reactions and the Marcus equation, Two electron transfer reactions.

Unit-5

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.

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 Elements 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
4. Ligand Field Theory And Its Application by B.N. Figgis and M.A. Hitchman, Wiley, NewYork, 2000.

Course Outcomes: After studying this course the student will be able to,

CO 1. Understand the basic of transition metal chemistry and think & develop new ideas in this field.

CO 2. Know geometries of 2 to 8 coordinate metal complexes, streoisomerism, kinetics and mechanism of substitution reactions in octahedral and square planar complexes.

CO 3. Understand mechanism of electron transfer reactions and stability of transition metal complexes.

CO 4. Develop new ideas for further research in the field of coordination chemistry.

CHE 409F: Natural Products

(4+0 Credits)

Course Objectives: Natural product chemistry is branch of chemistry that deals with chemicalcompounds or substances produced by a living organism-that is, found in nature. Natural products can also be prepared by chemicalsynthesis (both semi synthesis and total synthesis) and have played a central role in the development of the field of organic chemistry by providing challenging synthetic targets.

Basic concepts and knowledge of chemistry of natural products are necessary to develop understanding of core organic chemistry i.e. simple to complex organic

structures, organic structural determination, semi-synthetic to total synthetic pathways of organic structures etc.

Unit- 1

Acetogenins : Classification, general method of structure determination of,

- **a.** Flavones- Chrysin
- **b.** Flavonols–quercetin
- **c.** Anthocyanins- Cyanin
- **d.** Anthocyanidins- cyanidin chlorides

Unit-2

Terpenoids : Introduction, isolation and general methods of determining structure of,

- **a. Monoterpenoids**
- **i.** Acyclic monoterpenoids: Citral and geraniol
- **ii.** Monocyclic monoterpenoids : α-Terpineol

Unit-3

Alkaloids: Introduction and general methods of determining structure of,

- **i.** Hemlock alkaloid- Coniine
- **ii.** Pyrrolidine-Pyridine alkaloid- Nicotine
- **iii.** Chincona alkaloids -Quinine
- **iv.** Opium alkaloids : Papaverine and Morphine
- **v.** Rauwolfia alkaloids

Unit-4

Carbohydrates: Structure and functions of,

Disaccarides- Lactose, Sucrose

Unit-5

Biosynthesis of natural products:

i. The acetate hypothesis, Isoprene rule, mevalonic acid from acetylco-enzyme – A, biogenesis of terpenoids
ii. Shikimic acid pathway of biogenesis of aromatic ring
iii. General biogenesis of alkaloids

Reference Books:

1. Organic Chemistry, I.L. Finar Vol. I and II, 2000

2. Natural Products, S.M. Chawla, 2018
3. Biochemistry-Lehninger, 2000
4. Biochemistry by L. Stryer, 1995

Course Outcomes: After studying this course the student will be able to,

CO 1. Understand basics of different classes of natural products- Acetogenins, Terpenoids, Alkaloids and Carbohydrates and their general structural determination.

CO 2. Know about acetate hypothesis, isoprene rule, biogenesis of – Terpenoid, aromatic ring (Shikimic acid pathway) and alkaloid.

CO 3. develop ideas for further research total organic synthesis.

(Practical) CHE 410F: Chemical Kinetics, separation and identification of binary inorganic / organic materials

(0+4 Credits)

Physical Chemistry exercises:

1. Solubility curve for water-acetic acid-chloroform systems
2. Determination of the rate constant of the acid-catalysed hydrolysis of ethyl acetate at laboratory temperature
3. Determination of the rate constant of the hydrolysis of ethyl acetate by sodium hydroxide at laboratory temperature
4. Conductometric titration between strong acid and strong alkali
5. Determination of the dimerization constantof benzoic acid in benzene medium by partition method

Inorganic:

Either both gravimetric and one volumetric, one gravimetric 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^{+}

Organic:

Analysis of binary organic mixture (Liquid-Liquid, Liquid-Solid, Solid-Solid)

B.Sc. Chemistry Research

Semester-VIII

CHE 406F: Analytical Chemistry
(4+0 Credits)

Course Objectives:

1. To study concepts and theories behind basic methods and techniques used in analytical chemistry. This theory can be used to solve many rigorous problems of universe.
2. To prepare the students for further research in analytical methods of chemistry.

Unit-1

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 the nature of the curves for oxidation-reduction and acid-base titrations, comparision with the conductometric method
c. **Voltametry:** Cyclic voltametry
d. **Polarography:** Dropping mercury electrode and its advantages, polarographically active species, concept of residual, diffusion and limiting current of half wave potential, Ilkovic equation and factors affecting diffusion current

Unit-2

Thermoanalytical Methods:

a. **Thermogravimetry:** Apparatus, factors affecting TG, Interpretation of TG curves of $CaC_2O_4.H_2O$ and $MgC_2O_4.2H_2O$
b. **Differential Thermal Analysis and Differential Scanning Calorimetry:** Apparatus, factors affecting DTA and DSC 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 and metal hydrates.

Unit-3

Radiochemical Methods

a. Isotope method
b. Inverse isotopic dilution

c. Neutron activation technique

Unit-4

Chromatographic Method:

a. **Gas Chromatography:** GLC and GSC

b. **HPLC**

Unit-5

Spectral Methods:

a. Nephelometry

b. Turbidimetry

c. Flame Photometry

Reference Books:

7. Fundamentals of Analytical Chemistry: D.A. Skoog, D.M. West and F.J. Holler, 1992, 6e
8. Quantitative Inorganic Analysis, A.I. Vogel, 2012, 7e
9. Instrumental Methods of Chemical Analysis: B.K. Sharma, 2011
10. Instrumental Methods of Chemical Analysis: H. Kaur, 2016, 12 e
11. Analytical Chemistry, Gary D. Christian, 2007, 6e
12. Instrumental Methods of Analysis: H.H. Willard, L.L. Merrit, Jr. J.A. Dean, 1974, 5e

Course Outcomes:

After studying this course the student will be able to,

CO 1. Understand the basic of this course and think & develop new ideas and concepts in analytical chemistry

CO 2. Know about electroanayltical, thermoanalytical, radiochemical, chromatographic and spectral techniques.

CHE 411F: Chemical Techniques

(4+0 Credits)

Unit I

Sampling methods and lab practices

Methods of sampling solids, liquids and gases, good lab practices, lab safety, waste disposal and managements, methods of storing chemicals, solvents and glassware.

Unit II

Introduction to basic non-instrumental laboratory techniques

Sample preparation, solution preparation, gravimetric analysis and volumetric techniques such as complexometric titration and types of EDTA titration.

Unit III

Introduction to basic instrumental laboratory techniques

Use and maintenance of analytical balance, potentiometer, pH meters, conductivity meters, mechanical stirrers, melting point apparatus, water heaters, water deionisers, magnetic stirrers and hot plates etc.

Unit IV

Fundamental aspects of various spectroscopy techniques

Introduction to UV-Visible, IR, NMR, EPR spectroscopies and Magnetic Measurements.

Unit V

Fundamental aspects of some analytical techniques

Basic principle, instrumentation and applications of Chromatographic methods, Atomic absorption spectroscopy and Flame photometry.

Reference Books:

1. Willard, H.H., Merritt, L.L., Dean, J.A., Instrumental methods of analysis, CBS Publishers and distributers, Shahdara, Delhi, 1986.
2. Vogel, A.I., Tatchell, A.R., Furnis, B.S., Hannaford, A.J., Smith, P.W.G. Vogel's practical organic chemistry, Pearson Education India, 1996.
3. Vogel, A.I., Elementary practical organic chemistry: Small scale preparations Part 1, Pearson Education India, 2010.
4. Silverstein, R. M., Webster, F.X., Spectrometric identification of organic compounds, John Wiley and Sons, 1997.

CHE-412F: Research Project

12 Credits

Under the research project, the student can conduct experiments, engage in review writing, perform lab work, or complete dissertation work related to the syllabus of a particular semester, all under the supervision of the assigned mentor.

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AECC 01F: ACADEMIC WRITING
(Semester I)

Unit 1
NTRODUCTION TO THE PROCESS OF WRITING

Significance of Vocabulary and language, Types and Tone of Writing - Descriptive,

Persuasive, analytical.

Purposes of writings - Academic communication, Review, Project Proposal

Unit 2

TOOLS OF WRITING

Understanding of the title, Gathering of materials - Summary,

Paraphrase and Notes - Paragraph formationand division - Structuring a write-up

Unit 3

WRITING ESSAYS

Forming essays - Addressing questions, addressing issues/topics, - using research
- other'swork, review, using quotes.

Unit 4

ETHICAL ASPECTS OF ACADEMIC WRITING

Style of writing Citation Style- types of citation styles - for books, book chapters andonline articles, Understanding of Plagiarism and how to avoid Plagiarism

Texbook(s):
1. L Lennie Irvin, What is Academic Writing,
2. John J Ruszkiewicz and Jay Dolmage, How to Write Anything,
3. Gordon Taylor, A Students' Writing Guide: How to Plan and Write Successful Essays,
4. John J Ruszkiewicz and Jay Dolmage, MLA & APA documentation and Format from How to Write Anything ,
5. F.M. Connel, A Textbook for the Study of Poetry, 2013

AECC 02F Personality Development and Leadership
(Semester II)

Unit I

Personality: Concept and Definition, Determinants of personality, Personality traits, Personality characteristics in organizations: Self-evaluation, Self-efficacy, Self-esteem, Self-monitoring: Positive and negative Impact. Organizational Context of Leadership and Personality.

Unit II

Leadership: Definition Importance of Leadership and Management, Leader vs Manager, Essential qualities of an effective leader

Unit III

Types of Leaders: Traditional, Transactional, Transformational, Inspirational and servant leadership, Issues in leadership: Emotional Intelligence and leadership, Trust as a factor, Gender and Leadership.

Unit IV

Theories of Leadership: Trait theory, Behavioral theories, Contingency theory .

Book Reference:

1. Organisational Behaviour ,M.Parikh and R.Gupta , TataMcGraw Hill Education Private Limited
2. Organisational Behavior, D. Nelson, J.C Quick and P. Khandelwal, Cengage Publication.

AECC 03F Industrial Waste Management
(Semester III)

Unit 1

Classification, sources and composition of solid, liquid and gaseous wastes, hazardous and non- hazardous wastes, special waste materials.

Unit 2

Storage and transport of and collection of industrial wastes.

Unit 3

Waste Minimization: Managements of waste, minimization, reuse and recycling, waste utilization and materials recovery.

Unit 4

Treatment of waste: Biological treatment, composting, anaerobic digestion, combustion, incineration and landfills, ultimate disposal.

Recommended Text Books

1. H. S. Peavy, D.R. Rowe and G. Techbanoglous, Environmental Engineering, Mcgraw Hill Books Co., 1985.
2. R. A. Corbitt, Started Handbook A Environmental Engineering; Mcgraw Hill New York, 1990.
3. A. M. Martin (ed), Bio-conservation of waste Materials to Industrial Products; Elsevier, Amsterdam, 1991.
4. O.P. Kharbanda and E. A. Stellworthy, Waste Management- towards a Sustainable Society, Gower, 1990.
5. E. Mortensen, Introduction to Solid Waste, Lecture Notes to Graduate Diploma in Environmental Engineering, University College, Ireland, 1990-1993.
6. K. L. Zirm, The Management of hazardous Substances in the environment, Applied Science, N.Y.
7. R. K. Somasekhar and Mariyengar(ED), Solid Waste Management- Current Status and Stratagies for Future, Allied Publishers, Mumbai2002.

AECC 04F Occupational Health Management
(Semester IV)

Unit I

Introduction, Classification of occupational health hazards, Storage and Handling of Hazardous Materials, First Aid & Emergency Procedure

Unit II Concept of personal protective equipments: types and uses, Threshold limit value, lethal dose and concentration,

Unit III

Approaches to prevent accident, Role of ILO: ILO Conventions & Recommendations.

Unit IV

Responsibilities of Government-Social organizations & Public Authorities, Risk Analysis & Risk Management

Recommended Text Books

1. Fundamentals of Industrial Hygiene by B.A. Plog & P. J. Quinlan
2. Handbook of Occupational Safety and Health by S. Z. Mansdorf.
3. Fundamentals of Occupational Safety and Health by J. Kohn & M. A. Friend

SECC 01F: Laboratory tools and techniques
Semester I

Unit: 1 Laboratory safety rules and Regulation

Addresses safety protocols, risk assessment, minimizing risks of hazards, chemical handling and storage, Equipment Safety and proper handling, Calibration of glasswares, hazard communication practices in chemical industries.

Unit: 2 Analytical techniques in Chemistry

Preparation of standard solutions in light of normality, molarity and molality, Theory and application of various analytical instruments commonly used in industry, such as chromatography and spectroscopy.

Unit: 3 Chemical Laboratory Management

Preparation of basic laboratory reagents such as Sodium hydroxide solution, neutral Ferric chloride solution, Ferrous sulphate solution, Iodine solution, Fehling solution, Nessler's reagent, Shiff's reagent etc. Principles of laboratory management including budgeting, equipment maintenance and personnel management, good laboratory practices.

Recommended books:

1. Vogels Text book of Quantitative Chemical Analysis, 5th edition
2. Vogels Text book of macro and semimicro qualitative inorganic analysis. G. Svela, 5th edition
3. Chemical reagent manual prepared by Chemistry department, SGTB Khalsa college under DBT's Star College Scheme, University of Delhi (Available online)

SECC 02F: Industrial Processes
Semester II

Unit: 1 Industrial Chemistry

Explore the application of chemistry in industrial processes including manufacturing and production. Visit of some industries and corporate offices situated near by Gorakhpur area.

Unit: 2 Process Chemistry/ Green Chemistry

Focus on optimisation and scale up of different chemical processes in industries, emphasizing on ideal process chemical route, its efficiency, greener way to synthesize compound with cost cutting processes.

Unit: 3 Quality control and Assurance

Principle and practices related to Quality control and Assurance in industries like pharmaceuticals, food and manufacturing. Food laws, food standardization and regulation agencies in India, national standards, international standards.

Recommended books:

1. E. Stocchi: Industrial Chemistry, Vol-1, Ellis Horwood Ltd. UK.
2. Sharma, B.K. & Gaur H. Industrial Chemistry, Goel Publishing House, Meerut (1996).
3. Handbook of analysis and quality control for fruits and vegetable products, S. Ranhganna, Tata McGraw-Hill Education, 1986-Food.
4. Srilaxmi, Food Science, Edition: 3rd (2004). 7.Lillian Hoagland Meyer, Food Chemistry (2008).

SECC 03F: Environmental studies and Computer application
Semester III

Unit: 1 Environmental impact assessment

Examine the environmental impact of chemical processes, sources of industrial pollution, preventive actions of global warming and green house effects, radiation effects by the uses of cell phones and protection tips

Unit: 2 Instrumental analysis

Calibration, maintenance and troubleshooting of instruments used in industries, Qualitative and quantitative analysis of compounds, practical applications and advantages of various equipments used in chemistry practices and industries.

Unit: 3 Basic computational skill for chemist

Introduction and application of MS Word office, Chem draw, origin software, communication and internet basic of computer network, basic of electronic mail and document handling in E-mail.

Recommended books:

1. Environmental pollution, download. Nos.org/333courseE/10.pdf
2. Fundamental concepts of applied chemistry J.C. Ghosh, S. Chand and CO, LTD, New Delhi.