Deccan Education Society's

Fergusson College (Autonomous)
Pune

Learning Outcomes-Based Curriculum

for 3/4 years B. Sc. / B. Sc. (Honours) Programme

as per the guidelines of

NEP-1.0

for

T. Y. B. Sc. (Chemistry)

With effect from the Academic Year

2025-2026

Program Outcomes (POs) for B. Sc. Programme	
PO1	**Disciplinary Knowledge:** Demonstrate comprehensive knowledge of the disciplines that form a part of a graduate programme. Execute strong theoretical and practical understanding generated from the specific graduate programme in the area of work.
PO2	**Critical Thinking and Problem Solving:** Exhibit the skills of analysis, inference, interpretation and problem-solving by observing the situation closely and designing the solutions.
PO3	**Social competence:** Display the understanding, and behavioural skills needed for successful social adaptation, work in groups, and exhibit thoughts and ideas effectively in writing and orally.
PO4	**Research-related skills and Scientific temper:** Develop the working knowledge and applications of instrumentation and laboratory techniques. Able to apply skills to design and conduct independent experiments, interpret, and establish hypotheses and inquisitiveness towards research.
PO5	**Trans-disciplinary knowledge:** Integrate different disciplines to uplift the domains of cognitive abilities and transcend beyond discipline-specific approaches to address a common problem.
PO6	**Personal and professional competence:** Performing dependently and also collaboratively as a part of a team to meet defined objectives and carry out work across interdisciplinary fields. Execute interpersonal relationships, self-motivation and adaptability skills and commit to professional ethics.
PO7	**Effective Citizenship and Ethics:** Demonstrate empathetic social concern and equity-centred national development, and the ability to act with an informed awareness of moral and ethical issues and commit to professional ethics and responsibility.
PO8	**Environment and Sustainability:** Understand the impact of the scientific solutions in societal and environmental contexts and demonstrate the knowledge of and need for sustainable development.
PO9	**Self-directed and Life-long learning:** Acquire the ability to engage in independent and life-long learning in the broadest context of socio-technological changes.

PSO No.	Program Specific Outcomes (PSOs) Upon completion of this programme, the student will be able to
PSO1	**Academic Competence:** **i.** Understand the fundamental concepts of theoretical and experimental aspects of physical, organic, inorganic, analytical and allied chemistry subjects. **ii.** Explain and clarify the understanding of thermodynamic, spectroscopic, kinetic and quantum models, stereochemistry and mechanism of organic reactions, chemical bonding and structure elucidation, analytical techniques and solving numerical problems. **iii.** Correlate and apply the theoretical chemistry knowledge in explaining practical schemes
PSO2	**Personal and Professional Competence:** **i.** Solve numerical problems, mechanisms, and analytical interpretation using chemistry concepts and knowledge. **ii.** Execute the knowledge of spectroscopic techniques learnt to characterize and identify structures of molecules used in drugs and pharmaceutical products. **iii.** Analyse chemical species qualitatively and quantitatively using appropriate analytical techniques. iv. Build confidence, patience, time management, leadership and intangible skills to achieve the goals in competitive examinations for higher learning courses in chemistry to meet global competencies.
PSO3	**Research Competence:** **i.** Identify and understand research literature and appropriate techniques used in chemistry-related problems. **ii.** Create awareness and promote research attitudes among students. **iii.** Interpret spectroscopic data to identify basic organic compounds.
PSO4	**Entrepreneurial and Social Competence:** **i.** Understand and explain the processes needed in domain-related industries and write their general aspects. **ii.** Apply information related to material safety data sheets (MSDS) needed in various industries. **iii.** Embrace the reduce, recycle and restore chemicals (3R's) approach and gain a sense of ethical, social and environmental awareness and responsibility.

T. Y.B. Sc. NEP 1.0						
Semester	**Paper**	**Paper Code**	**Title**	**Type**	**Credits**	**Exam Type**
V	**Major**	CHE-301	PHYSICAL CHEMISTRY-I	Theory	2	CE+ESE
		CHE-302	INORGANIC CHEMISTRY-I	Theory	2	CE+ESE
		CHE-303	ORGANIC CHEMISTRY-I	Theory	2	CE+ESE
	Elective (Any two)	CHE-304 OR CHE-305	ANALYTICAL CHEMISTRY-I OR LABORATORY SAFETY AND WASTE MANAGEMENT	Theory	2	CE+ESE
				Theory	2	CE+ESE
		CHE-306 OR CHE-307	INDUSTRIAL CHEMISTRY-I OR POLYMER CHEMISTRY	Theory	2	CE+ESE
				Theory	2	CE+ESE
	Major	CHE-311	CHEMISTRY PRACTICAL-5	Practical	2	CE+ESE
		CHE-312	CHEMISTRY PRACTICAL-6	Practical	2	CE+ESE
	VSC	CHE-331	BIOCHEMISTRY-I	Theory	2	CE
		CHE-332	CHEMISTRY PRACTICAL-7	Practical	2	CE
	Minor	CHE-321	ANALYTICAL METHODS	Theory	2	CE+ESE
	FP	CHE-345	FIELD PROJECT	Theory / Practical	2	CE
VI	**Major**	CHE-351	PHYSICAL CHEMISTRY-II	Theory	2	CE+ESE
		CHE-352	INORGANIC CHEMISTRY-II	Theory	2	CE+ESE
		CHE-353	ORGANIC CHEMISTRY-II	Theory	2	CE+ESE
	Elective (Any two)	CHE-354 OR CHE-355	ANALYTICAL CHEMISTRY-II OR ENVIRONMENTAL CHEMISTRY	Theory	2	CE+ESE
				Theory	2	CE+ESE
		CHE-356 **OR** CHE-357	INDUSTRIAL CHEMISTRY-II **OR** PHARMACOLOGY	Theory	2	CE+ESE
				Theory	2	CE+ESE
	Major	CHE-361	CHEMISTRY PRACTICAL-8	Practical	2	CE+ESE
		CHE-362	CHEMISTRY PRACTICAL-9	Practical	2	CE+ESE
	VSC	CHE-382	CHEMISTRY PRACTICAL-10	Practical	2	CE
	Minor	CHE-371	BIOCHEMISTRY-II	Theory	2	CE+ESE
	OJT	CHE-395	ON JOB TRAINING	Theory / Practical	4	CE

	CHE-301 Physical Chemistry-I **Major-Theory**	
	Number of Credits: 02 **Number of Hours: 30**	
Course Outcomes (COs) **On completion of the course, the students will be able to:**		**Bloom's cognitive level**
CO1	Define and outline the fundamentals of molecular spectroscopy, electrochemistry, and nuclear Chemistry.	1
CO2	Classify and analyse various types of nuclear processes and specify the type of counters used for measurement of radioactivity. Discuss the types of spectroscopic methods (rotational, vibrational and Raman spectra)	2
CO3	Explain the various applications of conductance and EMF measurements.	3
CO4	Calculate the bond length and force constant of molecules by analysing rotational -vibrational spectra.	4
CO5	Evaluate the behaviour of strong and weak electrolyte using conductometrically.	5
CO6	Solve the numerical based on spectroscopy, nuclear chemistry, electrochemistry and electrical conductance.	6

CHE-301 Physical Chemistry-I
(Major- Theory)

Unit No.	Title of Unit and Contents	No. of hours
1	**Investigations of Molecular Structure:** Molar refraction, electrical polarization of molecules, permanent dipole moment, determination of dipole moment, rotational spectra of diatomic molecules, intensities of spectral lines, vibrational spectra of diatomic molecule, rotational vibrational spectra of diatomic molecule, selection rule. Born-Oppenheimer approximation, quantum and classical theory of Raman spectra, Raman effect, pure rotational Raman spectra.	12
2	**Electrochemical and Electrolytic Cell:** Reversible and irreversible cells, EMF and its measurements, standard cells, cell reaction and EMF, single electrode potential and its calculation, calculation of cell EMF, thermodynamics of cell EMF, types of electrodes, types of electrochemical reactions, applications of EMF measurement (solubility product of sparingly soluble salt, determination of pH and potentiometric titrations) Electrolytic conductance, specific, equivalent, and molar conductance, variation of equivalent conductance with concentration, Kohlrausch's law and its applications to determine Equivalent conductance at infinite dilution	12

	of a weak electrolyte. Transport number, determination of transport number by Hittorf's method and moving boundary method. Inter ionic theory of conductance, Debye-Hückel-Onsager equation.	
3	**Nuclear Chemistry:** The atom, nucleus and outer sphere, classification of nuclides, nuclear stability and binding energy, discovery of radioactivity, types of radioactivity, general characteristics of radioactive decay and decay kinetics, types of nuclear reaction, measurements of radioactivity, gaseous ion collection method, proportional, G.M. and Scintillation counters. Applications of radioactivity - radiochemical principles in the use of tracers, typical applications of radioisotopes as a tracer chemical investigation - reaction mechanism, structure determination - phosphorus pentachloride and thiosulphate age determination - by Carbon-14 dating and Uranium Lead / Thorium - Lead Ratio and medical applications - assess the volume of blood in patient's body, Goitre.	6

Learning Resources- References

Sr. No.	References
1.	Principles of Physical Chemistry, Fourth Edition by S. H. Maron and C. F. Prutton
2.	Fundamentals Molecular Spectroscopy by C. N. Banwell
3.	Essentials of Nuclear Chemistry by H. J. Arnikar
4.	Elements of physical Chemistry by Atkins and Paula, fifth edition 2009 (Indian Edition)
5.	Principle of Physical chemistry by Puri Sharma Pathania
6.	Mortimer, R. G. Physical Chemistry 3rd Ed. elsevier: NOIDA, UP, 200.

	CHE-302-Inorganic Chemistry-I **Major-Theory**	
	Number of Credits: 02 **Number of Hours: 30**	
Course Outcomes (COs) **On completion of the course, the students will be able to:**		**Bloom's cognitive level**
CO1	Recall and outline the fundamental theories of Chemical Bonding.	1
CO2	Explain Molecular orbital theory including features and formation of MO's by LCAO principles. Extend this to homonuclear diatomic, heteronuclear diatomic and triatomic molecules.	2
CO3	Discuss the assumptions and concepts of Crystal Field theory and illustrate the splitting of d-orbitals in octahedral and tetrahedral field along with distribution of electrons. Calculate and compare 10 Dq, CFSE, magnetic moment for Oh and Td complexes.	3
CO4	Define organometallic compounds and classify them on the basis of hapticity. Discuss structure and bonding. Calculate 18-electron rule and apply to infer stability of organometallics.	4
CO5	State and explain symmetry elements and symmetry operations. Label with diagram axis, plane and centre of symmetry. Combine symmetry elements and determine point groups applying systematic approaches.	5
CO6	Explore the MO Theory of Octahedral Coordination Complexes, Ligand field theory. Illustrate the concepts of CLO.	6

CHE-302 Inorganic Chemistry-I
(Major-Theory)

Unit No.	Title of Unit and Contents	No. of hours
1	**Molecular Orbital Theory:** Limitations of Valence Bond theory (VBT), Need of Molecular orbital theory (MOT), Molecular orbital concept of bonding, Linear combination of atomic orbitals (LCAO) (elementary pictorial approach): Different types of combination of Atomic orbital (AO's): s-s, s-p, p-p and d-d, Non-bonding combination orbitals (formation of NBMO), M.O. Orbital designations, HOMO, LUMO. Energy level diagram for homonuclear diatomic molecules and their ions: H_2, H_2^+, He_2^+, Li_2, Be_2, B_2, C_2, N_2, O_2, O_2^+, O_2^-, O_2^{2-}, F_2, Ne_2 - Bond order and existence of molecule, energy (β) and magnetic behavior. M.O. energy level diagram, for heteronuclear diatomic molecules/ions like CO, NO, NO^+, HCl, HF and heteronuclear triatomic molecules/ions like H_3^+ (3c-2e), BeH_2, CO_2, NO_2. **Molecular Orbital Theory of Coordination Complexes** - Introduction, Assumptions, MO treatment to octahedral complexes with sigma bonding, Formation of MO's from metal orbitals and Composite Ligand Orbitals (CLO), MO correlation diagram for octahedral complexes (sigma bonding only).	10

2	**Crystal Field Theory:** Introduction and need of Crystal Field Theory (CFT), Assumptions, Shapes and degeneracy of d orbital, splitting of d-orbitals, Application of CFT to octahedral complexes, pairing energy(P) and distribution of electrons in eg and t2g level, calculation of magnetic moment using spin-only formula, Crystal Field Stabilization Energy (CFSE), calculation of CFSE, for octahedral (weak and strong field) and tetrahedral complexes with d^1 to d^{10} metal ion configurations. Evidence for CFSE - effect of crystal field splitting on i) Ionic radius and ii) Lattice energy. Interpretation of spectra of complexes, calculation of 10 Dq and factors affecting magnitude of 10Dq, d-d transitions and colour of the complexes, Jahn-Teller distortion theorem for octahedral complexes and its illustration, CFT of tetrahedral and square planar complexes, calculations of CFSE, Spectrochemical series, Nephelauxetic effect and Nephelauxetic series, Limitations of CFT, modified CFT (LFT), Problems related to calculation of 10 Dq, CFSE and spin only magnetic moment for octahedral, tetrahedral & square planar complexes (i.e. for high spin & low spin complexes).	10
3	**Molecular Symmetry:** Introduction and importance of molecular symmetry. Symmetry elements and symmetry operations (E, Cn, Sn, σ, i) with examples. Point Group concept and systematic identification of point groups in simple molecules according to symmetry elements present.	5
4	**Organometallic Compound:** Definition and classification of organometallic compounds on the basis of bond type, 18-electron and 16-electron rules (MO Theory) with examples (carbonyls, nitrosyls, cyanides). Structures of mononuclear and binuclear carbonyls, pi-acceptor behaviour of CO, synergic effect. Hapticity (η) of organometallic ligands with examples. Metal-olefin complexes: Zeise's salt (preparation, structure and bonding). Ferrocene (preparation and structure).	5

Learning Resources- References

Sr. No.	References
1.	Concise Inorganic Chemistry by J.D. Lee - 5th Edition.
2.	Inorganic Chemistry - D.F. Shiver & P.W. Atkins - C.H. Longford ELBS 2nd Edition.
3.	Basic Inorganic Chemistry - F.A. Cotton and G. Wilkinson, Wiley Eastern Ltd 1992.
4.	Concept and Model of Inorganic Chemistry by Douglas - Mc Daniels - 3rd Edition.
5.	New Guide to Modern Valence Theory by G.I. Brown - 3rd Edition.
6.	Coordination Chemistry by A. K. De.
7.	Chemical application to Symmetry and Group theory - F. A. Cotton
8.	Inorganic Chemistry by A. G. Sharpe - 3rd Edition.

	CHE-303-Organic Chemistry-I **Major-Theory**	
	Number of Credits: 02 **Number of Hours: 30**	
Course Outcomes (COs) **On completion of the course, the students will be able to:**		**Bloom's cognitive level**
CO1	Define the terms used in the 1H NMR,chemical shift, coupling, coupling constant, splitting, anisotropic effect.	1
CO2	Explain the principle involved in, 1H NMR and infer different phenomenon that occur 1H NMR	2
CO3	Solve nucleophilic addition, C-C coupling and aromatic substitution reactions with given reaction conditions.	3
CO4	Apply the selectivity rules for regio and chemoselectivity in reactions. Distinguish the type of C-C coupling reactions and nucleophilic reactions.	4
CO5	Prioritize the stereochemical outcome of electrocyclic and cycloaddition reactions. Determine the reaction mechanism in general from a theoretical perspective. Justify the major and minor product and its reaction mechanism.	5
CO6	Create the green chemistry methods for practical implementation. Design the molecules with bridge structure with desired functionalities.	6

CHE-303 Organic Chemistry-I
(Major- Theory)

Unit No.	Title of Unit and Contents	No. of hours
1	**UV Spectroscopy:** Introduction, nature of UV, Beer's law, absorption of UV radiation by organic molecules leading to different excitation. Terms used in UV Spectroscopy-Chromophore, Auxochrome, Bathochromic shift (Red shift), hypsochromic shift (Blue shift), hyperchromic and hypochromic effect. Effect of conjugation on position of UV band. Calculation of λmax by Woodward and Fisher rules for dienes and enone systems, Colour and visible spectrum, Applications of UV Spectroscopy - Determination of structure. **IR Spectroscopy:** Principle of IR Spectroscopy, Fundamental modes of vibrations (3N-6, 3N-5) Types of vibrations (Stretching and bending), Hooks law, Condition for absorption of IR radiations, vibration of diatomic molecules. Regions of IR	15

	Spectrum: fundamental group region, fingerprint region, aromatic region, Characteristic of IR absorption of functional groups: Alkanes, alkenes, alkynes, alcohol, ethers, alkyl-halides, carbonyl compounds (-CHO, >C=O, -COOR, -COOH), amines, amides and Aromatic Compounds and their substitution Patterns. Factors affecting IR absorption: Inductive effect, resonance effect, hydrogen bonding. Application of IR Spectroscopy in determination of structure, chemical reaction and hydrogen bonding. Structure Elucidation problems based on UV and IR.	
2	**Nucleophilic Addition to carbonyl compounds:** Structure and reactivity of carbonyl compounds. Prochirality, Types of addition reactions: direct and conjugate addition, Addition of water, cyanide hydride. Enamine reaction, Wittig reaction, Wittig Horner reaction. Nucleophilic addition to α,β-unsaturated carbonyl system: Addition of enolates (Michael addition and Retro Michael reaction, Regioselectivity and Chemoselectivity)	6
3	**Introduction to Pericyclic reactions:** Basic principles and mechanism of pericyclic reactions: Electrocyclic, Cycloaddition and Sigmatropic. Cycloaddition reactions: Diene, Dienophile, [2+2], [4+2] cycloaddition and stereochemistry.	4
4	**Organometallics:** Addition of organometallic compounds to carbonyl compounds (Mg, Cu, Li, Zn). C-C coupling reaction of organotitanium and organopalladium (Mc Murray, Ziegler Natta reaction and suzuki coupling).	5

Learning Resources- References

Sr. No.	References
1.	Advanced Organic Chemistry (Part A & B) - A. Carey and R. J. Sundberg.
2.	Mechanism and Structure in Organic Chemistry - E.S. Gould.
3.	Organic Chemistry by J. Clayden, N. Greeves, S. Warren and P. Wothers (Oxford)
4.	Modern Methods of Organic Synthesis by Carruthers and Iain Coldham
5.	Organic Chemistry by Morrison and Boyd 6th Edn.
6.	Organic Chemistry by Graham Solomans.
7.	Organic Chemistry by I. L. Finar Vol. II Vth Edn.

8.	Organic chemistry - by Cram, Hammond, Pine and Handrickson.
9.	Photochemistry and Pericyclic reactions - Jagdamba Singh, Jaya Singh 3rd Ed.
10.	Organic Photochemistry: A Visual Approach - Jan Kopecky, VCH publishers (1992).
11.	Stereochemistry of Organic Compounds, Principles and application by D. Nasipuri.
12.	Stereochemistry conformations and mechanism by P. S. Kalsi.
13.	Green Chemistry by V. K. Ahluwalia.

CHE-304-Analytical Chemistry-I Elective -Theory		
Number of Credits: 02 No. of Hours: 30		
Course Outcomes (COs) On completion of the course, the students will be able to:		**Bloom's cognitive level**
CO1	Recall the basic concepts learnt in topics like ionic equilibrium, spectrophotometry, and define basic laws (like Beer's law), learn equations like Ilkovic equations.	1
CO2	Differentiate between different thermogravimetric techniques. Explain the principle, construction and working of various analytical instruments	2
CO3	Solve numericals based on interpretation of the graphical and numerical data obtained from the analytical instrument. Identify the factors affecting the qualitative and quantitative analysis in each of the techniques learnt.	3
CO4	Compare the various analytical techniques to select a proper analytical technique for estimation of chemical species under investigation.	4
CO5	Choose proper analytical techniques to estimate/determine quality and quantity of chemical species under investigation.	5
CO6	Draw a conclusion by study of the various results interpreted in the form of graphs, charts obtained from the analytical instruments.	6

CHE-304 Analytical Chemistry-I
(Elective-Theory)

Unit No.	Title of Unit and Contents	No. of hours
1	**Gravimetric Analysis:** Common ion effect and solubility product principles, Conditions for good precipitation, Factors affecting precipitation like acid, temperature, nature of solvent, Supersaturation and precipitation formation, Precipitation from homogeneous solution and examples, Co-precipitation, post-precipitation and remedies for their minimization, Washing of precipitate and ignition of precipitate, Brief idea about method of filtration and drying of precipitate.	7

2	**Thermal methods of analysis:** Principle of thermal analysis, classification of thermal techniques, Principle, instrumentation and applications of TGA and DTA, factors affecting the thermal analysis, numerical problem.	5
3	**Spectrophotometry:** Introduction, Electromagnetic spectrum, Interaction of electromagnetic radiations with the matter, Mathematical Statement and derivation of Lambert's Law and Beer's Law, Terminology involved in spectrophotometric analysis, Instrumentation of single beam-colorimeter, Instrumentation of single and double beam spectrophotometer, Principle of additivity of absorbance and simultaneous determination, Spectrophotometric Titrations, Experimental Applications-Structure of organic compounds, Structure of complexes, Numerical Problems	9
4	**Polarography:** Introduction to voltammetric methods of analysis, Principles of polarographic analysis, Dropping Mercury Electrode, Instrument and working of polarographic apparatus, Ilkovic equation and quantitative analysis, Polarogram and chemical analysis, Analysis of mixture of cations, Factors affecting polarographic wave, Quantitative Applications, Numerical Problems	3
5	**Atomic Absorption Spectroscopy:** Introduction and theory of atomic absorption spectroscopy, Instrumentation of single beam atomic absorption Spectrophotometer, Measurement of absorbance of atomic species by AAS, Spectral and Chemical Interferences, Qualitative and Quantitative Applications of AAS. Numerical Problems.	4
6	**Flame Emission Spectroscopy:** Introduction and theory of atomic emission spectroscopy, Instrumentation of single beam flame emission spectrophotometer, Measurement of emission of atomic species, Interferences in emission spectroscopy, Methods of analysis calibration curve method, Standard addition method, and internal, standard method, Qualitative and Quantitative Applications of FES, Numerical Problems.	2

Learning Resources- References

Sr. No.	References
1.	Vogel's textbook of Inorganic Quantitative Analysis, Jeffery, Basset, Mendham Deney, 5th Ed, Longman Scientific Technical, USA (co published with John Wiley Sons).
2.	Vogel's textbook of Inorganic Quantitative Analysis, Mendham, Deney Barnes, 6thEd, Pearson education
3.	Analytical Chemistry by G. D. Christian, et al , Wiley, 6th Ed.
4.	Principles of Instrumental Analysis: Holler, Skoog, Crouch 6th Ed. Thomson Publication.
5.	Modern Analytical Chemistry, David Harvey, Mc-Graw Hill Higher education
6.	Vogel's Qualitative Inorganic Analysis, G. Svehla, Pearson, 7th Ed.

	CHE-305 Laboratory Safety and Waste Management **Elective-Theory**	
	Number of Credits: 02 **Number of Hours: 30**	
Course Outcomes (COs) **On completion of the course, the students will be able to:**		**Bloom's cognitive level**
CO1	Outline and understand the principles of chemical toxicology and safety in the laboratory.	1
CO2	Interpret the safety data sheets to categorise chemicals according to their hazards.	2
CO3	Classify, illustrate and implement the methods to manage hazards.	3
CO4	Compare and integrate the methods to handle chemical waste.	4
CO5	Apprise the safety measures and apply to chemical waste management.	5
CO6	Identify, modify and construct a plan for safe laboratory operations and waste management.	6

CHE-305 Laboratory Safety and Waste Management
(Elective)

Unit No.	Title of Unit and Contents	No. of hours
1	**Principles, Ethics and Practices:** Introduction and importance of laboratory safety, Four Principles of safety-RAMP, Hazards in different Labs, The Student Safety Ethics, Safety rules, Role as a Student, Critical analysis of Lab incidents (include reactions), Green Chemistry alternatives to conventional methods in labs and industries, The Twelve Principles of Green Chemistry and Sustainability.	6
2	**Understanding and Communicating Laboratory Hazards:** Potential pathways of exposure and blocking these pathways to prevent exposure, Hazard recognition through the basics of understanding labels, signs, symbols, terms, and other sources of information, Material Safety Data Sheets (MSDS), Safe Handling Precautions, Interpreting MSDS Information, overview of GHS Safety Data Sheets and GHS labellig Project work: Creation of MSDS / GHS Safety Data sheets.	5
3	**Laboratory Hazards: Toxic Substances and Biological Agents:** Types of hazards, Chemical Hazards: corrosive acids, bases, gases, oxidizers, flammables, fire triangle, water reactive compounds, pyrophoric chemicals and reactions (Grignard's reaction), peroxides, cryogens, catalysts. Radiation Hazards: ionizing, non-ionizing radiations and electric and magnetic field. **Introduction to Toxicology**:	8

	Basic principles of toxicology, Structure Activity Relationships, Factors Influence Toxicity, Acute and Chronic Toxicity, Mercury toxicity, Carcinogens, Mutagens, Biological Hazards and Biosafety - hazards of biological agents and some general approaches to prevent exposures.Experimental Session / Case Study: Radiation Hazards, Metal Toxicity	
4	**Handling chemicals and Minimizing hazards in laboratory:** Introduction to handling hazardous chemical waste, storing flammable and corrosive liquids, maintaining a safe and secure laboratory, managing chemicals in laboratory. Safety measures for common laboratory operations. Managing risk-decision about safety, eye and face, skin protection-clothes, gloves and tools, chemical hoods, contamination and ventilation, safety measures for common laboratory operations, radiation, laser and biological safety cabinets. Experimental Session / Case Study: Risk Management	6
5	**Chemical waste management in Industries:** Chemical Industry Waste management, Disposal Measures: Waste Combustion, Landfill Disposal of Wastes, Asbestos Disposal, Utilization of Product Wastes: Plastics Recycling, Zero Waste: Concept and Practice. **Seminar / Project / Case study / Research Paper Review / Industrial Visit and report (wherever applicable in all the units)**	5

Learning Resources- References

Sr. No.	References
1.	Laboratory safety for chemistry students, second edition, Robert H. Hill, Jr. David C. Finster, John Wiley & Sons.
2.	Solid Waste Management, Principles and Practice, Ramesha Chandrappa, Diganta Bhusan Das, Springer.
3.	Production-Integrated Environmental Protection and Waste Management in the Chemical Industry, Claus Christ, WILEY-VCH.
4.	Fundamentals of Industrial Safety and Health, Dr. K. U. Mistry, Siddharth Prakashan.
5.	Hazardous Waste Management Rules - 2016, 1st editon, Ministry of Environment, Forest & Climate Change, Govt. of India.

	CHE-306-Industrial Chemistry-I **Elective-Theory**	
	Number of Credits: 02 **Number of Hours: 30**	
Course Outcomes (COs) **On completion of the course, the students will be able to:**		**Bloom's cognitive level**
CO1	List the importance of Chemical industry products, define the basic concepts, terminologies and recall reactions learned in chemical industries.	1
CO2	Explain the basic requirements, general terms, processes of chemical industries and rephrase the steps and reactions involved in it and discuss the estimation of raw sugar and different grades of alcohol.	2
CO3	Apply the knowledge and interpret application of various soap products and examine the MSDS and safety measures of hazardous chemicals.	3
CO4	Classify and compare use of additives, builders, alcohols by relating their chemical compositions and applications.	4
CO5	Conclude the reasons for different observations and facts and justify the principle involved in chemical processes of chemical industry products.	5
CO6	Organize the flow-sheets diagrams and discuss manufacturing process of industry products and Compile/ the study report for commercial chemical products.	6

CHE-306 Industrial Chemistry-I
(Elective-Theory)

Unit No.	Title of Unit and Contents	No. of hours
1	**Modern Approach to Chemical Industry:** Introduction, Basic requirements of chemical industries, Chemical production, Raw materials, Unit process, Unit operation, Quality control, Quality assurance, Process control, Research and Development, Pollution control, Human resource, Safety measures, Conversion, Selectivity and Yield, Introduction to Copyright act, Patent act, Trademarks, MSDS. MSDS of hazardous chemicals (Benzene, Chloroform, Phenol).	4
2	**Manufacture of basic chemicals:** **a. Ammonia:** Manufacture of NH_3 by Modified Haber–Bosch process, Physico-chemical principles involved, uses of NH_3. **b. Sulphuric acid:** Manufacture of H_2SO_4 by Contact process, Physico-chemical principles involved, uses of H_2SO_4. **c. Nitric acid:** Manufacture of HNO_3 by Ostwald`s process, Physico-chemical principles involved, uses of HNO_3.	7

3	**Soaps and detergents:** **a) Soap industry:** Introduction, Importance, Raw materials for soaps, Manufacture soap, Special soap products, Toilet soap, Superfatted soap, Transparent soap, Medicated soap, Shaving soap and shaving cream, Cleansing powders**,** Washing action of soap. **b) Detergent industry:** Meaning of the terms- Detergent, Surfactants, Emulsion and Emulsifying agents, Wetting and Non-wetting, Hydrophobic and Hydrophilic nature, Amphipathic structures, Types of surfactants, Raw materials for detergents, Detergent builders, Additives, Manufacture of detergents, Washing action of detergents.	7
4	**Sugar Industry:** Introduction, Importance of sugar industry, Manufacture of cane sugar: Raw material, Extraction, Clarification and Concentration of cane juice, Crystallization of sucrose, Centrifugation. Utilization of by-products of sugar industries, Testing and Estimation cane sugar.	7
5	**Fermentation Industry:** Introduction, Importance, Basic requirement of fermentation process, Factors favoring fermentation, Fermentation operations. Manufacture of Industrial alcohol (Ethyl alcohol) from a) Molasses b) Food grains, c) Fruits. Grades of alcohol: Silence spirit, Rectified spirit, Absolute alcohol, Proof spirit, Denatured spirit, Duty and Duty - free alcohol. Importance of power alcohol as fuel.	5

Learning Resources- References

Sr. No.	References
1.	Industrial Chemistry-B.K. Sharma, Goyal publishing house, Mirut
2.	Shreeve’s Chemical Process Industries 5th Edition, G.T. Oustin, McGraw Hill
3.	Riegel's Handbook of Industrial Chemistry, 9th Edition, Jems A. Kent
4.	Industrial chemistry – R.K. Das, 2nd Edition,1976.
5.	Ref. websites: 1. www.wikipedia.org/wiki/copyright_act_of1976 2.www.wikipedia.org/wiki/patent act 3. www.wikipedia.org/wiki/trademark 4. https://www.ccohs.ca/oshanswers/legisl/msdss.html

	CHE-307-Polymer Chemistry **Elective-Theory**	
	Number of Credits: 02 **Number of Hours: 30**	
Course Outcomes (COs) **On completion of the course, the students will be able to:**		**Bloom's cognitive level**
CO1	Define and describe the basic concepts of polymers. Classify the type and discuss the physical properties of polymers.	1
CO2	Distinguish between simple compounds, polymers, natural, synthetic, organic and inorganic polymers. Explain Polymerisation Techniques with suitable examples.	2
CO3	Classify the polymer reactions and their applications. Discuss the use of polymer according to its physical and chemical properties.	3
CO4	Predict the Mechanisms of polymerization and Polymer reactions and explain their effects on physical and chemical properties.	4
CO5	Determine the reaction for synthesis of a given polymer and decide the reaction to change polymer properties.	5
CO6	Determine and modify the structure of the polymer according to its application.	6

CHE-307 Polymer Chemistry
(Elective-Theory)

Unit No.	Title of Unit and Contents	No. of hours
1	**Introduction to Polymer Chemistry:** Brief History, Polymer definition, Classification (based on Origin, Thermal response and their form), Structures, Chemical bonding & Molecular forces in Polymers. b) **Nomenclature of Polymers:** Nomenclature of Polymers - i) Common/Trivial names ii) Source - Based names, iii) Structure-Based names (Non IUPAC), iv) IUPAC Structure-based and Linkage-based nomenclature system and v) Trade names / Brand names & Abbreviations	**7**
2	**Molecular Weights of Polymers:** a) Average Molecular weight, Number Average & Weight Average Molecular weight, Molecular weight & degree of polymerisation, Practical significance of polymer molecular weights b) Molecular weight determination by End Group Analysis & Viscosity method and c) Problems based on Number Average & Weight Average Molecular weight.	**5**
3	**Chemistry of Polymerization with Suitable Examples:** a) Introduction: Functionality and solubility of monomer b) Chain Polymerization: Free	**7**

	radical Polymerization, Ionic polymerization, Co-ordination polymerization - Ziegler-Natta catalyst c) Step Polymerization: Polycondensation, Polyaddition polymerization, and Ring Opening polymerization.	
4	**Polymerisation Techniques with suitable examples:** Bulk polymerisation, Solution polymerization, Suspension polymerization, Emulsion polymerization, Melt polycondensation, Solution Polycondensation, Interfacial condensation, electrochemical polymerisation, Salient features of different polymerization techniques.	**5**
5	**Polymer Reactions:** Introduction, Hydrolysis, Hydrogenation, Addition and Substitution reactions, Cross-linking reactions, Cure reactions, Reactions of various aliphatic and aromatic pendant groups in polymers.	**6**

Learning Resources- References

Sr. No.	References
1.	Polymer Science by V. R. Gowarikar, N. V. Vishvanathan, Jaydev Shreedhar New Age International Ltd. Publisher 1996 (Reprint 2012)
2	Textbook of Polymer Science by Fred Billmeyer, 3rd Edn. A Wiely-Interscience Publication John Wiely & Sons New York 1984. (Reprint 2008).
3.	Introductory Polymer Chemistry by G. S. Misra New Age International (P) Ltd. Publisher 1996.
4.	Polymer Chemistry by Charles E. Carraher (Jr.), 6th Edn., (First Indian Print 2005), New York- Basel.
5.	Inorganic Polymers by G. R. Chatwal Himalaya Publishing House 1st Edn.1996.
6.	Polymer Science - A Text Book by V. K. Ahluwalia, Anuradha Mishra.
7	Principle of Polymer Science by P. Bahadur, N. V. Sastry, 2nd Edn., Narosa Publishing House.
8.	Polymer Chemistry by Ayodhya Singh, 2008, Published by Campus Book International, New Delhi.
9.	Organic Polymer Chemistry by Jagdamba Singh, R. C. Dubey, 4th dn., 2012.
10.	Advanced Polymer Chemistry by V. K. Selvaraj, 1st Edn., 2008, Published by Campus International, New Delhi.

	CHE-311-Chemistry Practical-5 Major-Practical	
	Number of Credits: 02 No. of Hours: 60	
Course Outcomes (COs) On completion of the course, the students will be able to:		**Bloom's cognitive level**
CO1	Outline the instrumental and non - instrumental experiments by studying lab hand - outs to perform Physico - chemical experiments.	1
CO2	Compute and prepare the standard solutions, Carry out the calibration pH-meter, potentiometer, conductometer, colorimeter and refractometer. Operate these instruments and analyse the data.	2
CO3	Carry out the quantitative and qualitative analysis using pH-meter, potentiometer, conductometer, colorimeter, refractometer and critical solution temperature.	3
CO4	Analyse the properties of radioactive particles using Geiger - Muller counter. Validate the Lamberts Beer's law. Interpret the spectra and evaluate the properties of molecules. Analyse the type, functional group and elements present in organic molecules.	4
CO5	Measure the rate constant, order and half period of the reaction by applying chemical kinetics.	5
CO6	Design the experiment for the analysis of samples.	6

CHE-311 Chemistry Practical-5
(Major-Practical)

Unit No.	Title of Unit and Contents
1	**Phenol-water system** To study the effect of addition of salt on critical solution temperature of phenol-water System.
2	**Potentiometry (Any two)** 1. To prepare standard 0.2 M Na_2HPO_4 and 0.1 M Citric acid solutions, hence prepare four different buffer solutions using them. Determine the pH values of these and unknown given solutions. 2. To determine the concentrations of strong acid and weak acid present in the mixture by titrating with strong base. 3. To determine the dissociation constant of monobasic acid potentiometrically.
3	**Conductometry (Any two)** 1. To determine the cell constant of the given cell using 0.01 M KCl solution and hence determine dissociation constant of a given monobasic weak acid. 2. To verify the Debye -Huckel-Onsagar equation for strong electrolyte. 3. To estimate the amount of lead present in given solution of lead nitrate by conductometric titration with sodium sulphate
4	**Refractometry (Any one)** 1. To determine the molecular refractivity of the given liquids A, B, C and D.

	2. To determine the specific refractivity of the given liquids A and B and their mixture and hence determine the percentage composition of their mixture C. 3. To determine the molar refraction of homologues methyl, ethyl and propyl alcohol and show the constancy contribution to the molar refraction by - CH_2 and butyl group.
5	**Chemical Kinetics (Any one)** 1. To study the effect of concentration of the reactants on the rate of hydrolysis of an ester. 2. To determine the order of reaction between $K_2S_2O_8$ and KI by half-life
6	**pH metry (Any one)** 1. To determine the degree of hydrolysis of an aniline hydrochloride. 2. To determine pka value and dissociation constant of given weak acid by pH-metric titration with strong base.
7.	**Radioactivity (Any one)** 1. To determine plateau voltage of the given G M counter. 2. To determine the resolving time of the GM counter. 3. To determine E_{max} of beta particles.
8.	**Colorimetry (Any one)** 1. Determination of λ_{max} and concentration of unknown solution of $KMnO_4$ in 2N H_2SO_4. 2. Determination of λ_{max} and concentration of unknown solution of Cu-NH_3 complex.
9	**Organic Qualitative analysis of Binary mixture (S+S)** **[Minimum 5 mixtures]** 1. Determination of Nature, Type of the mixture. 2. Separation of the mixture into two components. 3. Purification of the component. 4. Individual analysis of the compound a. Preliminary Test, b. To determine physical constant, c. To determine elements, d. To determine functional groups.

Learning Resources- References

Sr. No.	References
1.	Practical Physical Chemistry, 3rd Edn. A. M. James and F. E. Prichard, Longman
2.	Experiments in Physical Chemistry, R. C. Das and B. Behra, Tata McGraw Hill
3.	Advanced Practical Physical Chemistry, J. B. Yadav, Goel Publishing House.
4.	Advanced Experimental Chemistry, Vol. - I, J. N. Gurtu and R. Kapoor, S. Chand and
5.	Physical Chemistry Experiments, Raghvan and Vishwanathan.
6.	Systematic Experimental Physical Chemistry by S. W. Rajbhoj and T. K. Chondhekar,
7.	Practical Organic Chemistry by - A. I. Vogel.
8.	Practical Organic Chemistry by - O. P. Agarwal.

	CHE-312-Chemistry Practical-6 Major-Practical	
	Number of Credits: 02	
Course Outcomes (COs)		**Bloom's**
CO1	Recapitulate the fundamentals of mole concepts. Comprehend the basic	1
CO2	Explain the reason for the formation of coordinate complexes.	2
CO3	Synthesize, analyze and interpret the color and magnetic properties of the	3
CO4	Understand the procedure and calculate the amount, yield and percentage	4
CO5	Determine the concentration of metals ions complexometrically.	5
CO6	Conclude and compile the result.	6

CHE-312 Chemistry Practical-6
(Major-Practical)

Unit No.	Title of Unit and Contents
1	**Organic Preparations [Any 4]** 1. Preparation of β-naphthyl methyl ether from β-naphthol. 2. Preparation of dibenzylidene acetone from acetone. 3. Preparation of benzimidazole from o-phenylenediamine. 4. Preparation of benzylic acid from benzil. 5. Preparation of 2, 4-dinitrophenylhydrazone derivative of aldehyde / ketone. 6. Green synthesis of 4-nitro-2-hydroxy benzoic acid using Calcium nitrate. 7. Green synthesis of benzhydrol from benzophenone. 8. Preparation of adduct of maleic anhydride and anthracene (Diels-Alder Reaction).
2	**Volumetric Estimations (Any Four)** 1. Estimation of Mn by Volhard's method. 2. Estimation of NO_2- by using $KMnO_4$. 3.Estimation of copper by Iodometry (from brass or coordination complex). 4. Fertilizer analysis (PO_4^{3-}). 5.Determination of magnesium from a commercial sample of milk of magnesia tablet. 6.Estimation of the amount of iron and oxalic present in potassium tris (oxalate) ferrate(III). 7.Estimation of Fe(III) and Mn(II) in a mixture using standardized $KMnO_4$ solution. 8. Estimation of Fe(III) and Cu(II) in a mixture using $K_2Cr_2O_7$.
3	**Inorganic preparations - Comment on color and Magnetic properties of the complexes (Any four)** 1. Potassiumtrioxalatoferrate(III), $K_3[Fe(C_2O_4)_3]$. 2. Trisacetylacetonatoiron(III), $[Fe(acac)_3]$. 3. Potassiumtrioxalatoaluminate(III), $K_3[Al(C_2O_4)_3]$..

	4. Manganese(III)acetylacetonate, $[Mn(acac)_3]$. 5. Tris(thiourea)copper(I)chloride, $[Cu(tu)_3]Cl$. 6. Potassiumdiaquabis-(oxalate)cuprate(II), $K_2[Cu(C_2O_4)_2.(H_2O)_2]$. 7. Tris(ethylenediamine)nickel(II)chloride, $[Ni(en)_3]Cl_2$. 8. Bis(acetylacetonato)copper(II), $[Cu(acac)_2]$.

Learning Resources- References

Sr. No.	References
1.	Practical Organic Chemistry by - A. I. Vogel.
2.	Practical Organic Chemistry by - O. P. Agarwal.
3.	Analytical Chemistry by G. D. Christian 6th Edition.
4.	Vogel's Textbook of Quantitative Chemical Analysis 6th Edition by R. C. D. Denney, J.
5.	Handbook of Preparative Inorganic Chemistry, Volume 2, Second Edition, Edited
6.	Inorganic Synthesis, Vol-I by H S Booth, First Edn, 1939.
7.	Journal of Chemical Education, 1983, 60 (11).
8.	Journal of Chemical Education, 1999, 79 (09).

	CHE-331 Biochemistry-I **Vocational Skill Course-Theory**	
	Number of Credits: 02 **No. of Hours: 30**	
Course Outcomes (COs) **On completion of the course, the students will be able to:**		**Bloom's cognitive level**
CO1	Recall names and structures of biomolecules and biochemical reactions. Label the parts of the cell and its organelles. Define the terminologies that align with properties of biomolecules and molecular mechanisms.	1
CO2	Classify biomolecules. Explain the in-vivo and in- vitro reactions of molecules and its significance. Compare and Contrast between features of biomolecules and cells.	2
CO3	Categorize the types of biomolecules based on their structure and properties. Apply the basic concepts of chemistry to understand the formation of macromolecules and types of bonds. Outline the concepts of central dogma of molecular biology to understand its correlation with metabolism.	3
CO4	Analyse the factors that affect enzyme kinetics. Explain the structural features of biomolecules to correlate with their properties and functions.	4
CO5	Evaluate the sequence of intermediates formed in biochemical pathways and hormonal regulation of metabolism.	5
CO6	Propose biochemical pathways based on the requirements of the cell under various conditions. Assemble monomeric units of biomolecules to form	6

CHE-331 Biochemistry-I
(Vocational Skill Course-Theory)

Unit No.	Title of Unit and Contents	No. of hours
1	**Molecular logic of life:** Biochemical composition of different types of cells and its organelles. Types of bonds in macromolecules. Biomolecules carbohydrates definition, classification, structures, biochemical significance of carbohydrates- simple, complex, derived and conjugated carbohydrates. Reactions of glucose- oxidation, reduction, rearrangements, furfural derivatives, Osazone, Reducing and nonreducing sugars. Lipids-Definition, classification, structures, biochemical significance of lipids- simple, complex, sphingolipids, steroids, derived and conjugated lipids. Saponification number, iodine number, acid number, rancidity, Lipoproteins, Blood group substances. Amino acids: Definition,classification, structures, biochemical significance of Amino acids- polar and non polar, Standard and nonstandard, Essential and nonessential. Amphoteric nature, Ampholytes, Zwitter ions, Interpretation of titration curve of amino acid. Proteins: Definition, classification, structures, biochemical significance of	12

	proteins. Hierarchy in structural organisation of proteins. Reactions involved in amino acid sequencing of proteins.	
2	**Biocatalysts:** Enzymes: Definition, Types of biochemical reactions. classification of enzymes. Conjugated enzymes-Apoenzyme, prosthetic groups (coenzymes and cofactors) and holoenzyme. Features of an active site. Theories of ES complex formation, enzyme specificity, factors affecting enzyme activity. Basics of enzyme kinetics. Significance of Km. Types of enzyme inhibitions. Industrial uses of enzymes.	4
3	**Introduction to Biosignaling:** Principles of signal transduction. Classification of endocrine hormones. Mechanism of hormone action. Neurotransmitters.	2
4	**Overview of metabolic pathways:** Metabolism, catabolism, anabolism, amphibolism. carbohydrate-metabolism glycolysis, fates of pyruvate, Kreb's cycle, HMP shunt. Lipid metabolism- Beta oxidation of fatty acids, Ketogenesis, TAG synthesis. Amino acids- Urea Cycle. Bioenergetics- Electron transport chain, proton gradient, oxidative phosphorylation in mitochondria. Chemiosmotic hypothesis of Peter Mitchell.	8
5	**Nucleic acids:** Nitrogenous bases: Nucleosides, nucleotides, polynucleotides. DNA as genetic material, Structure of DNA, RNA and its significance.	2
6	**Overview of central dogma of molecular mechanisms:** Replication, transcription, genetic code, translation. Basic principles and applications of genetic engineering. Gene cloning. Gene therapy.	2

Learning Resources- References

Sr. No.	References
1.	Nelson, D.L. & Cox, M.M. Lehninger Principles of Biochemistry, W.H. Freeman, 2013
2.	Biochemistry – Albert Lehninger 1st Edition. Kalyani Publishers
3.	Harper's Illustrated Biochemistry 32nd edition, Mcgrraw Hill Lange,2023.
4.	Berg, J.M., Tymoczko, J.L. & Stryer, L. Biochemistry, W.H. Freeman, 2002.
5.	Talwar, G.P. & Srivastava, M. Textbook of Biochemistry and Human Biology, 3rd Ed
6.	Biochemistry- U. Satyanarayana,U. Chakrapani, 6th edition 2021
7.	Textbook of biochemistry – West & Todd, 4th edition
8.	Fundamentals of Biochemistry – Donald Voet, 5th edition Wiley Publishers
9.	Biotechnology- U Satyanarayana, U. Chakrapani
10.	Biochemistry- Geoffrey Zubay 4th edition

	CHE-332 Chemistry Practical-7 Vocational Skill Course-Practical	
	Number of Credits: 02 Number of Hours: 60	
Course Outcomes (COs) On completion of the course, the students will be able to:		**Bloom's cognitive level**
CO1	Outline the instrumental and non - instrumental experiments by studying lab hand - outs to perform physico - chemical experiments	1
CO2	Identify and apply the appropriate solvent system for purification (crystallization) and Thin Layer chromatography techniques to distinguish the product in organic synthesis.	2
CO3	Compute and prepare the standard solutions, Carry out the calibration of polarimeter and conductometer. Operate these instruments and analyse the data. Apply the least square fitting method of the graph to other data.	3
CO4	Analyze the given spectra and evaluate the properties of the molecules.	4
CO5	Interpret and explain the results of volumetric estimation of organic molecules.	5
CO6	Develop the skills required in chemistry such as proper handling of apparatus and chemicals.	6

CHE-332 Chemistry Practical-7
(Vocational Skill Course-Practical)

Unit No.	Title of Unit and Contents
1	Introduction to microsoft excel and other equivalent tools, curve fitting, data analysis and error estimation.
2	Interpretation of rotational spectra of diatomic molecules.
3	Determine the rate constant of inversion of sugar using polarimetry
4	To determine the partial molar volumes and excess molar volumes of the binary mixtures of water-ethanol systems.
5	Determine Critical Micellar Concentration (CMC) of sodium lauryl sulphate[Soap soln] from the measurement of conductivities at different concentrations
6	**Purification techniques** Recrystallization Thin Layer Chromatography
7	**Organic Estimations** 1. Estimation of acetone 2. Estimation of acetamide

8	**Complexometric Estimations** 1. Estimation of Nickel(II) complexometrically using murexide indicator 2. Estimation of Zinc(II) complexometrically. 3. Estimation of Ca(II) and Mg(II) in a mixture complexometrically.
9	**Quantitative - Physico-chemical Experiments** Prepare solution of Fe(III)/Cu(II) and salicylic acid in different molar proportion and determine metal ligand ratio in the complexes.

Learning Resources- References

Sr. No.	References
1.	Systematic Experimental Physical Chemistry by S. W. Rajbhoj and T. K. Chondhekar, Aniali Publication
2.	Advanced Practical Physical Chemistry, J. B. Yadav, Goel Publishing House.
3.	Advanced Experimental Chemistry, Vol. - I, J. N. Gurtu and R. Kapoor, S. Chand and Company.
4.	Physical Chemistry Experiments, Raghvan and Vishwanathan.
5.	College Practical Chemistry by Ahluwalia
6.	Text book of physical chemistry practical by Dr. Bhavin Dhaduk.
7.	Analytical Chemistry by G. D. Christian 6th Edition.
8.	Vogel's Textbook of Quantitative Chemical Analysis 6th Edition by R. C. D. Denney, J. D. Barnes, M. J. K. Thomas.
9.	Handbook of Preparative Inorganic Chemistry, Volume 2, Second Edition, Edited by George Braue R, Academic Press, 1965.
10.	Inorganic Synthesis, Vol-I by H S Booth, First Edn, 1939.

	CHE-321 Analytical Methods Minor-Theory	
	Number of Credits: 02 Number of Hours: 30	
Course Outcomes (COs) On completion of the course, the students will be able to:		**Bloom's cognitive level**
CO1	Summarize the techniques and steps involved in analytical chemistry. Recall the concepts of analytical chemistry.	1
CO2	Interpret the results and observations obtained in form the various analytical experiments using advanced computational methods.	2
CO3	Apply the analytical techniques in the analysis of soil, water, cosmetics and food products.	3
CO4	Distinguish between various chromatographic techniques and their application in analysis of ions and paints.	4
CO5	Prioritize the uses of phenolphthalein in trap cases; analyze arson accelerants gasoline and Pb, As, Cr from the cosmetic product in connection with IS4707.	5
CO6	Create the spectrophotometric analytical methods for estimation of macro nutrients encompassing Potassium, Calcium, Magnesium, Iron, Caffeine and Benzoic Acid in different samples.	6

CHE-321 Analytical methods
(Minor-Theory)

Unit No.	Title of Unit and Contents	No. of hours
1	**Introduction:** Introduction to Analytical Chemistry and its interdisciplinary nature. Concept of sampling. Importance of accuracy, precision and sources of error in analytical measurements. Presentation of experimental data and results, from the point of view of significant figures Finding the best straight line, Calibration curves, Standard addition, internal standards, A spreadsheet for least squares.	4
2	**Analysis of soil:** Composition of soil, Concept of pH and pH measurement, Complexometric titrations, Chelation, Chelating agents, use of indicators a. Determination of pH of soil samples. b. Estimation of Calcium and Magnesium ions as Calcium carbonate by complexometric titration.	3
3	**Analysis of water:** Definition of pure water, sources responsible for contaminating water, water sampling methods, water purification methods. a. Determination of pH, acidity and alkalinity of a water sample. b. Determination of dissolved oxygen (DO) of a water sample.	3

4	**Analysis of food products:** Nutritional value of foods, idea about food processing and food preservations and adulteration. a. Identification of adulterants in some common food items like coffee powder, asafoetida, chilli powder, turmeric powder, coriander powder and pulses, etc. b. Analysis of preservatives and colouring matter.	3
5	**Chromatography** Definition, general introduction on principles of chromatography, paper chromatography, TLC etc. a. Paper chromatographic separation of mixture of metal ion (Fe^{3+} and Al^{3+}). b. To compare paint samples by TLC method.	4
6	**Ion-exchange** Column, ion-exchange chromatography etc. Determination of ion exchange capacity of anion / cation exchange resin (using batch procedure if use of column is not feasible).	4
7	**Analysis of cosmetics** Major and minor constituents and their function a. Analysis of deodorants and antiperspirants, Al, Zn, boric acid, chloride, sulphate. b. Determination of constituents of talcum powder: Magnesium oxide, Calcium oxide, Zinc oxide and Calcium carbonate by complexometric titration.	4
8	**Suggested Applications (Any one)** a. To study the uses of phenolphthalein in trap cases. b. To analyze arson accelerants. c. To carry out analysis of gasoline. d. To estimate the Pb, As, Cr from the cosmetic product in connection with IS4707.	4
9	**Suggested Instrumental demonstrations** a. Estimation of macro nutrients: Potassium, Calcium, Magnesium in soil samples by flame photometry. b. Spectrophotometric determination of Iron in Vitamin / Dietary Tablets. c. Spectrophotometric Identification and Determination of Caffeine and Benzoic Acid in Soft Drink.	8

Learning Resources- References

Sr. No.	References
1.	Willard, H. H., Merritt, L. L., Dean, J. & Settoe, F. A. Instrumental Methods of Analysis. 7th Ed. Wadsworth Publishing Co. Ltd., Belmont, California, USA, 1988.
2.	Skoog, D. A. Holler F. J. & Nieman, T. A. Principles of Instrumental Analysis, Cengage Learning India Ed.
3.	Skoog, D. A.; West, D. M. & Holler, F. J. Fundamentals of Analytical Chemistry, 6th Ed., Saunders College Publishing, Fort Worth (1992).
4.	Harris, D. C. Quantitative Chemical Analysis, W. H. Freeman.
5.	Dean, J. A. Analytical Chemistry Notebook, McGraw Hill.

6.	Day, R. A. & Underwood, A. L. Quantitative Analysis, Prentice Hall of India.
7.	Freifelder, D. Physical Biochemistry 2nd Ed., W. H. Freeman and Co., N. Y. USA (1982).
8.	Cooper, T. G. The Tools of Biochemistry, John Wiley and Sons, N. Y. USA. 16 (1977).
9.	Vogel, A. I. Vogel's Qualitative Inorganic Analysis, 7th Ed., Prentice Hall.
10.	Vogel, A. I. Vogel's Quantitative Chemical Analysis, 6th Ed., Prentice Hall.
11.	Robinson, J. W. Undergraduate Instrumental Analysis, 5th Ed., Marcel Dekker, Inc., New York (1995).
12.	Practical skills in Chemistry by John R. Dean, Alan M. Jones, Prentice Hall, 2002.

CHE-345 Field Project **Field Project** **Theory/Practical**
Number of Credits: 02 **No. of Hours: 60**

	CHE-351 Physical Chemistry-II **Major-Theory**	
	Number of Credits: 02 **No. of Hours: 30**	
Course Outcomes (COs) **On completion of the course, the students will be able to:**		**Bloom's cognitive level**
CO1	Recall and describe the fundamentals of chemical thermodynamics, quantum chemistry, phase rule and adsorption.	1
CO2	Discuss the concepts, equations, and principles of classical and quantum mechanics	2
CO3	Using the entropy and free energy predict the spontaneity of chemical reaction	3
CO4	Explain different laws of thermodynamics and analyze different thermodynamic equations. Explain the formulation of Schrödinger equation and apply it to 1D and 3D box.	4
CO5	Calculate the degree of freedom of the different systems based on Gibb's phase rule and interpret the phase diagrams. Validate the Freundlich and Langmuir adsorption isotherms. Compare and connect the analogy between particle in box and Jhan Teller distortion.	5
CO6	Solve the numerical based on quantum chemistry and chemical thermodynamics.	6

CHE-351 Physical Chemistry-II
(Major- Theory)

Unit No.	Title of Unit and Contents	No. of hours
1	**Quantum Chemistry:** Failures of classical mechanics, black body radiation, photoelectric effect, Concept of quantization, atomic spectra (no derivation), wave particle duality, uncertainty principle, Postulates of quantum theory (wave function and its interpretation, well-behaved function, quantum mechanical operators, eigen values and eigen functions, expectation values) formulation of Schrodinger equation, particle in box (1D, 2D and 3D box, No derivations for 2D and 3D box), sketching of wave function and probability densities for 1D box, correspondence principle, degeneracy (lifting of degeneracy, Jhan-Teller distortion), applications to conjugated systems such as butadiene, hexatriene and β-carotene.	10
2	**Chemical Thermodynamics:** Thermodynamic Terms: -System, Boundary, Surroundings, Homogenous and heterogeneous systems, Types of thermodynamic systems, Intensive and extensive properties, States of systems (equilibrium and non-equilibrium states), Thermodynamic process, Reversible and irreversible	6

	process, Nature of heat and work, Internal energy, First law of thermodynamics, Carnot cycle, enthalpy of system, molar heat capacities, Adiabatic expansion of an ideal gas, work done in Adiabatic reversible expansion Second law of thermodynamics: spontaneous process, entropy, standard entropy of formation, entropy as predictor of spontaneity.	
3	**Free Energy and Equilibrium:** Recapitulation, Helmholtz free energy, variation of Helmholtz free energy with volume and temperature, Helmholtz free change energy for chemical reaction, Gibb's free energy, variation of Gibb's free energy with pressure and temperature, Gibb's free energy change for chemical reaction, Free energy change for physical transitions, Free energy change for an ideal gas; standard free energy change, Gibb's Helmholtz equation, Properties and significance of Gibb's free change, Van't Hoff reaction isotherm, thermodynamic equilibrium constants, Relation between Kp and Kc for gaseous reactions, variation of equilibrium constant with temperature, Criteria for chemical equilibrium, Physical equilibrium, Clapeyron equation, Clausius–Clapeyron equation, Application of Clausius - Clapeyron equation, numericals.	6
4	**Phase Rule:** Meaning of Phase, components, and degree of freedom with examples, Definitions, Gibb's phase rule, one component system (moderate pressure only) for sulphur and water system, two component systems for silver-lead and bismuth-cadmium, three component system.	5
5	**Surface Chemistry:** Adsorption phenomenon, Adsorption of gases by solids, Types of adsorptions, Freundlich and Langmuir adsorption isotherms, adsorption of solute by solids, types of adsorptions (Physical & Chemisorption's). BET equation (no derivation), determination of surface area using Langmuir and BET equations.	3

Learning Resources- References

Sr. No.	References
1.	Principles of Physical Chemistry, Fourth Edition by S. H. Maron and C. F. Prutton
2.	Quantum Chemistry by Donald Mcquarrie
3.	Fundamentals of Quantum Chemistry by James E. House.
4.	Physical Chemistry - A Molecular Approach by Donald A. McQuarrie, John D. Simon
4.	Elements of physical Chemistry by Atkins and Paula, fifth edition 2009 (Indian Edition)
5.	Principle of Physical chemistry by Puri Sharma Pathania
6.	Mortimer, R. G. Physical Chemistry 3rd Ed. elsevier: NOIDA, UP, 200.
7.	Engel, T. & Reid, P. Physical Chemistry 3rd Ed. Pearson, 2013
8.	Chemical Thermodynamics by M. Roy.
9.	Elements of Chemical thermodynamics, L.K Nash 2nd Ed.

	CHE-352-Inorganic Chemistry-II Major-Theory	
	Number of Credits: 02 Number of Hours: 30	
Course Outcomes (COs) On completion of the course, the students will be able to:		**Bloom's cognitive level**
CO1	Name and classify elements in f-block, report oxidation states, properties and application.	1
CO2	Describe electronic states, term symbols and spin-orbit coupling. Determine terms and construct microstate table of polyelectronic transition metal ions.	2
CO3	State and clarify the rules for electronic transitions and apply to interpret visible electronic absorption spectra.	3
CO4	Categorize solids on the basis of bonding. Predict the structural arrangement in lattices. Calculate ionic radii and solve numericals. Interpret Born Haber cycle and its applications.	4
CO5	Analyze and solve the problems.	5
CO6	Recapitulate the roles of metals in bioinorganic chemistry. Classify and explain function of enzymatic and non-enzymatic metals. Exemplify structure and function of important metallo-proteins.	6

CHE-352 Inorganic Chemistry-II
(Major-Theory)

Unit No.	Title of Unit and Contents	No. of hours
1	**Chemistry of f-block elements:** Introduction of f-block elements- on the basis of electronic configurations, occurrence and reactivity. The shapes of f-orbitals. **Lanthanides -** Position in periodic table, Name and electronic configuration of lanthanides, Chemistry of lanthanides with reference to (i) lanthanide contraction, (ii) Oxidation states (iii) magnetic and spectral properties, and (iv) separation (Group / Individual) by modern methods (ion exchange and solvent extraction method), applications of lanthanides. **Actinides -** Position in periodic table, Name and electronic Configuration of actinides, Oxidation States, Occurrence, and general methods of preparation of transuranic elements [viz., a) Neutron Bombardment, b) Accelerated projectile bombardment and c) Heavy ion bombardment], Nuclear Fuels-Nuclear Fusion fuels & nuclear fission fuels, applications of actinides. IUPAC nomenclature system for super heavy elements with atomic no. (z) greater than 100, Comparison between Lanthanides and Actinides.	6

2	**Electronic Spectra:** Introduction: Electronic configuration, electronic states and terms for poly-electronic atoms, Term symbols, coupling of spin momenta (Ms), orbital momenta (Ml) and spin- orbit coupling or Russell-Saunders coupling. Determination of Terms for p^2 electronic configuration (as in a carbon atom). Terms and micro states for transition metal atoms / ions. Types of electronic transitions like intra - ligand transitions, charge transfer transitions and intra-metal transitions and (d-d or ligand field transitions for transition metals). Rules for electronic transitions: Spin and Orbital or Laporte selection rules. Orgel Diagrams for D Terms (i.e, d^1, $d^4$and d^6, d^9electronic configurations) and its use in interpretation of visible electronic absorption spectra of these configurations. Charge Transfer Spectra - MLCT, LMCT (elementary ideas).	10
3	**Ionic Solids:** Importance of solid-state chemistry. Classification of solids on the basis of bonding. Crystalline and amorphous solids, Closest packing of rigid spheres (hcp, ccp), Structures of sodium chloride and caesium chloride. Packing density in simple cubic, bcc, fcc and hcp lattices (numerical problems expected). Crystal structures simple cubic, body centered cubic and face centered cubic, Properties of ionic solids, packing arrangements of anions in an ionic solids, Voids in crystal structure- tetrahedral and octahedral, Ionic radius, Palings univalent and crystal radii, Conversion of univalent radii to crystal radii, problems based on conversion of radii, Radius ratio effect, calculation of limiting radius ratio Lattice energy, Born-Lande equation, Born Haber cycle and its applications, Point defects with respect to Frenkel and Schottky defects.	8
4	**Bioinorganic Chemistry:** Introduction, classification of elements according to their action in biological system, excess and deficiency of some trace metals. Role of metal ions (Na-/ K, Zn, Cu, Mg) present in biological systems - enzymatic and non-enzymatic processes. Iron and its application in bio-systems, Haemoglobin and Myoglobin - structure and functions. Fe-S electron transfer proteins. Bioinorganic Chemistry of Co: Vitamin-B12, its structure and function.	6

Learning Resources- References

Sr. No.	References
1.	Concise Inorganic Chemistry by J. D. Lee - 5th Edition.
2.	Inorganic Chemistry - D. F. Shiver & P. W. Atkins - C. H. Longford ELBS - 2nd
3.	Basic Inorganic Chemistry - F. A. Cotton and G. Wilkinson, Wiley Eastern Ltd. 1992.
4.	Concept and Model of Inorganic Chemistry by Douglas - Mc Daniels - 3rd Edition.
5.	Inorganic Chemistry by J. E. Huheey, 4th Edition, Pearson Education.
6.	Inorganic Chemistry by A. G. Sharpe - 3rd Edition
7.	Principles of Bioinorganic Chemistry by S. J. Lippard and J. M. Berg, 1st Edition.

	CHE-353-Organic Chemistry-II **Major-Theory**	
	Number of Credits: 02 **Number of Hours: 30**	
Course Outcomes (COs) **On completion of the course, the students will be able to:**		**Bloom's cognitive level**
CO1	Recall the functional groups in organic chemistry and the terms involved in retro synthesis. Choose the functional group with specific reactivity in organic reactions.	1
CO2	Explain the principle involved in isolation and synthesis of natural products.	2
CO3	Analyze the different methods of synthesis of nanoparticles in organic transformation.	3
CO4	Compute the λmax of chromophores in natural products conjugated dienes, enone system and analyze the different observations in UV, IR, ^{1}H NMR.	4
CO5	Examine the product formed during organic transformation by using organometallic reagents.	5
CO6	Design the synthesis route for the given target molecule and imagine the retro synthesis for the given target molecule.	6

CHE-353 Organic Chemistry-II
(Major- Theory)

Unit No.	Title of Unit and Contents	No. of hours
1	**Retrosynthesis:** Describe disconnection approaches, synthons of natural reactivity and umpolung, Synthetic equivalence, FGI, TM. One group disconnection, Retrosynthesis and Synthesis of target molecules: Acetophenone, Crotonaldehyde, Cyclohexene, Benzylbenzoate, and Benzyl diethyl malonate.	6
2	**Natural Products:** a) Terpenoids: Isolation, Classification. Citral - structure determination using chemical and spectral methods, Synthesis of Citral by Barbier and Bouveault Synthesis. b) Alkaloids: Extraction, Purification, Some examples of alkaloids and their natural resources. Ephedrine - structure determination using chemical methods. Synthesis of Ephedrine by Nagi.	7
3	**^{1}H NMR Spectroscopy:** Principles of PMR Spectroscopy, Magnetic and nonmagnetic nuclei, Precessional motion of nuclei without mathematical details, Nuclear resonance, chemical shift, shielding, & deshielding effect. Measurement of chemical shift, delta and Tau-scales. TMS as reference and its advantages, peak area, integration, spin-spin coupling, coupling constants, J-value	12

	(Only first order coupling be discussed). Problems of structure elucidation based on UV, IR, ^{1}H NMR.	
4	**Green chemistry:** Principles and significance of green chemistry, role of ultrasound, microwaves and ionic liquids in chemical reactions, different methods to synthesize and characterize nanoparticles.	5

Learning Resources- References

Sr. No.	References
1.	Designing Organic Synthesis by Stuart Warren 1983.
2.	Organic Chemistry by Cram and Hammond.
3.	Organic Chemistry by Clayden, Greeves, Warren and Wothers
4.	Organic Chemistry by I. L. Finar Vol. II Vth En.
5.	Introduction to Spectroscopy - D. L. Pavia, G. M. Lampman, G. S. Kriz, 3rd Ed. (Harcourt College Publishers).
6.	Spectrometric identification of organic compounds R. M. Silverstein, F. X. Webster, 6th Ed. John Wiley and Sons.
7.	Spectroscopic methods in organic chemistry - D. H. Williams and I. Flemming, McGraw Hill
8.	Absorption spectroscopy of organic molecules - V. M. Parikh
9.	Nuclear Magnetic Resonance - Basic Principles - Atta - Ur - Rehman, Springer - Verlag (1986).

	CHE-354 Analytical Chemistry-II Elective-Theory	
	Number of Credits: 02 Number of Hours: 30	
Course Outcomes (COs) On completion of the course, the students will be able to:		**Bloom's cognitive level**
CO1	Acquaint with the basic concept of solvent extraction, chromatography and mass spectrometry.	1
CO2	Explain principle, construction and working of various chromatographic techniques, turbidimetry, nephelometry, mass spectrometry.	2
CO3	Solve numericals based on different analytical methods	3
CO4	Compare between different techniques to choose appropriate methods for sample analysis.	4
CO5	Apply various chromatographic techniques for qualitative and quantitative estimations of chemical species under investigation.	5
CO6	Identify the role of various chromatographic, extraction techniques and nephelometric techniques in the field of analysis and research.	6

CHE-354 Analytical Chemistry-II
(Elective-Theory)

Unit No.	Title of Unit and Contents	No. of hours
1	**Solvent Extraction:** Introduction, Principle of solvent extraction, Distribution coefficient, distribution ratio, relation between Distribution coefficient and distribution ratio, factors affecting solvent extraction, percentage extracted, solvent extraction method, separation factor, batch extraction, counter current extraction, application of solvent extraction, numerical problems.	5
2	**Chromatography:** Introduction and classification of chromatographic methods, Principle of chromatographic analysis with match box model, Theoretical plates and column efficiency, Theory, Principle, technique and applications of Column Chromatography, Ion exchange Chromatography, Thin layer Chromatography, Paper Chromatography, Numerical Problems	5
3	**Gas Chromatography:** Introduction, Theory, Principle, GSC and GLC, Separation mechanism involved in GSC and GLC, Instrumentation of Gas chromatography, Working of gas chromatography, Detectors TCD, FID, ECD used in GC. Gas chromatogram and qualitative-quantitative analysis, . Applications of	5

	gas chromatography .	
4	**High Performance Liquid Chromatography:** Introduction, need of liquid chromatography, Separation mechanism involved in adsorption and partition HPLC, Instrumentation and working of HPLC, Applications of HPLC, Introduction to supercritical fluid chromatography.	4
5	**Electrophoresis:** Introduction, Principle and theory of electrophoresis, Different types of electrophoresis techniques, Moving Boundary Electrophoresis, Zone electrophoresis-Paper, Cellulose acetate and Gel electrophoresis, Applications of electrophoresis.	5
6	**Nephelometry and Turbidimetry:** Introduction, Principles and instrumentation of nephelometric and turbidimetric analysis, difference between nephelometric and turbidimetric measurements, choice between Nephelometry and Turbidimetry, factors affecting nephelometric and turbidimetric measurements, quantitative applications, numerical problems.	4
7	**Introduction to Mass Spectrometry:** **Mass Spectrometry:** Basic principles, introduction of components only.	2

Learning Resources- References

Sr. No.	References
1.	Vogel's textbook of Inorganic Quantitative Analysis, Jeffery, Basset, Mendham Deney,5th Ed, Longman Scientific Technical, USA (co published with John Wiley Sons)
2.	Vogel's textbook of Inorganic Quantitative Analysis, Mendham, Deney Barnes, 6th Ed, Pearson education
3.	Analytical Chemistry by G. D. Christian, et al , Wiley, 6th Ed.
4.	Principles of Instrumental Analysis: Holler, Skoog, Crouch 6th Ed. Thomson Publication.
5.	Modern Analytical Chemistry, David Harvey, Mc-Graw Hill Higher education.
6.	High performance Liquid Chromatography, (Analytical Chemistry through open learning series) Second Ed, Sandie Lindsay, Wiley
7.	Gas Chromatography, (Analytical Chemistry through open learning series) 2nd Ed, Ian A.Fowlis, Wiley
8.	Mass Spectrometry: Principles and Applications, 3rd Edition Edmond de Hoffmann, Vincent Stroobant. Wiley

	CHE-355-Environmental Chemistry **Elective-Theory**	
	Number of Credits: 02 **Number of Hours: 30**	
Course Outcomes (COs) **On completion of the course, the students will be able to:**		**Bloom's cognitive level**
CO1	Learn basic concepts in environment and environmental pollution, units to describe concentrations. Identify different segments of environment and types of pollutants	1
CO2	Classify different types of pollutants. Correlate different parameters with quality of water.	2
CO3	Sketch hydrological cycles of different water ingredient. Solve numerical for quantification of water pollutants.	3
CO4	Devise methods for sampling and monitoring of water quality parameters. Categorise different types of pollutants.	4
CO5	Plan experiments to judge water quality parameters and quantification of pollutants.	5
CO6	Design water treatment plants and develop methods for monitoring pollutants.	6

CHE-355 Environmental Chemistry
(Minor-Theory)

Unit No.	Title of Unit and Contents	No. of hours
1	**Concepts and Scope of Environmental Chemistry** Introduction, Environmental Pollution and Classification, Units of concentration, Segments of Environment, Biogeochemical cycles of C, N, P, S and O system	5
2	**Hydrosphere and Water Pollution** Water resources, Hydrological Cycle: stages of hydrological cycle and chemical composition of water bodies, Microbially mediated aquatic reactions, Classification of water pollutants Organic and Inorganic pollutants, Sewage and Domestic waste, Sediments, Detergents, Pesticides, Eutrophication, Sampling and monitoring water quality parameters: pH, D.O. (Winkler Method), COD, TOC, Total hardness, free chlorine	8
3	**Analytical Techniques in water Analysis** Water quality parameters and standards, domestic water quality parameters, surface water, sampling, preservation, Monitoring techniques and methodology (pH, conductance, DO, ammonia, nitrate and nitrite, Cl, F, CN, Sulfide, sulphate, phosphate, total hardness, boron, metals and	9

	metalloids- As, Cd, Cr, Cu, Fe, Pb, Mn, Hg (Exclude polarographic and AAS methods), COD, BOD, TOC, phenols, pesticides, surfactants, tannins and lignins, E. Coli, Case studies of water pollution	
4	**Water pollution and treatment methods** Water pollutants, Eutrophication, Wastewater treatment (domestic waste water, aerobic treatment, anaerobic treatment, upflow aerobic sludge bed, industrial wastewater treatment, drinking water supplies, Trace elements in water, chemical speciation (Cu, Pb, Hg, As, Se, Cr)	8

Learning Resources- References

Sr. No.	References
1.	Environmental Chemistry – A. K. De, 5th Edition (New age international publishers.)
2.	Environmental Chemistry – A. K. Bhagi and C. R. Chatwal (Himalaya Publishing House).
3.	Environmental Chemistry – H. Kaur 2nd Edition 2007, PragatiPrakashan, Meerut, India.
4.	Environmental Chemistry – J. W. Moore and E. A. Moore (Academic Press, New York).
5.	Basic Concepts of Analytical Chemistry: S. M. Khopkar, Wiley Eastern (1995).

	CHE-356 Industrial Chemistry-II Elective-Theory	
	Number of Credits: 02 Number of Hours: 30	
Course Outcomes (COs) On completion of the course, the students will be able to:		**Bloom's cognitive level**
CO1	List the importance of chemical industry products, define the basic concepts, terminologies and recall reactions learned in chemical industries.	1
CO2	Explain the different terms, chemical processes involved in chemical industries and synthesis of dyes, petrochemicals and rephrase the steps and reactions involved in it.	2
CO3	Apply the knowledge to demonstrate the manufacturing processes in small-scale industries and interpret application of various industrial products.	3
CO4	Classify and compare types of different organic dyes, fertilizers, petrochemicals, glasses by relating their chemical compositions and applications.	4
CO5	Conclude the reasons for different observations, facts and justify the principle involved in chemical processes.	5
CO6	Organize the flow-sheets diagrams and discuss manufacturing process of industry products and compile the study report for small-scale industries.	6

CHE-356 Industrial Chemistry-II
(Elective-Theory)

Unit No.	Title of Unit and Contents	No. of hours
1	**Glass industry:** Introduction, Importance, Physical and Chemical properties of glass, Chemical reactions. Manufacture of glass using Tank furnace. Forming of glass: Pressing, Blowing, Drawing, Rolling. Annealing, Finishing, Grading and Gauging of glass articles. Special glasses: Coloured, Safety, Hard, Boro-silicate, Optical, Conducting, Glass laminates.	7
2	**Fertilizer Industry:** Introduction, Micronutrients, Importance of fertilizers, Organic manure, Vermi-compost, N, P, K ratio. Types of fertilizers. a. Nitrogenous fertilizers: Manufacture of Urea. b. Phosphatic fertilizers: Manufacture of Single and Triple super phosphate. c. Potash fertilizers. d. Mixed fertilizers: Manufacture of Mixed fertilizer.	6

3	**Dyes:** Introduction, Importance, Qualities of good dye, Colour, Colour and Chemical constitution, Otto-Witt`s theory of colour, Resonance theory, Molecular approach to colour. Classification of dyes according to their applications. Meaning of terms: Chromophore, Auxochrome, Bathochromic (Red) and Hypsochromic (Blue) shift. Synthesis and Uses of following dyes: Methyl orange, Rosaniline, crystal violet, phenolphthalein, Fluorescein, Alizarin.	5
4	**Petrochemicals and fuels:** a) Introduction, Occurrence, Composition of petroleum, Refining of petroleum, Processing of petroleum, Cracking, Applications of petrochemicals, Synthetic petroleum, Lubricating oils, Additives. b) Fuels: Calorific value of fuel, Flash point, Octane rating (Octane number), Cetane number. Liquid fuel - Diesel, Bio-diesel, Gasoline. Gaseous fuel - LPG, CNG.	8
5	**Small Scale Industries:** Introduction and Aspects of Small - Scale Industries, Safety Matches, Agarbattis, Naphthalene balls, Wax Candles, Shoe Polish, Gum Paste, Writing and fountain Pen ink, Plaster of Paris, How to Remove Stains.	4

Learning Resources- References

Sr. No.	References
1.	Industrial Chemistry-B.K. Sharma, Goyal publishing house, Mirut
2.	Shreve’s Chemical Process Industries 5th Edition, G.T. Austin, McGraw Hill
3.	Riegel's Handbook of Industrial Chemistry, 9th Edition, James A. Kent
4.	Industrial chemistry – R.K. Das, 2nd Edition,1976.
5.	The Petroleum chemicals industry by R. F. Golds tine, e & Fn London
6.	Fundamentals of petroleum chemical technology by P Belov.

	CHE-357 Pharmacology **Elective-Theory**	
	Number of Credits: 02 **No. of Hours: 30**	
Course Outcomes (COs) **On completion of the course, the students will be able to:**		**Bloom's cognitive level**
CO1	Identify and describe the pharmacological actions of different categories of drugs	1
CO2	Understand the detailed mechanism of drug action at organ system / sub cellular / macromolecular levels	2
CO3	Examine and apply the basic pharmacological knowledge in the prevention and treatment of various diseases.	3
CO4	Compare and differentiate pharmacology with other biomedical sciences.	4
CO5	Determine signal transduction mechanism of various receptors	5
CO6	Rearrange the drugs according to their mechanism of action.	6

CHE-357 Pharmacology
(Elective-Theory)

Unit No.	Title of Unit and Contents	No. of hours
1	**Introduction to Pharmacology, scope of Pharmacology:** Routes of administration of drugs, their advantages and disadvantages. Various processes of absorption of drugs and the factors affecting them. Metabolism, distribution and excretion of drugs General mechanism of drugs action and the factors which modify drug action	**9**
2	**Pharmacological classification of Drug:** The discussion of drugs should emphasize the following aspect: Drugs acting on the Central Nervous System: (a) General anesthetics, adjunction to anesthesia, intravenous anesthetics. (b) Analgesic antipyretics and non-steroidal anti - inflammatory drugs, Narcotic analgesics, Antirheumatic and antigout remedies, Sedatives and Hypnotics, Psychopharmacological agents, anticonvulsants, analeptics	**6**
3	**Drugs acting on the respiratory system** Respiratory stimulants, Bronchodilators, Nasal decongestants, Expectorants and Antitussive agents.	**10**
4	**Cardiovascular drugs:** Cardiotonics, Antiarrhythmic agents, Antianginal agents, Antihypertensive agents, Peripheral Vasodilators and drugs used in atherosclerosis. Chemotherapy of cancer	**5**

Learning Resources- References

Sr. No.	References
1.	Barar F S K., Text Book of Pharmacology, Interprint, new Delhi.
2.	Crossland J and Thomson J H., Essentials of Pharmacology, Harper and Row Publishers NY
3.	Goodman and Gilman's, The Pharmacological basis of Therapeutics; Editors: J. G. Hardman, L. E. Limbird, P. B. Molinoss, R. W. Ruddon and A. G. Gil, Pergamon Press."
4.	Katzung, B. G., Basic and Clinical Pharmacology, Prentice Hall, International.
5.	Paul L., Principles of Pharmacology, Chapman and Hall.
6.	T'heoharides T. C., Pharmacology, Little Brown and Co.

	CHE-361 Chemistry Practical-8 **Major -Practical**	
	Number of Credits: 02 **Number of Hours: 60**	
Course Outcomes (COs) **On completion of the course, the students will be able to:**		**Bloom's cognitive level**
CO1	Outline the instrumental and non - instrumental experiments by studying lab hand - outs to perform Physico - chemical experiments	1
CO2	Compute and prepare the standard solutions, Carry out the calibration pH-meter, potentiometer, conductometer, colorimeter and refractometer. Operate these instruments and analyse the data.	2
CO3	Carry out the quantitative analysis using pH-meter, potentiometer, conductometer, colorimeter.	3
CO4	Validate the Lamberts Beer's law. Interpret the spectra and evaluate the properties of molecules, Freundlich and Langmuir adsorption isotherm.	4
CO5	Measure the rate constant, activation energy of the reaction using the chemical kinetics. Analyse the type, functional group and elements present in organic molecules.	5
CO6	Design the experiment for the analysis of samples	6

CHE-361 Chemistry Practical-8
(Major-Practical)

Unit No.	Title of Unit and Contents
1	**Adsorption** 1.To investigate the adsorption of oxalic acid /acetic acid by activated charcoal and test the validity of Freundlich and Langmuir adsorption isotherms.
2	**Chemical Kinetics (Any two)** 1. To determine the energy of activation of the reaction between potassium iodide and potassium persulphate for an unequal concentration of the reactants. 2. To determine the first order velocity constant of the decomposition of hydrogen peroxide by volume determination of oxygen. 3. To study the kinetics of iodination of acetone.
3	**Viscosity (Anyone)** 1. To determine the molecular weight of a high polymer by using solutions of different concentrations. 2. Determine the radius of the molecule by viscosity measurement
4	**Colorimetry (Any one)** 1. To determine the indicator constant of the methyl red indicator. 2. To estimate copper (II) with EDTA by photometrically.

5	**Potentiometry (Any two)** 1. To determine the formal redox potential of Fe2+/ Fe3+ system potentiometrically. 2.To determine the amount of NaCl in the given solution by titration against silver nitrate potentiometrically 3. Determine the standard oxidation potential of the metal metal-ion electrode by using a secondary standard calomel electrode.
6	**pH metry (Any one)** 1. To determine the dissociation constant of oxalic acid by pH-metric titration with strong base. 2. To determine the isoelectric point of the amino acid.
7	**Conductometry (Any one)** 1. To investigate the conductometric titration of (a) Strong acid against strong base and (b) weak acid against strong base. (c) mixture of strong and weak acid versus strong base 2. To determine the Ni(II) with EDTA by conductometry.
8	**Transport number** To determine the transport number of hydrogen and chloride ions by moving boundary method.
9	**Organic Qualitative Analysis of Binary Mixture (L+S, L+L) [Minimum 5 mixtures**] 1. Determination of Nature. 2. Separation of the mixture into two components. 3. Type of the mixture. 4. Purification of the component. 5. Individual analysis of the compound a) Preliminary test b) To determine physical constant. c) To determine elements. d) To determine functional group

Learning Resources- References

Sr. No.	References
1.	Practical Physical Chemistry, 3rd Edn. A. M. James and F. E. Prichard, Longman Publication.
2.	Experiments in Physical Chemistry, R. C. Das and B. Behra, Tata McGraw Hill
3.	Advanced Practical Physical Chemistry, J. B. Yadav, Goel Publishing House.
4.	Advanced Experimental Chemistry, Vol. - I, J. N. Gurtu and R. Kapoor, S. Chand and Company.
5.	Physical Chemistry Experiments, Raghvan and Vishwanathan.
6.	Systematic Experimental Physical Chemistry by S. W. Rajbhoj and T. K. Chondhekar, Anjali Publication
7	Practical Organic Chemistry by - A. I. Vogel.
8	Practical Organic Chemistry by - O. P. Agarwal.

	CHE-362-Chemistry Practical-9 Major-Practical	
	Number of Credits: 02 No. of Hours: 60	
Course Outcomes (COs) On completion of the course, the students will be able to:		**Bloom's cognitive level**
CO1	Recall and memorize the terms gravimetry, qualitative, quantitative, common ion effect and solubility product.	1
CO2	Develop the practical skill in gravimetric methods to estimate the amount of metal ion gravimetrically	2
CO3	Interpret and explain the results of volumetric estimation of organic molecules.	3
CO4	Adapt and analyze the separation of metal ions by qualitative analysis and identify the groups based on solubility product and common ion effect.	4
CO5	Separate and test the metal ions by column/paper chromatography.	5
CO6	Infer the observation and compile the result.	6

CHE-362 Chemistry Practical-9
(Major-Practical)

Unit No.	Title of Unit and Contents
1	**Organic Preparations [Any Five]** 1. Preparation of benzopinacol from benzophenone. 2. Preparation of benzoic acid from ethyl benzoate. 3. Preparation of quinone to hydroquinone. 4. Preparation of benzoyl glycine from hippuric acid 5. Isolation of caffeine from tea leaves. 6. Preparation of para bromo acetanilide from acetanilide. 7. Preparation of para nitroiodobenzene from para nitroaniline. 8. Green synthesis of acetanilide from aniline using Zinc / acetic acid.
2	**Quantitative - Gravimetric** 1. Gravimetric estimations of Fe as Fe_2O_3. 2. Gravimetric estimations of Nickel as Ni - DMG. 3. Gravimetric estimations of Al as Aluminum oxide / oximate. 4. Gravimetric estimations of Ba as $BaSO_4$ using homogeneous precipitation method.
3	**Qualitative Analysis (Four Mixtures)** 1. Qualitative semi-micro analysis of mixtures containing four radicals. Emphasis should be given to the understanding of the chemistry of different reactions and to assign the most probable composition. **OR**

	2. Separation and identification of binary mixture of cations by - column chromatography (including colorless Zn + Al / Zn + Mg) or by paper chromatography (separation of Fe^{3+}, Al^{3+}, and Cr^{3+}).

Learning Resources- References

Sr. No.	References
1.	Practical Organic Chemistry by - A. I. Vogel.
2.	Practical Organic Chemistry by - O. P. Agarwal.
3.	Analytical Chemistry by G. D. Christian 6th Edition.
4.	Vogel's Textbook of Quantitative Chemical Analysis 6th Edition by R. C. D. Denney, J. D. Barnes, M. J. K. Thomas.
5.	Macro and Semi - micro Qualitative Inorganic Analysis Arthur IVogel, 5th Edition.

	CHE-382-Chemistry Practical-10 **Vocational Skill Course-Practical**	
	Number of Credits: 02 **No. of Hours: 60**	
Course Outcomes (COs) **On completion of the course, the students will be able to:**		**Bloom's cognitive level**
CO1	understand the principle applications and limitations of Beers law.	1
CO2	Carry out the quantitative analysis using a colorimeter .	2
CO3	Calculate the molecular properties using computational chemistry tools.	3
CO4	Learn purification methods of organic molecules.	4
CO5	Estimate the amount of organic molecules volumetrically. Infer the observation and compile the result.	5
CO6	Construct the phase diagram of two component system. Develop practical training skills by industrial visits.	6

CHE-382-Chemistry Practical-10
(Vocational Skill Course-Practical)

Unit No.	Title of Unit and Contents
1	To determine the three dissociation constants of polybasic acid such as H_3PO_4 by potentiometry
2	Construct the phase diagram for 2 component system by plotting cooling curve for a mixture of different compositions.
3	Determine Critical Micellar Concentration (CMC) of soap by surface tension method
4	Determine concentration of iron complex by colorimetry.
5	Estimate the molecular properties such as geometry optimization, confirmational analysis, vibrational spectra using computational methods.
6	**Purification techniques:** 1. Distillation 2. Column Chromatography
7	**Organic Estimations:** 1. Estimation of ethyl benzoate 2. Determination of molecular weight of mono/dibasic acid.

8	**Quantitative - Colorimetric Estimation:** 1. Colorimetric estimations of Iron by thiocyanate method. 2. Colorimetric estimations of Cobalt by using the R - nitroso salt method. 3. Colorimetric estimations of Titanium by H_2O_2. 4. Colorimetric estimations of Copper.
9	**Industrial visit:** One day visit to a chemical industry and report writing.

Learning Resources- References

Sr. No.	References
1.	Systematic Experimental Physical Chemistry by S. W. Rajbhoj and T. K. Chondhekar, Anjali Publication
2.	Advanced Practical Physical Chemistry, J. B. Yadav, Goel Publishing House.
3.	Advanced Experimental Chemistry, Vol. - I, J. N. Gurtu and R. Kapoor, S. Chand and Company.
4.	Physical Chemistry Experiments, Raghvan and Vishwanathan.
5.	College Practical Chemistry by Ahluwalia
6.	Text book of physical chemistry practical by Dr. Bhavin Dhaduk.
7.	Computational Chemistry by Eroll Lewars, Springer International Publishing.
8.	Practical Organic Chemistry by - A. I. Vogel.
9	Practical Organic Chemistry by - O. P. Agarwal.
10	Analytical Chemistry by G. D. Christian 6^{th} Edition.
11	Vogel's Textbook of Quantitative Chemical Analysis 6^{th} Edition by R. C. D. Denney, J. D. Barnes, M. J. K. Thomas.
12	Macro and Semi - micro Qualitative Inorganic Analysis Arthur IVogel, 5^{th} Edition.

	CHE-371-Biochemistry-II **Minor-Theory**	
	Number of Credits: 02 **Number of Hours: 30**	
Course Outcomes (COs) **On completion of the course, the students will be able to:**		**Bloom's cognitive level**
CO1	Recall names and structures of biomolecules and biochemical reactions. Label the parts of the cell and its organelles. Define the terminologies that align with properties of biomolecules and molecular mechanisms.	1
CO2	Classify biomolecules. Explain the in-vivo and in- vitro reactions of molecules and its significance. Compare and Contrast between features of biomolecules and cells.	2
CO3	Categorize the types of biomolecules based on their structure and properties. Apply the basic concepts of chemistry to understand the formation of macromolecules and types of bonds. Outline the concepts of central dogma of molecular biology to understand its correlation with metabolism.	3
CO4	Analyse the factors that affect enzyme kinetics. Explain the structural features of biomolecules to correlate with their properties and functions.	4
CO5	Evaluate the sequence of intermediates formed in biochemical pathways and hormonal regulation of metabolism.	5
CO6	Propose biochemical pathways based on the requirements of the cell under various conditions. Assemble monomeric units of biomolecules to form macromolecules.	6

CHE-371 Biochemistry-II
(Minor-Theory)

Unit No.	**Title of Unit and Contents**	**No. of hours**
1	**Molecular logic of life:** Biochemical composition of different types of cells and its organelles. Types of bonds in macromolecules. Biomolecules carbohydrates definition, classification, structures, biochemical significance of carbohydrates- simple, complex, derived and conjugated carbohydrates. Reactions of glucose- oxidation, reduction, rearrangements, furfural derivatives, Osazone, Reducing and nonreducing sugars. Lipids- Definition, classification, structures, biochemical significance of lipids- simple, complex, sphingolipids, steroids, derived and conjugated lipids. Saponification number, iodine number, acid number, rancidity, Lipoproteins, Blood group substances. Amino acids: Definition,classification, structures, biochemical significance of Amino acids- polar and non polar, Standard and nonstandard, Essential and nonessential. Amphoteric nature, Ampholytes, Zwitter ions, Interpretation of titration curve of amino acid.	12

	Proteins: Definition, classification, structures, biochemical significance of proteins. Hierarchy in structural organisation of proteins. Reactions involved in amino acid sequencing of proteins.	
2	**Biocatalysts:** Enzymes: Definition, Types of biochemical reactions. classification of enzymes. Conjugated enzymes-Apoenzyme, prosthetic groups (coenzymes and cofactors) and holoenzyme. Features of an active site. Theories of ES complex formation, enzyme specificity, factors affecting enzyme activity. Basics of enzyme kinetics. Significance of Km. Types of enzyme inhibitions. Industrial uses of enzymes.	4
3	**Introduction to Biosignaling:** Principles of signal transduction. Classification of endocrine hormones. Mechanism of hormone action. Neurotransmitters.	2
4	**Overview of metabolic pathways:** Metabolism, catabolism, anabolism, amphibolism. carbohydrate-metabolism glycolysis, fates of pyruvate, Kreb's cycle, HMP shunt. Lipid metabolism- Beta oxidation of fatty acids, Ketogenesis, TAG synthesis. Amino acids- Urea Cycle. Bioenergetics- Electron transport chain, proton gradient, oxidative phosphorylation in mitochondria. Chemiosmotic hypothesis of Peter Mitchell.	8
5	**Nucleic acids:** Nitrogenous bases: Nucleosides, nucleotides, polynucleotides. DNA as genetic material, Structure of DNA, RNA and its significance.	2
6	**Overview of central dogma of molecular mechanisms:** Replication, transcription, genetic code, translation. Basic principles and applications of genetic engineering. Gene cloning. Gene therapy.	2

Learning Resources- References

Sr. No.	References
1.	Nelson, D.L. & Cox, M.M. Lehninger Principles of Biochemistry, W.H. Freeman, 2013
2.	Biochemistry – Albert Lehninger 1st Edition. Kalyani Publishers
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