Deccan Education Society's

Fergusson College (Autonomous)
Pune

Learning Outcomes-Based Curriculum

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

as per guidelines of

NEP-2020

for

F. Y. B. Sc. (Chemistry)

With effect from Academic Year

2023-2024

Program Outcomes (POs) for B. Sc. Programme	
PO1	**Disciplinary Knowledge:** Demonstrate comprehensive knowledge of the disciplines that form a part of an 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 design the solutions.
PO3	**Social competence:** Display the understanding, behavioural skills needed for successful social adaptation, work in groups, exhibits 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, establish hypothesis 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 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 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, 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 reduce, recycle and restore chemicals (3R's) approach and gain the sense of ethical, social and environmental awareness and responsibility.

Fergusson College (Autonomous), Pune
Proposed First Year Curriculum as per NEP 2020

Department of Chemistry

Structure for Major / Minor

Semester	Paper	Paper Code	Paper Title	Type	Credits
I	Major	CHE-101	Introduction to Chemistry	Theory	4
		CHE-100	Chemistry Practical - 1	Practical	2
	Minor	CHE-111	General Chemistry	Theory	2
		CHE-112	Chemistry Practical- 1	Practical	2
	OE-1	CHE-120	Food Chemistry	Theory	2
	OE-2	CHE-121	Chemistry in daily life	Theory	2
	SEC-1	CHE-140	Good Laboratory Practices and Methods	Skill	2
II	Major	CHE-151	Fundamentals of Chemistry	Theory	4
		CHE-150	Chemistry Practical - 2	Practical	2
	Minor	CHE-161	Basics of Physical and Inorganic chemistry	Theory	2
		CHE-162	Chemistry Practical - 2	Practical	2
	OE-3	CHE-170	Chemistry of Perfumes	Theory	2
	OE-4	CHE-171	Basics of Forensic Science	Theory	2

OE – Open Elective, SEC- Skill Enhancement Course.

Teaching and Evaluation (Only for FORMAL education courses)

Course Credits	No. of Hours per Semester Theory / Practical	No. of Hours per Week Theory / Practical	Maximum Marks	CE 40 %	ESE 60%
1	15 / 30	1 / 2	25	10	15
2	30 / 60	2 / 4	50	20	30
3	45 / 90	3 / 6	75	30	45
4	60 / 120	4 / 8	100	40	60

Eligibility: As per the rules and regulations of Savitribai Phule Pune University (SPPU)

	F. Y. B. Sc. Semester I	
CHE-101	**Introduction to Chemistry (Major- Theory)**	**Credits: 4 Hours: 60**
	Course Outcomes (COs) On completion of the course, the students will be able to:	**Bloom's cognitive level**
CO1	Recall fundamental concepts of structures, equations, laws and principles related to atoms and molecules	1
CO2	Discuss atomic models, atomic spectrum, quantum numbers and various types of chemical bonds and their electronic properties.	2
CO3	Apply fundamental concepts of chemistry in solving numerical and chemical properties	3
CO4	Differentiate the types of chemical properties and reactions with respect to atomic and molecular structures. Compare theories of chemical bonding and classify the types of hybridization and explain geometries of molecules.	4

Unit	Content	No. of hours
I	**Chemical Mathematics:** Scientificnotation, powers and roots, Logarithms, graphical presentation of functions, differential calculus, Integral calculus.	**6**
II	**Atomic Structure:** Rutherford atomic model, electromagnetic spectrum, Bohr's theory, its limitations and atomic spectrum of hydrogen atom, de Broglie equation, Heisenberg's Uncertainty, Principle and its significance, Schrödinger's wave equation, significance of ψ and ψ^2, quantum numbers and their significance, normalized and orthogonal wave functions, sign of wave functions, Radial and angular wave functions for hydrogen atom, radial and angular distribution curves, shapes of *s*, *p*, *d* and *f* orbitals.	**10**
III	**Distribution Law:** Nernst distribution law, Statement and thermodynamic proof for Nernst distribution law, Limitation of distribution law, association, and dissociation of solute in solvent (modification in distribution law), application of distribution law, numericals.	**4**
IV	**Chemical Bonding:** Electronic theory of valence, attainment of stable configuration, Types of bonds – ionic, covalent, coordinate, metallic bonds - qualitative idea. Types of overlaps: s-s, s-p, p-p, p-d, d-d and their examples, Ionic bond: General characteristics, types of ions, size effects, radius ratio rule (CN 2, 3, 4) and its limitations. Covalent bond: Lewis structure, Valence Bond Theory (Heitler-London approach). Pauling-Slater Theory. Concept of hybridization, equivalent and non-equivalent hybrid orbitals. Types of hybridization involving s, p, & d orbitals, hybridization geometries in the molecules like i) BeF2 ii) BF3 iii)	**10**

	[MnCl4]2- iv) [Ni(CN)4]2-v) Fe(CO)5 vi) [Cr(H2O)6]2+, vii) IF7, Formal charge, Valence shell electron pair repulsion theory (VSEPR), shapes of simple molecules and ions containing lone pairs and bond pairs of electrons: H2O, NH3, PCl5, PCl6-, SF6, SO42-, ClF3, Cl2O, BrF5, I3-, BrF2+, TeCl4, XeO3.	
V	**Periodicity of Elements:** Long form of periodic table, *s*, *p*, *d*, *f* block elements, Classification of elements, electronic configuration, Pauli's Exclusion principle, Hund's rule of maximum multiplicity, Aufbau's principle and its limitations, variation of orbital energy with atomic number, detailed discussion of the following properties of the elements with reference to *s* and *p*-block, Effective nuclear charge, shielding or screening effect, Slater rules, variation of effective nuclear charge in periodic table, Atomic and ionic radii, Ionization enthalpy, Successive ionization enthalpies and factors affecting ionization enthalpy and trends in groups and periods. Applications of ionization enthalpy, Electron gain enthalpy (Electron affinity) and trends in groups and periods, Electro-negativity, Pauling's scale. Variation of electro-negativity with bond order and hybridization.	**10**
VI	**Structural effects and reactivity of organic compounds:** Organic Compounds: Covalent bond, hybridization, shapes of molecules, influence of hybridization on bond properties, inter and intramolecular hydrogen bonding, Electronic Displacements: Inductive, resonance and mesomeric effects hyper conjugation, tautomerism and their applications, dipole moment, organic acids and bases, their relative strength, strength of acids and bases, pKa and pKb values of common organic acids and bases, Homolytic and heterolytic fission with suitable examples, curly arrow rules, formal charges; electrophiles and nucleophiles nucleophlicity and basicity, types, shape and their relative stability of carbocations, carbanions, free radicals and carbenes. Introduction to types of organic reactions and their mechanism, addition, elimination, substitution.	**10**
VII	**Chemistry of Aliphatic and Aromatic Hydrocarbons: Introduction** to Hydrocarbons, Classification of hydrocarbons. **Alkanes**: IUPAC nomenclature, formation of alkanes, Wurtz reaction, Wurtz-Fittig reactions, free radical substitutions: Halogenation-relative reactivity and selectivity. **Alkenes**: IUPAC nomenclature, synthesis of alkenes, mechanism of E1, E2, E1cb reactions Saytzeff and Hofmann eliminations **Reactions of alkenes:** Electrophilic additions reactions and their mechanisms: Markownikoff/Anti Markownikoff addition, oxymercuration-demercuration, hydroboration oxidation, ozonolysis, reduction, syn and anti-hydroxylation, 1,2/1, 4 addition reactions in conjugated dienes, Diels-Alder reaction, allylic and benzylic bromination and mechanism, e.g.propene, 1-butene, toluene,ethylbenzene and their industrial applications. **Alkynes:** IUPAC nomenclature, acidity, electrophilic and nucleophilic additions, hydration to form carbonyl compounds, alkylation of terminal alkynes.	**10**

References:

1. Principles of PhysicalChemistry by Maron and Prutton, 1992
2. Mortimer, R. G. Physical Chemistry 3rd Ed. elsevier: NOIDA, UP, 200.
3. Chemistry The Central Science 14 th Ed. Person
4. Mathematics in Chemistry by Sourav Pal and K V Raman 2004
5. Physical Chemistry: A Molecular Approach by Donald A. McQuarrie and John D. Simon.

F. Y. B. Sc. Semester I		
CHE-100	**Chemistry Practical - 1** **(Major-Practical)**	**Credits:** 2 **Hours:** 60
Course Outcomes (COs) **On completion of the course, the students will be able to:**		**Bloom's cognitive level**
CO1	List out the safety measures in chemistry lab. Recall the examples of cations, anions and different types of organic compounds with their functional groups.	**1**
CO2	Classify the type of tests for qualitative analysis of organic and inorganic samples	2
CO3	Apply the principles of techniques to determine physical constants, purification of organic samples and detection of basic and acidic radicals.	3
CO4	Interpret the results of qualitative analysis to confirm the presence of given unknown organic and inorganic samples. Write a comprehensive journal of the experimental analysis	4,6

Expt. Type	**Title of the Experiment**
I	Laboratory Safety
II	**Organic Chemistry Practicals [Any FIVE]** (a) Purification of Organic Compound by Crystallization Method by using different solvents (two compounds), Distillation (Demonstration), Sublimation Method (one compound) (b) Qualitative analysis / characterization of organic compound containing C, H, (O), N, S elements (no element test), (c) Separation of a mixture of ortho and para nitrophenol OR ortho and para nitroaniline by thin layer chromatography (TLC) (d) Use of software for drawing chemical structures of molecules.
III	**Inorganic Chemistry Practicals [Any FIVE]** **Mixtures without Phosphate & Borate]** (a) Semi-micro inorganic qualitative analysis of binary mixture containing two cations and two anions.

References:

1. Khosla, B.D.; Garg, V. C. and Gulati Senior practical physical chemistry, R. Chand &Co.:New Delhi, 2011.
2. Garland, C. W.; Nibler, J.W. and shoemaker, D. P Experiments in physical chemistry 8thEd. McGraw-Hill: New work, 2003.
3. Mendham, J., A. I. Vogel's Qualitative Organic Chemical Analysis 6th Ed., Pearson, 2009.
4. Mann, F.G. & Saunders, B.C. Practical Organic Chemistry, Pearson Education, 2009.
5. Furniss, B.S.; Hannaford, A.J.; Smith, P.W.G.; Tatchell, A.R. Practical Organic Chemistry,5th Ed., Pearson, 2012.
6. Vogel's Qualitative Inorganic Analysis 7th Edn, Revised by G Svehla, Pearson 2009.

F. Y. B. Sc. Semester I		
CHE-111	**General Chemistry** **(Minor-Theory)**	**Credits: 2** **Hours: 30**
Course Outcomes (COs) **On completion of the course, the students will be able to:**		**Bloom's cognitive level**
CO1	Define basic concepts and describe electronic factors in organic chemistry and types of bonds.	1
CO2	Explain the mechanisms of organic reactions and classify the organic compounds based on their nomenclature and their basic properties. Arrange the elements according to their physical properties as well as chemical properties	2
CO3	Apply basic concepts to classify and differentiate organic compounds and justify the chemical and physical properties for organic compounds. Calculate the charge on given chemical species and solve the given chemical reaction	3
CO4	Distinguish between the compounds or elements on the basis of their chemical and Physical properties. Explain the relation between trend and the chemical properties of compounds or Elements.	4

Unit	Content	No of Hours
I	**Basics of Organic Chemistry** Organic Compounds: Covalent bond, hybridization, shapes of molecules, influence of hybridization on bond properties, inter and intra molecular hydrogen bonding, Electronic Displacements: Inductive, resonance and mesomeric effects, hyper conjugation,	8

	tautomerism and their applications, dipole moment, organic acids and bases, their relative strength, strength of acids and bases, pKa and pKb values of common organic acids and bases, Homolytic and heterolytic fission with suitable examples, curly arrow rules, formal charges; electrophiles and nucleophiles nucleophlicity and basicity, types, shape and their relative stability of carbocations, carbanions, free radicals and carbenes. Introduction to types of organic reactions and their mechanism, addition, elimination, substitution and rearrangement reactions	
II	**Chemistry of Hydrocarbons** Introduction to Hydrocarbons, Classification of hydrocarbons (up to aromatic hydrocarbons), Alkanes: IUPAC nomenclature, formation of alkanes, Wurtz reaction, Wurtz-Fittig reactions, free radical substitutions: Halogenation-relative reactivity and selectivity, Alkenes: IUPAC nomenclature, formation of alkenes by elimination reactions, mechanism of E1, E2, E1cb reactions, Saytzeff and Hofmann eliminations, Reactions of alkenes: Electrophilic additions their mechanisms (Markownikoff/Anti Markownikoff addition), mechanism of oxymercuration-demercuration, hydroborationoxidation, ozonolysis, reduction (catalytic and chemical), syn and anti-hydroxylation (oxidation), 1, 2 and 1, 4 addition reactions in conjugated dienes, Diels-Alder reaction, allylic and benzylic bromination and mechanism, e.g. propene, 1-butene, toluene, ethylbenzene and their industrial application of hydrocarbons, Alkynes: IUPAC nomenclature, acidity, electrophilic and nucleophilic additions, hydration to form carbonyl compounds, alkylation of terminal alkynes.	10

III	**Research in India in the field of Chemistry** Introduction to Premier Indian Research Institutes in Chemistry, Shantiswaroop Bhatnagar awardees in last 5 years in Chemistry.	2
IV	**Periodicity of Elements** Long form of periodic table, s, p, d, f block elements, Classification of elements, electronic configuration, detailed discussion of the following properties of the elements with reference to s and p-block, Effective nuclear charge, shielding or screening effect, Slater rules, variation of effective nuclear charge in periodic table, Atomic and ionic radii, Ionization enthalpy, Successive ionization enthalpies and factors affecting ionization enthalpy and trends in groups and periods. Applications of ionization enthalpy, Electron gain enthalpy (Electron affinity) and trends in groups and periods, Electro-negativity, Pauling's scale. Variation of electro-negativity with bond order and hybridization.	10

References:

1. Clayden, J., Greeves, N., & Warren, S. G. Organic chemistry. Oxford: Oxford University Press, 2012.
2. Morrison, R. N. & Boyd, R. N. Organic Chemistry, 6th Edition, (Pearson Education), 1992.
3. Finar, I. L. Organic Chemistry (Volume 1), Dorling Kindersley (India) Pvt. Ltd. (Pearson Education), 1964.
4. McMurry, J.E. Fundamentals of Organic Chemistry, 7th Ed. Cengage Learning India Edition, 2013.
5. J. D. Lee Concise Inorganic Chemistry: Fifth Edition, Wiley, 2007.
6. Bodie Douglas and DarlMcdaniel Concepts and Models of Inorganic Chemistry Third Edition, Wiley,1994.
7. Duward Shriver, P. W. Atkins Inorganic Chemistry, Fifth Edition, Oxford University Press, 2002.
8. Donald A. Tarr, Gary Messler Inorganic Chemistry Third Edition, Pearson, 2013.
9. F. Albert Cotton and Geoffrey Wilkinson Advanced Inorganic Chemistry, Sixth Edition, 2013.

F. Y. B. Sc. Semester I		
CHE-112	**Chemistry Practical - 1 (Minor-Practical)**	**Credits: 2 Hours: 60**
Course Outcomes (COs) On completion of the course, the students will be able to:		**Bloom's cognitive level**
CO1	List out the safety measures in chemistry lab. Recall the examples of cations, anions and different types of organic compounds with their functional groups.	1
CO2	Classify the type of tests for qualitative analysis of organic and inorganic samples	2
CO3	Apply the principles of techniques to determine physical constants, purification of organic samples and detection of basic and acidic radicals.	3
CO4	Interpret the results of qualitative analysis to confirm the presence of given unknown organic and inorganic samples. Write a comprehensive journal of the experimental analysis	4,6

Unit	Title of the Experiment	No. of Hours
I	**Laboratory Safety**	**4**
II	**Organic Chemistry Practicals [Any FIVE]** **(**a) Purification of Organic Compound by Crystallization Method by using different solvents (two compounds), Distillation (Demonstration), Sublimation Method (one compound) (b) Qualitative analysis / characterization of organic compound containing C, H, (O), N,S elements (no element test), (c) Separation of a mixture of ortho and para nitrophenol OR ortho and para nitroaniline by thin layer chromatography (TLC) (d) Use of software for drawing chemical structures of molecules	**28**
III	**Inorganic Chemistry Practicals [Any FIVE]** Mixtures without Phosphate & Borate] (a) Semi-micro inorganic qualitative analysis of binary mixture containing two cations and two anions.	**28**

References:
1. Khosla, B.D.; Garg, V. C. and Gulati Senior practical physical chemistry, R. Chand &Co.:New Delhi, 2011.
2. Garland, C. W.; Nibler, J.W. and shoemaker, D. P Experiments in physical chemistry 8thEd. McGraw-Hill: New work, 2003.
3. Mendham, J., A. I. Vogel's Qualitative Organic Chemical Analysis 6th Ed., Pearson, 2009.
4. Mann, F.G. & Saunders, B.C. Practical Organic Chemistry, Pearson Education, 2009.
5. Furniss, B.S.; Hannaford, A.J.; Smith, P.W.G.; Tatchell, A.R. Practical Organic Chemistry,5th Ed., Pearson, 2012.
6. Vogel's Qualitative Inorganic Analysis 7th Edn, Revised by G Svehla, Pearson 2009

F. Y. B. Sc. Semester I		
CHE-120	**Food Chemistry (OE-1)**	**Credits: 2 Hours: 30**
Course Outcomes (COs) On completion of the course, the students will be able to:		**Bloom's cognitive level**
CO1	Recall terminologies of food regulation laws, food ingredients, nutrition and digestion process.	1
CO2	Classify nutrients, types of food additives and their features.	2
CO3	Apply the principles of food preparation and preservation techniques to retain nutritive value of foods with healthy alternatives.	3
CO4	Interpret the results of qualitative and quantitative analysis of components in food.	4

Unit	**Content**	**No. of hours**
I	**Types of Nutrients:** Basic concept on Food and Nutrition. Scope of Nutrition, Classification of food. Types of Macro and Micronutrients. Sources and significance. Recommended daily intake. Structure and functions of the digestive system. Process of digestion and absorption of food. Significance of digestive juices in digestion.	**07**
II	**Food Adulterants and Healthy choices:** Types of Food toxins. Food adulteration in various daily food items. Healthy alternatives.	**08**
III	**Food preservation methods:** Definition, objectives, and principles of food preservation. Different ancient and modern methods of food preservation to retain nutritive value.	**08**

IV	**Food analysis and Food regulation laws:** Identification and analysis of macro and micronutrients in food. Weight for age, height for age, weight for height, body Mass Index (BMI) Waist - Hip Ratio, (WHR). Skin fold thickness. Simple home testing of food adulterants. National and International Food Adulteration prevention laws. Reading of food label and ingredients.	**07**

References:

1. Mann J and TruswellS(2017) : Essentials of Human Nutrition, 5th Ed. Oxford University Press.
2. Handbook of Food and Nutrition- Dr.M.Swaminathan,Bangalore Press
3.Sadasivan S and ManikamK(2007): Biochemical Methods, 3rd Ed. New Age International (P) Ltd.
4. Subalakshmi, G and Udipi, SA(2006):Food processing and preservation, 1st Ed. New Age International (P)Ltd.

	F. Y. B. Sc. Semester I	
CHE-121	**Chemistry in daily life (OE-2)**	**Credits: 2 Hours: 30**
	Course Outcomes (COs) On completion of the course, the students will be able to:	**Bloom's cognitive level**
CO1	Define chemical terms of commercial items used in daily life and its features.	1
CO2	Classify oils, soaps, detergents, food additives and polymers.	2
CO3	Apply the basic concepts of chemistry in understanding the components of commercial products used in daily life and its significance.	3
CO4	Analyse food additives in various food products.	4
CO5	Explain the principles and procedures involved in the manufacturing process of daily use products.	5
CO6	Design simple procedures for preparation of commonly used products in everyday life.	6

Unit	**Content**	**No. of hours**
I	**Oils and fats**: Composition of edible oils, detection of purity, rancidity of fats and oil. Tests for adulterants like argemone oil and mineral oils. Halphen test.	**6**
II	**Soaps & Detergents**: Definition, classification, manufacturing of soaps and detergents, composition and uses	**6**

III	**Food additives**, adulterants, and contaminants- Food preservatives like benzoates, propionates, sorbates, disulphites. Artificial sweeteners: Aspartame, saccharin, dulcin, sucralose, and sodium cyclamate. Flavors: Vanillin, alkyl esters (fruit flavors), and monosodium glutamate. Artificial food colorants: Coal tar dyes and non-permitted colors and metallic salts. Analysis of pesticide residues in food.	**10**
IV	**Fibers and polymers**: natural fibers, cotton, wool, silk, rayon, artificial fibers,polyamides, acrylic acid, PVC, PVA; Experiments: Synthesis of polymers,soaps,detergents,sanitizers	**8**

References:

1.Kaim W, Bioinorganic Chemistry, Vol 4, Brigitte Scwederski, Wiley, 1994.

2. Crichton R. H. Biological Inorganic Chemistry – An Introduction, elsevier, 2008.

3. Berg J. M., Tymoczeko J. L., Stryer l. Biochemistry, W. H. Freeman, 2008.

4. Bertini, I., Gray, H. B., Lippard, S. J. and Valentine, J. S. (1994) Bioinorganic Chemistry. University Science Books (1994)

5. Lippard S., Berg J. M. Principles of Bioinorganic Chemistry; University Science Books 1994.

6. Polymer science, V. R. Gowariker, N. V.Viswanathan, J. Sreedhar, New Age International

F. Y. B. Sc. Semester I		
CHE-140	**Good Laboratory Practices and Methods (SEC-1)**	**Credits: 2 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 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 (SOP) and laboratory waste management.	6

Unit	Content	No. of hours
I	**Principles, Ethics and Practices** Introduction to Good lab practice (GLP) History, Scope, fundamental Points of GLP, 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). Standard Operating Procedures (SOP) in the laboratory. GLP compliance and preparation for certification: ISO/ ICE 17025 and laboratory accreditation, Quality control lab and Quality assurance	**6**
II	**Understanding and Communicating Laboratory Hazards** Potential pathways of exposure and blocking these pathways to prevent exposure, Hazard recognition through the basics of understanding label, signs, symbols, terms, and other sources of information, Safe handling and interpreting the material safety data sheet (MSDS), overview of GHS Safety Data Sheets and GHS labelling.	**8**

III	**Laboratory Hazards and responses** **Chemical Hazards**: corrosive acids, bases, gases, oxidizers, flammables, fire triangle, water reactive compounds, pyrophoric chemicals and reactions, peroxides, cryogens. **Radiation Hazards**: ionizing, nonionizing radiations and electric and magnetic field. **Biological Hazards:** and Biosafety - hazards of biological agents and some general approaches to prevent exposures. **Introduction to Toxicology**: Basic principles of toxicology, Factors Influence Toxicity, Acute and Chronic Toxicity, Mercury toxicity, Carcinogens, Mutagens. **Responses**: chemical spills (acids, bases and other chemicals) and fire, classes of fires and types of fire extinguishers. First aid in chemical lab, emergency safety equipment. **Demonstration**: Fire extinguisher	**10**
IV	**Handling chemicals and Minimizing hazards in laboratory** Introduction to handling hazardous chemical waste, storingflammable and corrosive liquids, maintaining a safe and secure laboratory, managing chemicals in the 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. Lab waste management, Green Chemistry alternatives to conventional methods in labs and industries, The Twelve Principles of Green Chemistry and Sustainability.	**6**

References:

1. Laboratory safety for chemistry students, second edition, Robert H. Hill, Jr.David C. Finster, John Wiley & Sons.
2. Handbook of Good laboratory practice (GLP),UNDP/World Bank/WHO Special Programme for Research and Training in Tropical Diseases (TDR) https://fctc.who.int/publications/i/item/handbook-good-laboratory-practice-%28-glp%29
3. Solid Waste Management, Principles and Practice, RameshaChandrappa, DigantaBhusan Das, Springer.
4. Production-Integrated Environmental Protection and Waste Management in the Chemical Industry, Claus Christ, WILEY-VCH.
5. Fundamentals of Industrial Safety and Health Dr. K.U. Mistry, Siddharth Prakashan.
6. Hazardous waste management rules-2016, 1st editon, Ministry of environment, forest & climate change, govt. of India

	F. Y. B. Sc. Semester II	
CHE-151	**Fundamentals of Chemistry (Major-Theory)**	**Credits: 4 Hours: 60**
	Course Outcomes (COs) On completion of the course, the students will be able to:	**Bloom's cognitive level**
CO1	Recall the gas laws, their properties and effect of parameters on them. List out different types of chemical reactions.	1
CO2	Understand terminologies of various states of matter and classification and nomenclature of isomers	2
CO3	Derive gas equations. Write the synthesis of organic compounds. Solve numerical problems based on states of matter and mole concept.	3,6
CO4	Identify the changes in organic molecules during reactions. Discuss the type of bonds and chemical forces involved in molecules.	4

Unit	Content	No. of hours
I	**Gaseous State:** Postulates of Kinetic Theory of Gases and derivation of the kinetic gas equation. Deviation of real gases from ideal behavior, compressibility factor, causes of deviation. van der Waals equation of state for real gases. Boyle temperature (derivation not required). Critical phenomena, critical constants, and their calculation from van der Waals equation. Andrew's isotherms of CO_2. Maxwell Boltzmann distribution laws of molecular velocities and molecular energies (graphic representation – derivation not required) and their importance. Temperature dependence of these distributions. Most probable, average and root mean square velocities (no derivation). Collision cross section, collision number, collision frequency, collision diameter and mean free path of molecules.	**10**
II	**Liquid State:** Intermolecular forces, physical properties of liquids- vapour pressure, surface tension and coefficient of viscosity and their determination, cleansing action of detergents, effect of temperature on physical properties, liquid crystals.	**5**
III	**Solid State:** Nature of the solid state, law of constancy of interfacial angles, law of rational indices, Miller indices, elementary ideas of symmetry, symmetry elements and symmetry operations, point and space groups, seven crystal systems and Bravais lattices, X-ray diffraction, Bragg's law, Relation between radius and edge, packing fraction and density of crystal.	**5**
IV	**Mole Concept:** GMV relationship, problems based on mole concept, methods of expressing concentrations, strength, normality, molarity, molality, %w/v, %v/v, ppm, standardization of solutions, primary and secondary standard substances, preparation of standard solution of acids	**7**

	and bases, problems related to acid base titration. Principles involved in volumetric analysis (from practical experiments) to be carried out.	
V	**Oxidation and Reduction:** Definitions of related terms, oxidizing and Reducing agents, Oxidation number, Rules to assign oxidation number. Balancing redox reactions by ion-electron method (both acidic and alkaline medium), Problem based on equivalent weight of oxidants and reductants. Standard Electrode Potential and its application to redox reactions.	**8**
VI	**Metallic bonding and Weak chemical forces:** Metallic Bond: Qualitative idea of free electron model, Semiconductors, Insulators. Weak Chemical Forces: vander Waals, ion-dipole, dipole-dipole, induced dipole, dipole induced dipole interactions, Lennard-Jones 6-12 formula, hydrogen bond, effects of hydrogen bonding on melting and boiling points, solubility, dissolution.	**5**
VII	**Stereochemistry:** Introduction to isomerism and its classification. Fischer Projection, Newmann and Sawhorse Projection formulae and their interconversions. Conformational isomerism in alkanes (Ethane, propane and n-butane) with energy profile diagrams, Geometrical isomerism Geometrical isomerism: cis–trans and, syn-anti isomerism E/Z notations with C.I.P rules, Optical isomerism: Optical activity, specific rotation, chirality/asymmetry, enantiomers, molecules with two or more chiral-centres, diastereoisomers, meso structures, racemic mixture and resolution, relative and absolute configuration, D/L, R/S and E/Z designations.	**10**
	Aromatic Hydrocarbons: Aromaticity: Hückel's rule, anti aromatic, non aromatic, homoaromatic, pseudoaromatic, mono and bicyclic aromatic hydrocarbons. Electrophilic aromatic substitution of benzene, naphthalene: sulphonation, nitration, halogenation, Friedel Craft alkylation/acylation reactions, with their mechanism, Directing effects of the groups. Industrial application of aromatic hydrocarbons. Aromatic Nucleophilic Substitution reactions. Benzyne intermediate.	**10**

References:

1. Principles of Physical Chemistry by Maron and Prutton, 1992
2. Clayden, J., Greeves, N., & Warren, S. G. (2012). Organic chemistry. Oxford: Oxford University Press, 2012.
3. Morrison, R. N. & Boyd, R. N. Organic Chemistry, 6th Edition, (Pearson Education), 1992.
4. Eliel, E. L. &Wilen, S. H. Stereochemistry of Organic Compounds, Wiley: London, 1994.
5. Kalsi, P. S. Stereochemistry Conformation and Mechanism, New Age International, 2005.
6. Mc Murry, J.E. Fundamentals of Organic Chemistry, 7th Ed. Cengage Learning India Edition, 2013.
7. J. D. Lee Concise Inorganic Chemistry: Fifth Edition, Wiley, 2007.
8. Bodie Douglas and DarlMcdaniel Concepts and Model of Inorganic Chemistry Third Edition, Wiley, 1994.
9. Duward Shriver, P. W. Atkins Inorganic Chemistry, Fifth Edition, Oxford University Press, 2002.
10. Donald A. Tarr, Gary Miessler Inorganic Chemistry Third Edition, Pearson, 2013.
11. F. Albert Cotton and Geoffrey Wilkinson Advanced Inorganic Chemistry, Sixth Edition, 1962.

12. Sarin and Sarin Numerical Problems in Chemistry, 1980.

F. Y. B. Sc. Semester II		
CHE-150	**Chemistry Practical- 2 (Major- Practical)**	**Credits: 2 Hours: 60**
	Course Outcomes (COs) On completion of the course, the students will be able to:	**Bloom's cognitive level**
CO1	List different glass apparatus and identify the correct volumetric glass apparatus required for experiment. Recall equations and principle behind the experiment.	1
CO2	Estimate the amount of analytes in the given sample.	2
CO3	Solve numerical calculations based on your observations.	3
CO4	Tabulate observations of physical and analytical experiments with specific units. Write a comprehensive journal report with graph based on experimental findings.	4, 6

Expt. Type	Content	Practical (hrs)
I	**Physical Chemistry Practicals (Any FIVE)**: • Polar plots of s, p orbitals. • Relative viscosity of given organic liquids by viscometer. • Molar gas constants (R)in different units by eudiometric method. • Dissociation constant of a weak acid by pH metry. • To determine molecular weight of solute by depression in freezing point method. Naphthalene – Sulphur. • To determine molecular weight of given electrolyte (KCl) and on-electrolyte (Urea) by Landberger's method and to study abnormal molecular weight of electrolyte. • Scientific graphing of following functions using MSExcel. Exponential, logarithmic, linear Determination of rate constant of acid catalyzed ester hydrolysis. • Heat of solution of potassium nitrate in water.	**5**
II	**Analytical Chemistry Practicals (Any FIVE):** • Cleaning and Maintenance of apparatus and instruments. • Calibration of apparatus: Burette, Pipette, Volumetric flask, Thermometers (1/10th, 110^0C and 360^0C). • Preparation standard solution of 0.05N oxalic acid(exact) and standardization and determination of strength of given 0.05N (approx) KMnO4 solution. • Determination of acetic acid in vinegar by titrimetric method. • Determination of percentage composition of ZnO and $ZnCO_3$ in the given mixture gravimetrically.	**5**

	• Estimation of hydroxide/sulphate and carbonate present together in mixture. • Estimation of Fe(II) by using standardized 0.05N (approx) KMnO4 solution. Estimation of the amount of Mg (II) present in the given solution complexometrically.	

References:

1. Khosla, B.D., Garg, V. C. and Gulati Senior Practical Physical Chemistry, R. Chand & Co.: New Delhi, 2011.
2. Garland, C. W. Nibler, J.W. and Shoemaker, D. P. Experiments in Physical Chemistry, 8th Ed. McGrawHill, New York, 2003.
3. Mendham, J., Vogel's Quantitative Chemical Analysis 6th Ed., Pearson, 2008.
4. Mann, F.G. & Saunders, B.C. Practical Organic Chemistry, Pearson Education,2009.
5. Furniss, B.S.; Hannaford, A.J.; Smith, P.W.G.; Tatchell, A.R. Practical Organic Chemistry, 5th Ed., Pearson, 2012.

F.Y.B.Sc. Semester II		
CHE-161	**Basics of Physical and Inorganic Chemistry (Minor-Theory)**	**Credits: 2 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 concepts of atomic structure and chemical bonding.	1
CO2	Discuss atomic model and interpret atomic spectrum. Explain the concept of wave particle duality and wave equation, quantum numbers and rules of orbital electron distribution	2
CO3	Apply mathematics for chemistry using graphical representation, differentiation, integration and solve numerical problems based on chemical mathematics, atomic structure, gaseous state, and chemical bonding	3
CO4	Illustrate the concept of hybridization to understand the molecular structure.	4
CO5	Compare different theories of bonding.	5
CO6	Classify the shapes of molecules as per VSPER theory.	6

Unit	Content	No. of hours
I	**Chemical Mathematics:** Scientific notation, powers and roots, Logarithms, graphical presentation of functions, differential calculus, Integral calculus.	5
II	**Atomic Structure:** Rutherford atomic model, electromagnetic spectrum, Bohr's theory, its limitations and atomic spectrum of hydrogen atom, de Broglie equation, Heisenberg's Uncertainty, Principle and its significance, Schrödinger's wave equation (no derivation) significance of ψ and ψ^2, quantum numbers and their significance.	7
III	**Gaseous State**: Postulates of Kinetic Theory of Gases and derivation of the kinetic gas equation. Deviation of real gases from ideal behaviour, compressibility factor, causes of deviation. van der Waals equation of state for real gases. Boyle temperature (derivation not required). Critical phenomena, critical constants, and their calculation from van der Waals equation. Maxwell Boltzmann distribution laws of molecular velocities and molecular energies (graphical representation – derivation not required) and their importance. Temperature dependence of these distributions. Most probable, average and root mean square velocities	8
IV	**Chemical Bonding:** Electronic theory of valence, attainment of stable configuration, Types of bonds – ionic, covalent, coordinate, metallic bonds. Types of overlaps: s-s, s-p, p-p, p-d, d-d and their examples, Concept of hybridization, equivalent and non-equivalent hybrid orbitals. Types of hybridization involving s, p, & d orbitals, hybridization	10

	geometries in the molecules like i) BeF_2 ii) BF_3 iii) $[MnCl_4]_2$ iv) $[Ni(CN)_4]_2$) $Fe(CO)_5$ vi) $[Cr(H_2O)_6]^{2+}$, vii) IF_7, Formal charge, Valence shell electron pair repulsion theory (VSEPR), shapes of simple molecules and ions containing lone pairs and bond pairs of electrons: H_2O, NH_3, PCl_5, PCl_6-, SF_6, SO_4^{2-}, ClF_3, Cl_2O, BrF_5, $TeCl_4$, XeO_3.	

References

chemistry

1. The Central Science 14 th Edition by Theodore L. Brown et al.
2. Principles of Physical Chemistry by Maron and Prutton, 1992.
3. Essentials of physical chemistry Bhal, Tuli and S. Chand, 2010.
4. Chemistry by John Murray & Robert C Fay.
5. J. D. Lee Concise Inorganic Chemistry: Fifth Edition, Wiley, 2008.
6. Bodie Douglas and Darl Mcdaniel Concepts and Model of Inorganic Chemistry Third Edition, Wiley, 1983.

F. Y. B. Sc. Semester II		
CHE-162	**Chemistry Practical- 2 (Minor- Practical)**	**Credits: 2 Hours: 60**
	Course Outcomes (COs) On completion of the course, the students will be able to:	**Bloom's cognitive level**
CO1	List different glass apparatus and identify the correct volumetric glass apparatus required for experiment. Recall equations and principle behind the experiment.	1
CO2	Estimate the amount of analytes in the given sample.	2
CO3	Solve numerical calculations based on your observations.	3
CO4	Tabulate observations of physical and analytical experiments with specific units. Write a comprehensive journal report with graph based on experimental findings.	4, 6

Expt. Type	Content	Practical (hrs)
I	**Physical Chemistry Practicals (Any FIVE)**: • Polar plots of s, p orbitals. • Relative viscosity of given organic liquids by viscometer. • Molar gas constants (R)in different units by eudiometric method. • Dissociation constant of a weak acid by pH metry. • To determine molecular weight of solute by depression in freezing point method. Naphthalene – Sulphur. • To determine molecular weight of given electrolyte (KCl) and on-electrolyte (Urea) by Landberger's method and to study abnormal molecular weight of electrolyte. • Scientific graphing of following functions using MSExcel. Exponential, logarithmic, linear Determination of rate constant of acid catalyzed ester hydrolysis. • Heat of solution of potassium nitrate in water.	**5**
II	**Analytical Chemistry Practicals (Any FIVE):** • Cleaning and Maintenance of apparatus and instruments. • Calibration of apparatus: Burette, Pipette, Volumetric flask, Thermometers (1/10th, 110^0C and 360^0C). • Preparation standard solution of 0.05N oxalic acid(exact) and standardization and determination of strength of given 0.05N (approx) KMnO4 solution. • Determination of acetic acid in vinegar by titrimetric method. • Determination of percentage composition of ZnO and $ZnCO_3$ in the given mixture gravimetrically. • Estimation of hydroxide/sulphate and carbonate present together in mixture. • Estimation of Fe(II) by using standardized 0.05N (approx) KMnO4 solution. Estimation of the amount of Mg (II) present in	**5**

	the given solution complexometrically.	

References:

1. Khosla, B.D., Garg, V. C. and Gulati Senior Practical Physical Chemistry, R. Chand & Co.: New Delhi, 2011.
2. Garland, C. W. Nibler, J.W. and Shoemaker, D. P. Experiments in Physical Chemistry, 8th Ed. McGrawHill, New York, 2003.
3. Mendham, J., Vogel's Quantitative Chemical Analysis 6th Ed., Pearson, 2008.
4. Mann, F.G. & Saunders, B.C. Practical Organic Chemistry, Pearson Education,2009.
5. Furniss, B.S.; Hannaford, A.J.; Smith, P.W.G.; Tatchell, A.R. Practical Organic Chemistry, 5th Ed., Pearson, 2012.

F. Y. B. Sc. Semester II		
CHE-170	**Chemistry of Perfumes (OE-3)**	**Credits:** 2 **Hours:** 30
	Course Outcomes (COs) On completion of the course, the students will be able to:	**Bloom's cognitive level**
CO1	Define basic concepts of perfumes, formulation and its physiological effects.	1
CO2	Apply basic concepts to extract perfumery chemicals using various methods.	2
CO3	Distinguish between the natural identical and synthetic perfumery compounds.	3
CO4	Identify the chemical process for the isolation of perfumes, flavours and alcohol. Develop the relationship between trend and the perfumery properties of compounds or their structure. Synthesise the given organic compound with a suitable route.	4,5

Unit	Content	No. of hours
I	**Introduction to Perfumes:** History, classification of perfumes, the concept of aroma, types and physiological effects. Composition, formulation and working mechanism of perfume. Introduction to perfumery chemicals: Natural sources, natural identical and synthetic compounds.	**8**
II	**Extraction Methods:** Extraction methods of perfumery chemicals. Examples of some important perfumery chemicals (synthesis, properties and chemistry). Essential oils – Production equipment, distillation, Steam distillation, Flower oils – Extraction with alcoholic extracts, absolute of enflurages and chassis. Extraction with volatile solvents, selection of solvent and extraction apparatus. Extraction using Soxhlet Apparatus.	**12**
III	**Isolation Methods:** Isolates – Methods of Isolation, properties & uses of the following:Eugenol, Pinene, Linalool, Citral and Geraniol. Flavours – Sources and properties of Vanilla, Rose, Pineapple, Peppermint, Mango, Raspberry, Orange & Lemon. Alcohol - Manufacture of ethanol, Purification of Ethanol, Deodorization of ethanol.	**10**

References:

1. W. A. Poucher, Perfumes, Cosmetics and soaps, Ninth edition, – (Pages 3 to 67 and relevant pages from 68 to 360).
2. P. P. Sharma, Cosmetic Formulation, Manufacturing, and Quality Control. 3rd Edition, 1998) Vandana Publications, Lucknow, (relevant pages from 569 to 573).
3. Giriraj Prasad, Manufacture of Perfumes, Cosmetics & Detergents.
4. D. D. Wasule Perfumes: History & Chemistry Vol-I.
5. S.B. Srivastva, Perfume flowers & essential oil industries by
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8. H. Panda, Perfumes and Flavours Technology Handbook, Asia Pacific Business Press Inc., 2010, Delhi
9. The Chemistry of Perfume: A Laboratory Course for Nonscience Majors. *J. Chem. Educ.* 2012, 89, 5, 613–619.

F. Y. B. Sc. Semester II		
CHE-171	**Basics of Forensic Science (OE-4)**	**Credits: 2 Hours: 30**
Course Outcomes (COs) On completion of the course, the students will be able to:		**Bloom's cognitive level**
CO1	Recall the scope and significance of forensic science.	1
CO2	Classify the types of evidences used for forensic investigation.	2
CO3	Use the principles of forensic science in understanding criminal case studies.	3

Unit	Content	No. of hours
I	**Introduction to Forensic Sciences** Scope of forensic science, evidence in criminal law (act, case studies).	**8**
II	**Physical Evidences** Identification, collection and preservation of sample. physical properties of sample material. Use of physical evidence (Fingerprint) and biological evidence (blood, semen, saliva and DNA) in criminal proceedings.	**12**
III	**Trace Evidences** Introduction, principle and analysis of trace evidence (hair, fibre and paints).	**10**

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1. Suzanne Bell, Forensic Chemistry, 1st edition, Person Education Ltd.
2. http://www.forensicsciencesimplified.org/..
3. B. B. Nanda and R. K. Tiwari, Forensic Science in India: A Vision for the Twenty-First Century, Select Publishers, New Delhi (2001).
4. M. K. Bhasin and S. Nath, Role of Forensic Science in the New Millennium, University of Delhi, Delhi (2002).
5. S. H. James and J. J. Nord, Forensic Science: An Introduction to Scientific and Investigative Techniques, 2nd Edition, CRC Press, Boca Raton (2005).
6. Brenner, J. C. (2004). Forensic Science: An Illustrated Dictionary. CRC Press. Eckert, W. G. (1997). Introduction to Forensic Sciences (2nd Edition). CRC Press.
7. S. Nath, R. C. (2013). Forensic Science and Crime Investigation: Abhijeet Publications.
8. Sharma, B. R. (2019). Forensic Science in Criminal Investigation & Trails. Universal Law Publishing Company.
9. Yount, L. (2006). Forensic Science: From Fibers to Fingerprints (Milestones in Discovery and Invention). Chelea House publications.