Programme Outcome (PO)

SL. NO	B. SC. CHEMISTRY (HONS.) PROGRAMME OUTCOME
P.O–1	After completion of the graduation degree in chemistry, a student becomes a premaster owing to achieving thorough knowledge in all disciplines of chemistry, be it in theory or in practical
P.O–2	The components contained in the course curricula are useful to a graduate student to think critically in designing a problem, how to solve the problem in right way and also how to analyze the results of chemical reactions.
P.O–3	The chemistry curriculum is designed in such a form that it promotes the students to gain a diverse knowledge on the fundamentals of chemistry covering all the principles and perspectives.
P.O–4	The branches of chemistry such as organic chemistry, inorganic chemistry, physical chemistry, analytical chemistry and the analogous ones is SEC and DSE branches usher the students in the chemistry vistas through which they see the farsightedness of the subject.
P.O–5	The practical exercises run in the laboratories cater the students to acquire knowledge about various chemical reagents and reactions. By the by, the students have their skills of handling the poisonous, explosive, corrosive dangerous and carcinogenic chemicals. Thus practice makes the graduate students market-ready in any kind of chemical industries.
P.O–6	The students improve themselves stepwise and steadily since the course is so systematized that it imparts the subject knowledge rightly through the three year B.Sc. program.

Course Outcome (CO)

Course Outcome (CO) of B.Sc. Major in Chemistry (CCF)
&
Course Outcome (CO) of B.Sc. Honours in Chemistry (CCF)
(For all the semesters of the Academic year, 2023-2024)
Department of Chemistry

CCF-COURSE		
SEMESTER	**PAPER**	**COURSE OUTCOME (CO)**
I (CCF)	**CHEM-H** **CC1-1-TH**	**Module : I** Chemical sciences at its grass root level involve elements to form the foundation level of chemistry. An element is characterized by its atoms which are exactly identical in their physical and chemical properties but totally different from the atoms of different elements. To be more specific the atomic behavior is exclusively dependent on the characteristic electron borne by the atom. Regarding the position of the electron, it is the extra nuclear part of an atom which houses the electrons, controls their interaction with the nucleus at the core of the atom as well as with the surrounding electrons. Therefore to explore the behavior of the electrons, studies on extra nuclear structure are highly essential. Chemistry without periodic table is meaningless. Periodic table is the main focal point from which chemical periodicity does arise. Periodicity plays the vital role to acquire the knowledge of chemistry on s & p -Block elements where noble gases are also included. **Module : II** Nomenclature of organic compounds. Idea of formal charge and Double bond Equivalent (DBE). Idea of spatial arrangement and structure of organic molecules considering Valence Bond Theory (VBT, hybridization) and Molecular Orbital Theory (MOT). Basics of electron displacement mechanism (inductive and resonance effect including hyperconjugation). Basics of Hückel π-MOT for acyclic and cyclic conjugated polyenes. Concept of aromaticity – antiaromatic, non-aromatic and homoaromatic molecules. Prediction of physical properties such as melting and boiling points based upon the understanding of non-covalent interactions. Preliminary idea of solvent-solute interactions as seen in organic chemistry. Concepts of stereochemistry: Bonding geometries of carbon compounds: concept of asymmetry; Fischer, sawhorse, flying wedge and Newman projection formulae and their inter translations. Concept of chirality and symmetry: symmetry elements and operations. Idea of stereoisomerism – enantiomerism and diastereomerism. Concept of asymmetry and dissymmetry. **Module : III** After successful completion of the course, student would learn the basic concept of Thermodynamics; zeroth law and first law of thermodynamics. They will know how to calculate heat, work and change of internal energy and enthalpy for different processes. They can explain basic principles of

		Thermochemistry. The students will also understand the concept of chemical kinetics, rate laws for zero, 1st and 2nd order reactions, temperature dependence of rate constant and Arrhenius equation.
	CHEM-H **SEC1-1-TH**	**Module: I, II, III** Analytical chemistry is divided into two parts, qualitative analysis and quantitative analysis. Quantitative analysis shows what elements (or ions) a give substance contains. The aim of quantitative analysis is determination of the quantitative contents of individual elements or compounds present in a substance. Quantitative analysis is of enormous importance in science and industry. For example, the chemical formula of an unknown substance is found from the percentage contents of its constituents, found by analysis. Chemical analysis is a most important method of investigation and is widely used in all branches of science that are related to chemistry. For example, it is of great importance in mineralogy, geology, physiology, microbiology and medical, agricultural and environmental sciences. Chemical analysis is no less important in industry. The technologist must know at every stage of the production process both the qualitative and quantitative composition of the materials undergoing conversion. At the present time no material is taken into production or released without analytical data which characterize its quality and suitability for subsequent analysis. These results not only form the basis of all the processing calculations but they also determine the cost of the materials, which forms the basis of financial estimates. Analysis of intermediate products is of enormous importance. The technologist uses the results of such analysis for most efficient utilization of the raw material, for prevention of troubles in the course of the process and therefore for prevention of spoilage. The solutions to a host of problems are to be made by the undergraduate students with the most diverse background in analytical methods in chemistry. Workers in many fields are constantly confronted by analytical problems, and in many cases they work out their own solutions. What distinguishes the analytical chemist from other workers is an interest in the method and technique in their own right. To analytical chemists, developing methods is the challenging part of the research. They are likely to be skeptical of data presented without a full disclosure of experimental details and they retain a critical attitude toward results which some workers would like to accept so as to get on with other things. Analytical chemists deal with real, practical systems, and much of their effort is expended in an attempt to apply sound theory to actual chemical situations.
II (CCF)	**CHEM-H** **CC2-2-Th**	**Module : I** Concept of pressure and temperature from kinetic theory of gas. Nature of distribution of velocities, Maxwell's distribution of speeds in one, two and three dimensions; Kinetic energy distribution in one, two and three dimensions, calculations of average, root mean square and most probable values in each case; Collision of gas molecules; Collision diameter; Collision number and mean free path; Frequency of binary collisions (similar and different molecules); Wall collision and rate of effusion Calculation of number

		of molecules having energy ≥ ε, Principle of equipartition of energy and its application to calculate the classical limit of molar heat capacity of gases. Deviation of gases from ideal behavior; Compressibility factor; Boyle temperature; Andrew's and Amagat's plots; van der Waals equation and its features; its derivation and application in explaining real gas behavior ; Existence of critical state, Critical constants in terms of van der Waals constants; Law of corresponding states; Virial equation of state; van der Waals equation expressed in the Virial form and significance of second virial coefficient; Intermolecular forces (Debye, Keesom and London interactions; Lennard-Jones potential - elementary idea. **Module: II** ***Chemical Bonding - I:*** **i)** Ionic bond: General characteristics, types of ions, size effects, radius ratio rule and its application and limitations. Packing of ions in crystals. Born-Lande equation with derivation and importance of Kapustinskii expression for lattice energy. Madelung constant, Born-Haber cycle and its application, Solvation energy. Elementary ideas on stoichiometric and non-stoichiometric defects in solids. Energetics of dissolution of the polar and non-polar solutes in different solvents. **ii)** Covalent Bonding: Polarizing power of cations and polarizabilty of the anions, ionic potential of positively charged species, Fajan's rules to assess polarisation qualitatively, Lewis structures following closed-shell representation, formal charge, Valence Bond Theory, The hydrogen molecule (Heitler – London approach), directional character of covalent bonds, hybridizations and molecular geometry, equivalent and non-equivalent hybrid orbitals, Bent's rules, dipole moments, VSEPR theory, shapes of molecules and ions containing lone pairs and multiple bonding manifesting σ and π bonds. Theoretical principles of inorganic qualitative analysis: Basic principles involved in analysis of cations and anions and solubility products, common ion effect concept. Principle involved in separation of cations into groups and choice of group reagents. Basis of classifying the interfering anions (fluoride, borate, oxalate and phosphate) and the need to remove them after Group II analysis during wet tests for he basic radicals. **Module: III** ***Concepts of stereochemistry-II:*** Chirotopicity and its relationship with stereogenicity; concept of pseudoasymmetry for ABA type systems. Relative and absolute configuration: R/S descriptors; erythro/threo and meso nomenclature of compounds; E/Z descriptors for C=C, combination of R/S- and E/Z isomerisms. Optical activity of chiral compounds: optical rotation, and specific rotation; racemic compounds, racemisation (through cationic, anionic intermediates); resolution of racemic organic acids and bases via diastereomeric salt formation; optical purity (o.p.) and enantiomeric excess (e.e.). ***Chemistry of reactive intermediates:*** Carbocations (carbenium and carbonium ions - non-classical carbocations), carbanions, carbon-based radicals: generation and stability, structure and elementary idea of philicity (electrophilic / nucleophilic behaviour) of these reactive intermediates. ***Reaction thermodynamics:*** Relationship between Gibbs free energy and equilibrium constant, enthalpy and entropy factor, calculation of enthalpy change via bond dissociation energy (BDE), intermolecular & intramolecular

		reactions. ***Reaction kinetics:*** Rate constant and its relation to free energy of activation; free energy profiles for one-step, and two-step reactions; catalyzed reactions, principle of microscopic reversibility; Hammond's postulate. ***Substitution Reaction-I:*** Free-radical substitution reaction: halogenation of alkanes, mechanism (with evidence) and stereochemical features; reactivity-selectivity principle in the light of Hammond's postulate.
	CHEM-H-SEC2-2-Th	Artificial Intelligence allows students to understand the informed and uninformed problem types and apply search strategies to solve them. It also could be successfully apply to difficult real life problems in a state space representation so as to solve them using AI techniques like searching and game playing. It also applied to formulate valid solutions for problems involving uncertain inputs or outcomes by using decision making techniques and to demonstrate and enrich knowledge to select and apply AI tools to synthesize information and develop models within constraints of application area.

CBCS-COURSE		
SEMESTER	**PAPER**	**COURSE OUTCOME (CO)**
II (CBCS)	**CEMA-CC2-3-(TH+P)**	Advanced ideas of stereochemistry: axial chirality, topicity, prostereo-isomerism, concept of chirotopicity and stereogenecity. Conformational analysis of acyclic molecules. Idea of reaction thermodynamics. Application of thermodynamic principles to acid-base and tautomeric equilibria. Basic concept of reaction kinetics including kinetic isotope effect. Idea of Kinetic versus thermodynamic control of organic reactions and study of prototypical reactions to understand the effect of various factors on such control. Detailed discussion of nucleophilic substitution at saturated carbon (SN_1, SN_2) along with NGP and SNi, nucleophilic substitution with allylic rearrangements. Stereochemical and regiochemical outcome of elimination (E_1, E_2, E1cB) reactions. The practical part focuses to develop the basic skill of benchtop organic synthesis through different onestep conversion methodologies.
	CEMA-CC2-4-(TH+P)	The prescribed curriculum in this semester primarily focuses on two broad domains: (i) Chemical bonding, and (ii) Radioactivity. The topic 'Chemical Bonding' deals with the extranuclear part of an atom and manifests various facets of chemical bonds that exist between the atoms in the molecules. Without having an advanced knowledge of chemical bonding, it is very hard to interpret the phenomenon like chemical reactivity. Versatile chemical structures that the subject is concerned with can only be rationally explained with a superior knowledge of chemical bonding. More importantly, the structure-reactivity correlation can be effectively done with a superior knowledge of chemical bonding. Therefore, the very existence of a molecule, its structure, chemical reactivity and the products generated from a chemical reaction can be comprehensively understood with the topic 'Chemical Bonding'. The chemical bonding course highlights ionic bonding, covalent bonding, metallic bonding, molecular orbital theory and short-range weak chemical forces. The course is compact and obviously promises to provide a stable foundation of bonding to the undergraduate students.

		Radioactivity, on the other hand, deals with the nuclear properties of an atom. The course encompasses the interesting topics, such as, nuclear stability, separation of radioisotopes, artificial transmutation, nuclear quantum numbers, nuclear energy and radio-chemical methods. The application of nuclear energy as an alternative source of non-renewable energy is indeed promising with respect to reducing the environmental pollution manifold. The use of various radioisotopes in diagnosis and curative processes, agriculture and in other fields, are really fascinating to explore by the undergraduate students. The composed course structure is really enlightening and enthralling to the students. The practical part of this course entails the procedures of estimation of vitamin-C, arsenite, antimony, available chlorine in bleaching powder, copper in brass, manganese and chromium in steel and iron cement. Therefore, the practical course is aimed to provide an analytical skill to perform quantitative estimation of metals, organic substance and even metalloids.
III (CBCS)	**CEMA-CC3-5-(TH+P)**	After successful completion of the course, student would learn the basic concept of Thermodynamics; zeroth law and first law of thermodynamics. They will know how to calculate heat, work and change of internal energy and enthalpy for different processes. They can explain basic principle of Thermochemistry. They would learn to define statement of the second law of thermodynamics, concept of heat reservoirs and heat engines; Carnot cycle. They will be able to explain the physical concept of entropy and its significance, auxiliary state functions and their variations. They will understand different kinds of thermodynamic relations and describe Gibbs-Duhem equation, chemical potential. The students would explain the thermodynamic conditions for equilibrium and its degree of advancement. They will be able to describe basic concept of conductance; different types of conductance and their variations with dilution for strong and weak electrolytes; Kohlrausch's law of independent migration of ions; Debye-Huckel limiting law; Ostwald's dilution law; Ionic mobility; applications of conductance measurement; Transport number. The students can explain different aspects of ionic equilibrium and their effects on various kinds of physical properties of the solution. They will also learn the basic concepts of electromotive force.
	CEMA-CC3-6-(TH+P)	Chemical periodic table is of enormous importance, since it offers a systematic arrangement of the elements with regard to similarities in their physical and chemical properties. Periodic table is the main focal point from which chemical periodicity does arise. Periodicity plays the vital role to acquire the knowledge of chemistry on s & p -block elements where noble gases are also included. Most of the polymers in the world are covered by organic molecules. But inorganic polymers are there those also form a part of polymer chemistry, although in lesser extent compared to the organic counterpart. Various biodegradable polymeric compound are now a day's belonging to inorganic classes. Coordination chemistry is a separate branch in inorganic chemistry that primarily originates from the pioneering work of Werner. The classification of metals and the ligands with respect to various properties of their own, the coordination compounds form the backbone of modern inorganic chemistry. The outcome of this course is a stepping stone for coordination chemistry-(II) in the next semester that deals with the more advanced aspects of such complexes.

	CEMA-CC3-7-(TH+P)	Idea of electrophilic addition to olefinic and acetylenic carboncarbon bonds, regioselectivity of addition, functionalization and downstream exploitation of unsaturated compounds. Details of functionalizing the ubiquitous benzene ring, attack of electrophiles and nucleophiles, substituents' directing ability, accessing highly functionalized aryl targets. Concepts relating to exploitation of the synthetic potential of the carbonyl group, its electrophilic and nucleophilic character, formation of carboncarbon bonds utilizing aldol and related reactions. Idea of conjugated addition enones, enals. Nucleophilic acyl substitution reactions of carboxylic acid derivatives. Concept of reversal of polarity (umpolung), construction of carbon-carbon bonds using nucleophilic carbon reagents, base-nucleophile dichotomy in different organometallics like organozinc, organolithium, organocopper and organomagnesiums. The practical part deals with the identification of pure organic samples – both solid and liquid single compounds.Quantitative estimation of organic analytes by acid-base titrimetric and other assorted techniques also form a part of the practical regime.
	CEMA-SEC-A2	Basic ideas about structures, metabolism of biopolymers and their function in human body - carbohydrates, proteins, lipids and lipoproteins, nucleic acids. Idea about enzyme catalysis in various biological processes, kinetics of enzyme catalysis. Theoretical background to the estimation techniques and tests of constituents of human urine and blood samples.
IV (CBCS)	**CEMA-CC4-8-(TH+P)**	Chemistry of amines, nitro, diazo compounds, exploration into the chemistry of carbon-nitrogen bonds, synthetic potential of organonitrogen compounds, their importance. Introduction to rearrangement reactions in organic chemistry and their applications in organic synthesis. The art of synthesis in organic chemistry, retrosynthetic analysis, concept of disconnection and synthons, analysis and planning of the forward synthesis, the concept of protecting groups, basics of stereoselective synthesis. Spectroscopic techniques as a tool for characterization and identification of organic compounds – UV, IR and 1H-NMR spectroscopy (one-dimensional). The practical aspects are primarily concerned to the qualitative analysis of single solid organic compounds: To critically evaluate the advantages and disadvantages of a variety of qualitative analysis methods and understanding the characteristics, roles and importance of qualitative research. Application of known organic reactions in identifying functional groups present and subsequent derivatization.
	CEMA-CC4-9-(TH+P)	The course can be divided into three parts. The first part deals with the application of thermodynamics with a distinct focus on the colligative properties and phase equilibrium. Phase diagrams deal with the state of matter of a substance at different temperatures and pressures. The second part embodies the rudimentary concepts of quantum mechanics, along with the physical interpretation of the wave function under the purview of Schrodinger wave equation. The concept of expectation value of energy and various operators with their respective applications also form a crucial part. Crystal structures highlighting the facts, such as, Bravais lattice, planes and specific heat also appear to be some enlightening topics at the interface of solid state physics.

	CEMA-CC4-10-(TH+P)	The prescribed curriculum in this semester primarily focuses on three broad domains: (i) Coordination Chemistry, (ii) Chemistry of d- and f- block elements and (iii) Reaction Kinetics and Mechanism. Coordination chemistry topic embodies all the theoretical aspects that can enable one student to understand the structure, bonding, electronic spectra, molecular magnetism and chemical reactivity of the coordination complexes. Since, the coordination complexes are abundant in nature and play vital roles in life sustaining processes, proper understanding of their chemical and physical behaviours is utmost essential for a student and that can be satisfactorily accomplished by this course structure. The d- and -f block elements, i.e., the transition metals and the inner-transition metals, comprise a rich chemistry of 58 elements of the periodic table. The chemistry of f-metals has been explored less compared to the d-metals due to an innate reluctance of forming covalent compounds by the former group. However, several applications of the 4f elements have made them promising candidates for laser and catalytic purposes. The beneficial impact of the industrial catalysis processes mediated by the transition metal compounds is also noteworthy, and an introduction in the realm of d- and f-block elements is simply worthy for the undergraduate students. Inorganic reaction mechanism is a subject of immense interest for the students. As the name suggests, the term 'mechanism' deals with several intermediate steps associated with an inorganic reaction. Since, the inorganic reactions are usually very fast, identifying the transition states and intermediates in any reaction profile is a daunting task. However, with the established theories, the reactions have been classified mechanistically. Knowledge in this particular aspect wills definite help a student to categorise new chemical reactions in terms of bond activation parameters. The practical part of this course is designed to introduce the students in the intriguing domain of inorganic complex synthesis. Synthesis is itself an art, and consciously practising that at this level, will definitely spur interest to the students and they can become successful synthetic chemist after an exposure to higher academics.
	CEMA-SEC-B3	After completion of the course, students will be able to understand the basic concept of drug administration, types of drugs, different phase of drug discovery. Rational design and development of lead compounds using modern computational techniques also form an part. They will learn the basic principles of synthesis, characterization and quantification of drugs. The fascinating and enthralling part is the understanding of the mechanism of actions of different types of drugs in physiological systems.
V (CBCS)	**CEMA-CC5-11-(TH+P)**	The first part explores the mathematical foundations of several facts of advanced quantum chemistry related to simple harmonic oscillator, angular momentum, hydrogen atom and hydrogen-like ions and LCAO approach. The course also focuses on statistical thermodynamics that provides a quantitative link between the properties of the microscopic particles and the behaviour of the bulk material. For a large number of particles, statistical thermodynamics is an extremely precise theory. It encompasses the equilibrium thermodynamics of the interacting and the noninteracting particles. The remaining part is the numerical analysis, which finds wide application in interdisciplinary science,

		and concerns the development and analysis of methods to compute numerical approximations to the solutions of mathematical problems.
	CEMA-CC5-12-(TH+P)	Information about the importance of polynuclear hydrocarbons and heterocyclic compounds containing one heteroatom, their synthesis and reactions. Conformational analysis of cyclohexane ring systems, case studies regarding substitution, elimination, rearrangement and oxidation reactions of cyclohexyl substrates. Frontier Molecular Orbital (FMO) analysis and synthetic importance of the three fundamental pericyclic processes – cycloaddition, electrocyclic reaction and sigmatropic rearrangements. Glycochemistry – structure, stereochemical aspects and reactions of monosaccharides up to hexoses, introduction to disaccharides. Detail concept of proteins and peptides – amino acids and their chemistry, formation of peptide bonds, structural hierarchy of proteins and their functions. Idea about the genetic material – deoxyribonucleic acids and ribonucleic acids, their building blocks – nucleotides and nucleosides, their reactions. The practical part highlights chromatographic separations: Basic theory of chromatography and hands-on training to set the column, TLC plates and papers for chromatographic separations; as well the spectroscopic analysis of known organic compounds: Assignment, identification and related explanation of IR, NMR signals to known organic compounds. In addition, discussion of elucidation of structure for organic compounds by IR, NMR spectral data using prototypical samples, also form an interesting part of the practical course.
	CEMA-DSE-A2	The topic computer programming basics, primarily deals with the first high-level FORTRAN programming language to facilitate the mathematical computations in science applications. Introduction to spreadsheet software is usually given to the students using Microsoft Excel, which is a spreadsheet program that is used to record and analyse numerical data. Statistical analysis deals with the science of collecting and analyzing data to identify trends and patterns and presenting them. Such applications of programming, handling various software, can eventually expose a student to compute the analytical solutions of a given problem.
	CEMA-DSE-A2	This discipline specific elective course primarily focuses on the structure, property, use and more importantly the synthesis of inorganic and organic materials having plethora of industrial applications. The subject matter broadly deals with silicates, fertilizers, surface coatings, batteries, alloys, catalysis, and chemical explosives. The course is designed in a way to ensure that the students come to know how the theoretical principles that they learn in different branches of chemistry are implemented in the industry. The practical part enables a student to determine the free acidity and calcium content of a fertiliser, metal composition of alloy, composition of an ore, and composition of cement.
VI (CBCS)	**CEMA-CC6-13-(TH+P)**	The course is composed of two versatile subjects: Bioinorganic chemistry and Organometallics. At the higher studies level there is no demarcation between chemical sciences and biological sciences. Both the sciences are in the same level. Therefore any chemistry honors student desiring to switch over to the Biological field in his future career, knowledge on bioinorganic field may serve as the fuel for him to cope up with biology related subject matter.

		Organometallics chemistry deserves immense importance in the context of industrial catalysis. Therefore, a knowledge over the aspects of metal-carbon bonding supported by ancillary ligands is worthwhile. A proper understanding of the stereo-electronic factors of organometallic complexes can eventually increase the cognitive power of a student to a different level. So long as organometallic chemistry is concerned, it is vital for the students choosing job in industrial field. The practical part focuses on the qualitative analysis of a mixture of inorganic salts. The module is highly effective in a sense that a student comes to know how to identify a specific radical in solution in presence of the others.
	CEMA-CC6-14-(TH+P)	After successful completion of the course, student would i) Understand various aspects of molecular spectroscopy. ii) Explain the basic principles of microwave, infrared, Raman Spectroscopy. iii) Understand principles and applications of electronic spectroscopy, fluorescence and phosphorescence, Jablonski diagram. iv) Understand laws of photochemistry, photochemical and biochemical processes, chemiluminescence, quantum yield. v) Understand the theory of reaction rate. vi) Discuss the theoretical basis of surface phenomenon, surface tension and surface energy; basic concept of adsorption and adsorption isotherms, heterogenous catalysis. vii) Describe different types of colloids, their properties and stability. viii) Explain the theoretical aspects of dipole moment and polarizability.
	CEMA-DSE-A3	Green chemistry is concerned with the environment pollution and its impact and also causes of environmental pollution such as depletion of natural resources, climate change, ozone depletion, heaps and heaps of landfills piling up. It also concern about the role of chemistry in environment pollution, development of environmentally efficient and benign reformations for conventional protocols. Green chemistry concepts such as twelve principles of green chemistry help to develop the basic understanding of toxicity, hazard and risk of chemical substances.
	CEMA-DSE-B4	It focuses the background of research motivation for the students. It is quite obvious that a certain percent of students always enter the research field after completion of post-graduate degree. This topic germinates the seed of research motivation in a student's tender mind.