Learning Outcome Based Curriculum (LOCF)

for

B.Sc. (Honours in Chemistry)

Undergraduate Programme (CBCS)

w.e.f. Academic Session 2020-21

Kazi Nazrul University
Asansol, West Bengal

Preamble

The objective of any programme at a Higher Education Institution is to create for its students a sound foundation for their character development which directly contributes to the well-being of a nation. Kazi Nazrul University envisions all its programmes in the spirit of its “motto” which is to inspire the youth to show steadfastness and devotion in a fearless pursuit of truth. The LOCF aims at preparing young minds for constructive and productive character development by honing their creative and humanistic skills for their own betterment as well as for the greater good of the society. In order to provide an opportunity to students to discover a method of thinking which will help them realise their true potential, the University offers a Learning Outcome-based Curriculum Framework (LOCF) for all its Under Graduate programmes.

The LOCF approach is intended to provide focused, outcome-based syllabi at the undergraduate level with an agenda to structure the teaching-learning experiences in a more student-centric manner by making the courses flexible and by offering students more choices. The LOCF approach has been adopted to strengthen the teacher-learner interaction as students engage themselves in programmes of their choice and learn to realize their inner calling. As the Under- Graduate Programmes focus on ‘preparing minds’, they will create individuals who will have intellectual prowess, interactive competence, courage to lead the world and also compassion and empathy for fellow human beings. The LOCF thus aims at strengthening not merely students’ employability skills but also at imparting to them vital life-skills required to lead a happy personal and social life.

Each programme vividly elaborates its nature and promises the outcomes that are to be accomplished by studying the courses. The programmes also state the attributes that they offer to inculcate at the graduation level. The graduate attributes encompass values related to students’ well-being, emotional stability, critical thinking etc. intermingled with a sense of social justice and harmony. In short, each programme prepares students for employability, sustainability and life-long learning. The new curriculum will empower students to innovate and also inspire them to convert their innovations into real business models for the country’s economic and social prosperity. The proposed LOCF offers better understanding of the business world and aims at building students’ entrepreneurial skills by giving them hands-on training. The Kazi Nazrul University hopes the LOCF approach of the programme will motivate students to transition from being passive knowledge-seekers to becoming active and aware knowledge-creators.

PART I

INTRODUCTION

Learning Outcomes based Curriculum Framework (LOCF) for Chemistry under CBCS

1. Introduction:

Quality higher education is always an important criterion for development of a nation. It includes innovations that can be useful for efficient governance of higher education institutions, systems and society at large. Thus, fundamental approach to learning outcome-based curriculum framework (LOCF) emphasizes upon demonstration of understanding, knowledge, skills, attitudes and values in particular programme of study. It is further expected to provide effective teaching – learning strategies including periodic review of the programme and its academic standard. The learning outcome-based curriculum framework for B.Sc. degree in Chemistry is intended to provide a broad framework and hence designed to address the needs of the students with chemistry as the core subject of study.

This curriculum framework for the bachelor-level program in Chemistry is developed keeping in view of the student centric learning pedagogy, which is entirely outcome-oriented and curiosity-driven. The platform aims at equipping the graduates with necessary skills for Chemistry-related careers and for higher education in Chemistry and allied subjects. It includes critical thinking, basic psychology, scientific reasoning, moral ethical reasoning and so on. While designing these frameworks, emphasis is given on the objectively measurable teaching-learning outcomes to ensure employability of the graduates. A major emphasis of these frameworks is that the curriculum focuses on issues pertinent to India and also of the west; for example, green chemistry and biomaterials etc. The major aims of it are:

1. To transform curriculum into outcome-oriented scenario.
2. To develop the curriculum for fostering discovery-learning.
3. To equip the students in solving the practical problems pertinent to India
4. To adopt recent pedagogical trends in education including e-learning, flipped class, hybrid learning and MOOCs
5. To mold responsible citizen for nation-building and transforming the country towards the future

2. Learning Outcome Based Curriculum:

Curriculum is the heart of any educational system. The Learning Outcomes-based Curriculum Framework (LOCF) for the B.Sc. (Hons.) degree in Chemistry provides a broad structural framework that can accommodate the current curricular needs as well as gives sufficient flexibility to include changes in content that assume importance as the frontiers of science grow. The inherent flexibility in framework allows design of course basket in tune with individual preferences. The basic uniformity in core course design ensures smooth movement across universities in the country.

2.i. Nature and extent of the B.Sc Chemistry Programme:

Chemistry is referred to as the science that systematically study the composition, properties, and reactivity of matter at atomic and molecular level. The scope of chemistry is very broad. The key areas of study of chemistry comprise Organic chemistry, Inorganic Chemistry, Physical Chemistry and Analytical Chemistry. Thus it covers a wide range of basic and applied courses as well as interdisciplinary subjects like nano-materials, biomaterials, etc.

2.ii. Aims of Bachelor's degree programme in Chemistry:

The aim of bachelor's degree programme in chemistry is intended to provide:

(i) Broad and balance knowledge in chemistry in addition to understanding of key chemical concepts, principles and theories.

(ii) To develop students' ability and skill to acquire expertise over solving both theoretical and applied chemistry problems.

(iii) To provide knowledge and skill to the students' thus enabling them to undertake further studies in chemistry in related areas or multidisciplinary areas that can be helpful for self-employment/entrepreneurship.

(iv) To provide the latest subject matter, both theoretical as well as practical, such a way to foster their core competency and discovery learning. A chemistry graduate as envisioned in this framework would be sufficiently competent in the field to undertake further discipline-specific studies, as well as to begin domain-related employment.

2.iii. Program Learning Outcomes:

The student graduating with the Degree B.Sc (Honours) Chemistry should be able to acquire:

(i) Systematic and coherent understanding of the fundamental concepts in Physical chemistry, Organic Chemistry, Inorganic Chemistry, Analytical Chemistry and all other related allied chemistry subjects.

(ii) Students will be able to use the evidence based comparative chemistry approach to explain the chemical synthesis and analysis.

(iii) The students will be able to understand the characateriziaton of materials.

(iv) Students will be able to understand the basic principle of equipments, instruments used in the chemistry laboratory.

(v) Students will be able to demonstrate the experimental techniques and methods of their area of specialization in Chemistry.

(vi) ***Disciplinary knowledge and skill***: A graduate student is expected to be capable of demonstrating comprehensive knowledge and understanding of both theoretical and experimental/applied chemistry knowledge in various fields of interest like Analytical Chemistry, Physical Chemistry, Inorganic Chemistry, Organic Chemistry, Material Chemistry, etc. Further, the student will be capable of using of advanced instruments and related soft-wares for in-depth characterization of materials/chemical analysis and separation technology.

(vii) ***Skilled communicator***: The course curriculum incorporates basics and advanced training in order to make a graduate student capable of expressing the subject through technical writing as well as through oral presentation.

(viii) ***Critical thinker and problem solver***: The course curriculum also includes components that can be helpful to graduate students to develop critical thinking ability by way of solving problems/numerical using basic chemistry knowledge and concepts.

(ix) ***Team player***: The course curriculum has been designed to provide opportunity to act as team player by contributing in laboratory, field based situation and industry.

(x) ***Skilled project manager***: The course curriculum has been designed in such a manner as to enabling a graduate student to become a skilled project manager by acquiring knowledge about chemistry project management, writing, planning, study of ethical standards and rules and regulations pertaining to scientific project operation.

2.iv Course Learning Outcomes:

In course learning outcomes, the student will attain subject knowledge in terms of individual course as well as holistically. The example related to core courses and their linkage with each other is stated below:

Programme Outcomes	**CC 1**	**CC 2**	**CC 3**	**CC 4**	**CC 5**	**CC 6**	**CC 7**	**CC 8**	**CC 9**	**CC 10**	**CC 11**	**CC 12**	**CC 13**	**CC 14**
Core competency	√	√	√	√	√	√	√	√	√	√	√	√	√	√
Critical thinking	√	√	√	√	√	√	√	√	√	√	√	√	√	√
Analytical reasoning	√	√	√	√	√	√	√	√	√	√	√	√	√	√
Research skills	√	√	√	√	√	√	√	√	√	√	√	√	√	√
Teamwork	√	√	√	√	√	√	√	√	√	√	√	√	√	√

Discipline Specific Elective (DSE):

Programme Outcomes	**DSE 1**	**DSE 2**	**DSE 3**	**DSE 4**	**DSE 5**	**DSE 6**
Core competency	√	√	√	√	√	√
Critical thinking	√	√	√	√	√	√
Analytical reasoning	√	√	√	√	√	√
Research skills	√	√	√	√	√	√
Teamwork	√	√	√	√	√	√

Skill Enhancement Electives (SEC):

Programme Outcomes	**SEC 1**	**SEC 2**	**SEC 3**	**SEC 4**
Core competency	√	√	√	√
Critical thinking	√	√	√	√
Analytical reasoning	√	√	√	√
Research skills	√	√	√	√
Teamwork	√	√	√	√

Generic Elective Courses (GE):

Programme Outcomes	**GE 1**	**GE 2**	**GE 3**	**GE 4**
Core competency	√	√	√	√
Critical thinking	√	√	√	√
Analytical reasoning	√	√	√	√
Research skills	√	√	√	√
Teamwork	√	√	√	√

The core courses would fortify the students with in-depth subject knowledge concurrently; the discipline specific electives will add additional knowledge about applied aspects of the program as well as its applicability in both academia and industry. Generic electives will introduce integration among various interdisciplinary courses. The skill enhancement courses would further add additional skills related to the subject as well as other than subject. In brief the student graduated with this type of curriculum would be able to disseminate subject knowledge along with necessary skills to suffice their capabilities for academia, entrepreneurship and Industry.

2.v Teaching Learning Outcomes:

The learning outcomes based course curriculum framework of Chemistry is designed to persuade the subject specific knowledge as well as relevant understanding of the course. The practical associated with this course helps to develop an important aspect of the teaching-learning process. Various types of teaching and learning processes will need to be adopted to achieve the same. The important relevant teaching and learning processes involved in this course are;

i. Class lectures
ii. Seminars
iii. Tutorials
iv. Group discussions and Workshops
v. Peer teaching and learning
vi. Question preparation
vii. Practicum, and project-based learning
viii. Substantial laboratory-based practical component and experiments
ix. Open-ended project work,
x. Technology-enabled learning

3. Attributes of a Chemistry Graduate:

Attributes of chemistry graduate under the outcome-based teaching-learning framework may encompass the following:

a. **Core competency:** The chemistry graduates are expected to know the fundamental concepts of chemistry and applied chemistry. These fundamental concepts would reflect the latest understanding of the field, and therefore, are dynamic in nature and require frequent and time-bound revisions.
b. **Communication skills:** Chemistry graduates are expected to possess minimum standards of communication skills expected of a science graduate in the country. They are expected to read and understand documents with in-depth analyses and logical arguments. Graduates are expected to be well-versed in speaking and communicating their idea/finding/concepts to wider audience
c. **Critical thinking:** Chemistry graduates are expected to know basics of cognitive biases, mental models, logical fallacies, scientific methodology and constructing cogent scientific arguments.
d. **Psychological skills:** Graduates are expected to possess basic psychological skills required to face the world at large, as well as the skills to deal with individuals and students of various sociocultural, economic and educational levels. Psychological skills may include feedback loops, self-compassion, self- reflection, goal-setting, interpersonal relationships, and emotional management.
e. **Problem-solving:** Graduates are expected to be equipped with problem-solving philosophical approaches that are pertinent across the disciplines;
f. **Analytical reasoning:** Graduates are expected to acquire formulate cogent arguments and spot logical flaws, inconsistencies, circular reasoning etc.
g. **Research-skills:** Graduates are expected to be keenly observant about what is going on in the natural surroundings to awake their curiosity. Graduates are expected to design a scientific experiment through statistical hypothesis testing and other *a priori* reasoning including logical deduction.
h. **Teamwork:** Graduates are expected to be team players, with productive co- operations involving

members from diverse socio-cultural backgrounds.

i. **Digital Literacy:** Graduates are expected to be digitally literate for them to enroll and increase their core competency via e-learning resources such as MOOC and other digital tools for lifelong learning. Graduates should be able to spot data fabrication and fake news by applying rational skepticism and analytical reasoning.

j. **Moral and ethical awareness:** Graduates are expected to be responsible citizen of India and be aware of moral and ethical baseline of the country and the world. They are expected to define their core ethical virtues good enough to distinguish what construes as illegal and crime in Indian constitution. Emphasis be given on academic and research ethics, including fair Benefit Sharing, Plagiarism, Scientific Misconduct and so on.

k. **Leadership readiness:** Graduates are expected to be familiar with decision- making process and basic managerial skills to become a better leader. Skills may include defining objective vision and mission, how to become charismatic inspiring leader and so on.

4. Qualification Descriptors:

The qualification descriptors for a Bachelor's degree in Chemistry may include following:

(i) Systematic and fundamental understanding of chemistry as a discipline.

(ii) Skill and related developments for acquiring specialization in the subject.

(iii) Identifying chemistry related problems, analysis and application of data using appropriate methodologies.

(iv) Applying subject knowledge and skill to solve complex problems with defined solutions.

(v) Finding opportunity to apply subject-related skill for acquiring jobs and self-employment.

(vi) Understanding new frontiers of knowledge in chemistry for professional development.

(vii) Applying subject knowledge for solving societal problems related to application of chemistry in day to day life.

(viii) Applying subject knowledge for sustainable environment friendly green initiatives.

(ix) Applying subject knowledge for new research and technology.

5. Assessment Methods:

Academic performance in various courses i.e. core, discipline electives, generic electives and skill enhancement courses are to be considered as parameters for assessing the achievement of students in Chemistry. A number of appropriate assessment methods of Chemistry will be used to determine the extent to which students demonstrate desired learning outcomes. Following assessment methodology should be adopted;

- The oral and written examinations (Scheduled and surprise tests),
- Closed-book and open-book tests,
- Problem-solving exercises,
- Practical assignments and laboratory reports,
- Observation of practical skills,
- Individual and group project reports,
- Efficient delivery using seminar presentations,
- *Viva voce* interviews are majorly adopted assessment methods for this curricullum.

Credit Distribution in Chemistry (Honours):

Sem	Core Course (14) of 6 Credits each	AEC (2) of 4/2 Credits each	GE (4) of 6 Credits each	DSE (4) of 6 Credits each	SEC (2) of 2 Credits each
I	Core 1	AECC1(Elective)	GE1		
	Core 2				
II	Core 3	AECC2(Elective)	GE2		
	Core 4				
III	Core 5		GE3		SEC1
	Core 6				
	Core 7				
IV	Core 8		GE4		SEC2
	Core 9				
	Core 10				
V	Core 11			DSE1	
	Core 12			DSE2	
VI	Core 13			DSE3	
	Core 14			DSE4	
No of credits	84	4 + 4	24	24	4+4
Total credits	148				

SEMESTER-I

Course Name: Inorganic Chemistry-I

Course Code: BSCHCEMC101

Course Type: **Core (Theoretical)**	Course Details: **CC-1**		L-T-P: **5-1-0**	
Credit: **6**	Full Marks: **50**	CA Marks		ESE Marks	
		Practical	Theoretical	Practical	Theoretical
		……	**10**	……	**40**

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

Learning objectives:

1. Atomic theory and its evolution.

2. Learning scientific theory of atoms, concept of wave function.

3. Elements in periodic table; physical and chemical characteristics, periodicity.

4. To predict the atomic structure, chemical bonding, and molecular geometry based on accepted models.

5. To understand atomic theory of matter, composition of atom.

6. Identity of given element, relative size, charges of proton, neutron and electrons, and their assembly to form different atoms.

7. Defining isotopes, isobar and isotone.

8. Physical and chemical characteristics of elements in various groups and periods according to ionic size, charge, etc. and position in periodic table.

9. Characterize bonding between atoms, molecules, interaction and energetics (ii) hybridization and shapes of atomic, molecular orbitals, bond parameters, bond- distances and energies.

10. Valence bond theory incorporating concepts of hybridization predicting geometry of molecules. 11. Importance of hydrogen bonding, metallic bonding.

Syllabus:

Unit-I: Atomic Structure

Bohr's theory, its limitations and atomic spectrum of hydrogen atom. Wave mechanics: 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. Contour boundary and probability diagrams. Pauli's Exclusion Principle, Hund's rule of maximum multiplicity, Aufbau's principle and its limitations, Variation of orbital energy with atomic number.

Unit – II: Periodicity of Elements

s, p, d, f block elements, the long form of periodic table. Detailed discussion of the following properties of the elements, with reference to s and p-block. (a) Effective nuclear charge, shielding or screening effect, Slater rules, variation of effective nuclear charge in periodic table. (b) Atomic radii (van'der Waals) (c) Ionic and crystal radii. (d) Covalent radii (octahedral and tetrahedral). (e) Ionization enthalpy, Successive ionization enthalpies and factors affecting ionization energy. Applications of ionization enthalpy. (f) Electron gain enthalpy, trends of electron gain enthalpy. (g) Electronegativity, Pauling, Mullikan, Allred Rachow scales, electronegativity and bond order, partial charge, hybridization, group electronegativity. Sanderson electron density ratio.

Unit – III: Chemical Bonding

(i) Ionic bond: General characteristics, types of ions, size effects, radius ratio rule and its limitations. Packing of ions in crystals. Born-Landé equation with derivation, expression for lattice energy. Madelung constant, Born-Haber cycle and its application, Solvation energy. (ii) Covalent bond: Lewis structure, Valence Shell Electron Pair Repulsion Theory (VSEPR), Shapes of simple molecules and ions containing lone-and bond-pairs of electrons multiple bonding, sigma and pi-bond approach, Valence Bond theory, (Heitler-London approach). Hybridization containing s, p and s, p, d atomic orbitals, shapes of hybrid orbitals, Bents rule, Resonance and resonance energy, Molecular orbital theory. Molecular orbital diagrams of simple homonuclear and heteronuclear diatomic molecules, MO diagrams of simple tri and tetra-atomic molecules, e.g., N_2, O_2, C_2, B_2, F_2, CO, NO, and their ions; HCl, BeF_2, CO_2 (idea of s-p mixing and orbital interaction to be given). Covalent character in ionic compounds, polarizing power and polarizability. Fajan rules, polarization. Ionic character in covalent compounds: Bond moment and dipole moment. ionic character from dipole moment and electronegativities.

Unit – IV: Metallic bonding and Weak chemical forces:

Metallic Bond: Qualitative idea of free electron model, Semiconductors, Insulators. (iv) Weak Chemical Forces: van'der Waals, ion-dipole, dipole-dipole, induced dipole dipole induced dipole interactions, Lenard-Jones 6-12 formula, hydrogen bond, effects of hydrogen bonding on melting and boiling points, solubility, dissolution.

Course Name: Organic Chemistry-I

Course Code: BSCHCEMC102

Course Type: **Core (Theoretical)**	Course Details: **CC-2**			L-T-P: **5-1-0**	
Credit: **6**	Full Marks: **50**	CA Marks		ESE Marks	
		Practical	Theoretical	Practical	Theoretical
		……	**10**	……	**40**

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

Learning objectives:

1. Basic of organic molecules, structure, bonding, reactivity and reaction mechanisms.

2. Stereochemistry of organic molecules – conformation and configuration, asymmetric molecules and nomenclature.

3. Aromatic compounds and aromaticity, mechanism of aromatic reactions.

4. Understanding hybridization and geometry of atoms, 3-D structure of organic molecules, identifying chiral centers.

5. Reactivity, stability of organic molecules, structure, stereochemistry.

6. Electrophile, nucleophiles, free radicals, electronegativity, resonance, and intermediates along the reaction pathways.

7. Mechanism of organic reactions (effect of nucleophile/leaving group, solvent), substitution vs. elimination.

Syllabus:

Unit – I: Basics of Organic Chemistry

Organic Compounds: Classification, and Nomenclature, Hybridization, Shapes of molecules, Influence of hybridization on bond properties. Electronic Displacements: Inductive, electromeric, resonance and mesomeric effects, hyperconjugation and their applications; Dipole moment; Organic acids and bases; their relative strength. Homolytic and Heterolytic fission with suitable examples. Curly arrow rules, formal charges; Electrophiles and Nucleophiles; Nucleophlicity and basicity; Types, shape and relative stabilities of reaction intermediates (Carbocations, Carbanions, Free radicals and Carbenes). Organic reactions and their mechanism: Addition, Elimination and Substitution reactions.

Unit – II: Stereochemistry

Concept of asymmetry, Fischer Projection, Newmann and Sawhorse projection formulae and their interconversions; 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, Diastereomers, meso structures, Racemic mixtures, Relative and absolute configuration: D/L and R/S designations.

Unit – III: Chemistry of Aliphatic Hydrocarbons

A. Carbon-Carbon sigma bonds

Chemistry of alkanes: Formation of alkanes, Wurtz Reaction, Wurtz- Fittig Reactions, Free radical substitutions: Halogenation - relative reactivity and selectivity.

B. Carbon-Carbon pi-bonds

Formation of alkenes and alkynes by elimination reactions, Mechanism of E^1, E^2, E1cb reactions. Saytzeff and Hofmann eliminations. Reactions of alkenes: Electrophilic additions their mechanisms (Markownikoff / Anti-Markownikoff addition), mechanism of oxymercuration, demercuration, hydroboration- oxidation, ozonolysis, reduction (catalytic and chemical), syn- and anti-hydroxylation (oxidation). 1, 2- and 1, 4- addition reactions in conjugated dienes and, Diels-Alder reaction; Allylic and benzylic bromination and mechanism, e.g. propene, 1-butene, toluene, ethyl benzene. Reactions of alkynes: Acidity, Electrophilic and Nucleophilic additions.

C. Cycloalkanes and Conformational Analysis

Cycloalkanes and stability, Baeyer strain theory, Conformation analysis, Energy diagrams of cyclohexane: Chair, Boat and Twist boat forms.

Unit – IV: Aromatic Hydrocarbons

Aromaticity: Huckel's rule, aromatic character of arenes, cyclic carbocations/carbanions and heterocyclic compounds with suitable examples. Electrophilic aromatic substitution: halogenation, nitration, sulphonation and Friedel-Craft's alkylation/acylation with their mechanism. Directing effects of substituent groups.

Course Name: Basics in Organic and Inorganic Chemistry

Course Code: BSCHCEMGE101

Course Type: **Core (Theoretical)**	Course Details: **GEC-1**		L-T-P: 5-**1-0**	
Credit: **6**	Full Marks: **50**	CA Marks		ESE Marks	
		Practical	Theoretical	Practical	Theoretical
		……	**10**	……	**40**

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

Learning objectives:

1. Atomic theory and its evolution.

2. Learning scientific theory of atoms, concept of wave function.

3. Elements in periodic table; physical and chemical characteristics, periodicity.

4. To predict the atomic structure, chemical bonding, and molecular geometry based on accepted models.

5. To understand atomic theory of matter, composition of atom.

6. Identity of given element, relative size, charges of proton, neutron and electrons, and their assembly to form different atoms.

7. Defining isotopes, isobar and isotone.

8. Physical and chemical characteristics of elements in various groups and periods according to ionic size, charge, etc. and position in periodic table.

9. Basic of organic molecules, structure, bonding, reactivity and reaction mechanisms.

10. Reactivity, stability of organic molecules, structure, stereochemistry.

11. Electrophile, nucleophiles, free radicals, electronegativity, resonance, and intermediates along the reaction pathways.

12. Mechanism of organic reactions (effect of nucleophile/leaving group, solvent), substitution vs. elimination.

Syllabus:

Unit – I: Atomic Structure

Bohr's theory: energy and radius calculations for H-like atoms, dual nature of matter and light, de Broglie's relationship, Heisenberg's uncertainty principle (qualitative), quantum numbers, Pauli exclusion principle, qualitative introduction of orbitals, shapes of orbitals, electron distribution of elements - Aufbau principle and Hund's rule.

Unit – II: Radioactivity

Theory of disintegration, rate constant, half life period (their interrelationship – deduction) idea of disintegration series, artificial transmutation and artificial radioactivity, uses and abuses of radioactivity. Stability of atomic nucleus, n/p ratio, mass defect, binding energy.

Unit – III: Periodic Table and Periodic Properties

Periodic law, Periodic classification of elements on the basis of electron distribution, s-, p- and d-block elements, connection among valencies, electron distribution and positions of the elements in the long form of the periodic table. Periodic properties: atomic radii, ionic radii, covalent radii, ionisation energy, electron affinity, electronegativity and its different scales.

Unit – IV: Functional Nature of Organic Compounds

Classification of organic compounds in terms of functional groups, their IUPAC nomenclature and valence bond structures.

Unit – V: Electron Displacement in Molecules

Concept of Inductive effect, Electromeric effect, Hyperconjugation, Resonance, Steric Inhibition of Resonance, Aromaticity and Tautomerism.

Unit – VI: Introduction to Organic Reaction Mechanism

Homolytic and heterolytic bond cleavage; Reaction intermediates: carbocation, carbanion, free radical (generation, shape, stability and reaction)

Classification of organic reactions (substitution, elimination, addition and rearrangement) and reagent types (electrophiles, nucleophiles, acids and bases), Ideas of organic reaction mechanism (SN^1, SN^2, E^1 and E^2) Aromatic electrophilic substitution mechanism, orientation and reactivity, bromine and HBr addition to alkenes mechanism

SEMESTER – II

Course Name: Physical Chemistry – I

Course Code: BSCHCEMC201

Course Type: **CORE**	Course Details: **CC-3**		L-T-P: **4-0-4**	
Credit: **6**	Full Marks: **100**	CA Marks	ESE Marks	
		Practical	Theoretical	Practical	Theoretical
		30	**10**	**20**	**40**

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

Learning objectives:

1. Familiarization with various states of matter.

2. Physical properties of each state of matter and laws related to describe the states.

3. Calculation of lattice parameters.

4. Electrolytes and electrolytic dissociation, salt hydrolysis and acid-base equilibria.

5. Understanding Kinetic model of gas and its properties.

6. Maxwell distribution, mean-free path, kinetic energies.

7. Behavior of real gases, its deviation from ideal behavior, equation of state, isotherm, and law of corresponding states.

8. Liquid state and its physical properties related to temperature and pressure variation.

9. Properties of liquid as solvent for various household and commercial use.

10. Solids, lattice parameters – its calculation, application of symmetry, solid characteristics of simple salts.

11. Ionic equilibria – electrolyte, ionization, dissociation.

12. Salt hydrolysis (acid-base hydrolysis) and its application in chemistry

Syllabus:

Unit – I: Properties of Gas

Idea of distribution functions, properties of gamma functions, Maxwell's speed and energy distributions in one-, two- and three- dimensions, distribution curves, different types of speeds and their significance, principle of equipartition of energy and its application to calculate the classical limit of molar heat capacity of gases

Collision of gas molecules, collision diameter, collision number and mean free path, frequency of binary collision in same and different molecules, wall collision and rate of effusion

Andrew's and Amagat's plots, compressibility factor, van der Waals equation and its features, critical constants and critical state, law of corresponding states, virial equation; significance of second virial coefficient, Boyle temperature, Dieterici equation and its features

Unit – II: Properties of Fluids

General features of fluid flow (streamline and turbulent flows) Reynolds number, nature of viscous drag for streamline motion, Newton's equation, viscosity coefficient, kinetic theory of gas viscosity, viscosity of gases vs liquids, Poiseuille's equation and its derivation, temperature dependence of viscosity, intrinsic viscosity, principle of determination of viscosity coefficients of liquids by Ostwald viscometer and falling sphere methods

Nature of the liquid state, vapour pressure, surface tension, surface energy, excess pressure, capillary rise and measurement of surface tension, condition of wetting, vapour pressure over a curved surface, temperature-dependence of surface tension, principle of determination of surface tension, concept of liquid crystals and super-fluids

Unit - III. Properties of Solid

Unit cell, Bravais lattice, crystal system, packing in cubic crystals, Miller indices, Bragg's equation and its applications, crystal structures of NaCl and KCl, Crystal defects

Unit – IV: Ionic Equilibria

Strong, moderate and weak electrolytes, degree of ionization, factors affecting degree of ionization, ionization constant and ionic product of water. Ionization of weak acids and bases, p^H scale, common ion effect; dissociation constants of mono-, di- and tri-protic acids
Ostwald's dilution law, pH, buffer solution and buffer capacity, Henderson equation, hydrolysis and hydrolysis constant of salts, indicators: acid-base and its function, Hammett acidity function

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Physical Chemistry-I Lab

1. Surface tension of a liquid/solution by drop-number method
2. Viscosity coefficient of a liquid/solution by Ostwald viscometer
3. p^H measurement of the different types of acid-base solutions

Course Name: Organic Chemistry-II

Course Code: BSCHCEMC202

Course Type: **CORE**	Course Details: **CC-4**			L-T-P: **4-0-4**	
Credit: **6**	Full Marks: **100**	CA Marks		ESE Marks	
		Practical	Theoretical	Practical	Theoretical
		30	**10**	**20**	**40**

After completion of the course, the learner shall be able to understand:

Learning objectives:

1. Familiarization about classes of organic compounds and their methods of preparation.

2. Basic uses of reaction mechanisms.

3. Name reactions, uses of various reagents and the mechanism of their action.

4. Preparation and uses of various classes of organic compounds.

5. Organometallic compounds and their uses.

6. Organic chemistry reactions and reaction mechanisms.

7. Use of reagents in various organic transformation reactions.

<u>Syllabus:</u>

Unit – I: Chemistry of Halogenated Hydrocarbons

Alkyl halides: Methods of preparation, nucleophilic substitution reactions – S_N^1, S_N^2 and S_N^i mechanisms with stereochemical aspects and effect of solvent etc.; nucleophilic substitution vs. elimination.

Aryl halides: Preparation, including preparation from diazonium salts. nucleophilic aromatic substitution; SN^{Ar}, Benzyne mechanism. Relative reactivity of alkyl, allyl/benzyl, vinyl and aryl halides towards nucleophilic substitution reactions. Organometallic compounds of Mg and Li and their use in synthesis.

Unit – II: Alcohols, Phenols, Ethers and Epoxides

Alcohols: preparation, properties and relative reactivity of 1°, 2°, 3° alcohols, Bouvaelt-Blanc Reduction; Preparation and properties of glycols: Oxidation by periodic acid and lead tetraacetate, Pinacol-Pinacolone rearrangement.

Phenols: Preparation and properties; Acidity and factors effecting it, Ring substitution reactions, Reimer–Tiemann and Kolbe–Schmidt Reactions, Fries and Claisen rearrangements with mechanism.

Ethers and Epoxides: Preparation and reactions with acids. Reactions of epoxides with alcohols, ammonia derivatives and $LiAlH_4$

Unit – III: Carbonyl Compounds

Structure, reactivity and preparation; Nucleophilic additions, Nucleophilic addition-elimination reactions with ammonia derivatives with mechanism; Mechanisms of Aldol and Benzoin condensation, Knoevenagel condensation, Claisen-Schmidt, Perkin, Cannizzaro and Wittig reaction, Beckmann and Benzil-Benzilic acid rearrangements, haloform reaction and Baeyer Villiger oxidation, α-substitution reactions, oxidations and reductions (Clemmensen, Wolff Kishner, $LiAlH_4$, $NaBH_4$, MPV, PDC and PGC); Addition reactions of unsaturated carbonyl compounds: Michael addition. Active methylene compounds: Keto-enol tautomerism. Preparation and synthetic applications of diethyl malonate and ethyl acetoacetate.

Unit – IV: Carboxylic Acids and their Derivatives

Preparation, physical properties and reactions of monocarboxylic acids: Typical reactions of dicarboxylic acids, hydroxy acids and unsaturated acids: succinic/phthalic, lactic, malic, tartaric, citric, maleic and fumaric acids; Preparation and reactions of acid chlorides, anhydrides, esters and amides; Comparative study of nucleophilic substitution at acyl group -Mechanism of acidic and alkaline hydrolysis of esters, Claisen condensation, Dieckmann and Reformatsky reactions, Hofmann bromamide degradation and Curtius rearrangement

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Organic Chemistry-II Lab

Qualitative analysis of organic compound:

A. Study on Physical Properties: Physical State, Colour, odour, acid-base character, ignition, solubility and melting point
B. Detection of special elements (N, S, Cl) by Lassaigne's test.
C. Detection of functional group: – COOH, – OH (Phenolic), – COOR, Carbonyl group, (aldehydic and ketonic), >C=C< (unsaturation), – NH_2, – NO_2, – $CONH_2$ and CONHAr (anilido)
D. Preparation of a suitable derivative of one functional group present in the sample.

Course Name: Elementary Physical Chemistry & Organic Chemistry

Course Code: BSCHCEMGE201

Course Type: **GE**	Course Details: GEC-**2**		L-T-P: **4-0-4**	
Credit: **6**	Full Marks: **100**	CA Marks		ESE Marks	
		Practical	Theoretical	Practical	Theoretical
		30	**10**	**20**	**40**

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

Learning objectives:

1. *Understanding Kinetic model of gas and its properties.*
2. *Maxwell distribution, mean-free path, kinetic energies.*
3. *Behavior of real gases, its deviation from ideal behavior, equation of state, isotherm, and law of corresponding states.*
4. *Laws of thermodynamics and concepts.*
5. *Partial molar quantities and its attributes.*
6. *Dilute solution and its properties.*
7. *Understanding the concept of system, variables, heat, work, and laws of thermodynamics.*
8. *Understanding the concept of heat of reactions and use of equations in calculations of bond energy, enthalpy, etc.*
9. *Understanding the concept of entropy; reversible, irreversible processes.*
10. *Understanding the application of thermodynamics: Joule Thomson effects*
11. *Stereochemistry of organic molecules – conformation and configuration, asymmetric molecules and nomenclature.*
12. *Aromatic compounds and aromaticity, mechanism of aromatic reactions.*
13. *Understanding 3-D structure of organic molecules, identifying chiral centers.*

Syllabus:

Unit – I: Kinetic Theory of Gases

Ideal gas equation, derivation of gas laws, Maxwell's speed and energy distributions (derivation excluded); distribution curves; different types of speeds and their significance, concept of equipartition principle, van der Waals equation, Virial equation, continuity of state, Boyle temperature, critical constants, specific heats and specific ratios, laws of partial pressure, vapour density and density method of determination of molecular weights, limiting density, abnormal vapour density, frequency of binary collisions; mean free path

Unit – II: Thermodynamics

Thermal equilibrium and zeroth law, First law, reversible and irreversible work, criteria of perfect gas, isothermal and adiabatic expansions, Joule-Thomson effect (derivation excluded); Thermochemistry: Hess's law and its application

Second law and its elementary interpretation, Carnot's cycle and theorems, Clausius inequality, criteria of spontaneity, free energy and entropy

Unit – III: Stereochemistry

Concept of constitution, configuration and conformation, chirality and chiral centre, optical activity, optical rotation, specific rotation, optical purity enantiomerism and diastereomerism, optical isomerism of lactic acid and tartaric acid, D, L and R, S nomenclature;

Geometrical isomerism with reference to fumaric acid and maleic acid; cis-trans and E, Z nomenclature; Conformational analysis of ethane.

Organic Qualitative Practical (Lab)

Detection of elements (N, S, Cl) and any one of the following groups in organic compounds (solid only): $-NH_2$, $-NO_2$, $-CONH_2$, -OH, >C=O, -CHO, -COOH

SEMESTER – III

Course Name: Inorganic Chemistry – II

Course Code: BSCHCEMC301

<table>
<tr><td>Course Type: CORE</td><td>Course Details: CC-5</td><td colspan="2"></td><td colspan="2">L-T-P: 4-0-4</td></tr>
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<tr><td>30</td><td>10</td><td>20</td><td>40</td></tr>
</table>

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

Learning objectives:

1. *Understanding coordination compounds – its nomenclature, and various types of ligands*
2. *Concept of Valence Bond Theory and its applications and drawbacks*
3. *Different types of isomerism (both geometrical and optical) in coordination chemistry*
4. *Understanding chelate effect, macrocyclic effect and their relation with the stability of the complex*
5. *Application of coordination complexes*
6. *Various concepts of acids and bases*
7. *Different factors favouring acid-base strength*
8. *Understanding HSAB concepts and relate to application in chemistry*
9. *Concepts of other non-aqueous solvents*
10. *Chemistry, reactivity and various properties of s- and p-block elements*
11. *Hands on experience on the identifications of various acid and basic radicals and qualitative estimation of radicals from a mixture of salts*

Syllabus:

Unit – I: Coordination Chemistry-I: Bonding in Coordination Compounds (Preliminary Concept) and Properties of Coordination Compounds

Werner’s Coordination theory, different types of ligands, metal chelates, IUPAC nomenclature of coordination compounds, electronic theory of complex compounds, effective atomic number (EAN) and its limitations, Valence bond theory in coordination compounds: different geometry, outer and inner orbital complexes, magnetic criterion of bond type, Principle of electroneutrality of atoms, limitations of VBT.

Stereochemistry, Coordination number, factors favouring low and high coordination numbers, isomerism (ionization, hydrate, ligand, linkage, coordination, geometrical and optical etc.) in coordination compounds, concept of Stability constant (stepwise and overall), chelate effect, macrocyclic effect and macro-polycyclic effect, application of coordination complexes in chemical analysis.

Unit – II: Acids and Bases

Brönsted Lowry’s concept, cosolvating agents, differentiating and leveling effect, Theory of solvent system, Lux-Flood concept, Lewis concept- Stability of the adduct (Drago-Wayland equation), change of bond length parameter in adduct formation, -acidity of the ligands, synergistic effect, Usanovich’s concept.

Strength of hydracids and oxyacids, different factors in determining acid-base strength: steric effects (B- and F-strain), salvation, H-bonding;

Hard and Soft acid base (HSAB) principle: classification and characteristic, hardness and frontier molecular orbital (FMO), electronegativity and hardness and softness, symbiosis, theoretical back ground, Non-aqueous solvent (liq. NH_3, liq. SO_2).

Unit-III: Chemistry of s and p Block Elements

General properties of s- and p-block elements, Comparative account of physical and chemical properties of the s and p-block elements, the diagonal relationship, variation of electronic configuration, elemental forms, metallic nature, magnetic properties (if any), catenation properties (if any), hydrides, halides, oxides, oxy-acids (if any), inert pair effect (if any), complex chemistry (if any) in respect of the following elements

(i) S-block elements: Li-Na-K, Be-Mg-Ca-Sr-Ba.

(ii) P-block elements: B-Al-Ga-In-Tl, C-Si-Ge-Sn-Pb, N-P-As-Sb-Bi, O-S-Se-Te, F-Cl-Br-I, He-Ne-Ar-Kr-Xe

Properties and reactions of important compounds

(i) Structure, bonding and reactivity of B_2H_6; $(SN)_x$ with x = 2, 4; phosphazines; interhalogens.

(ii) Structure of borates, silicates, polyphosphates, borazole, boron nitride, silicones, thionic acids.

(iii) Reactivity of polyhalides, pseudo halides, fluorocarbons, freons and NO_x with environmental effects.

(iv) Chemistry of hydrazine, hydroxylamine, N^{3-}, thio- and per-sulphates

Compounds of Noble Gases: Occurrence and uses, rationalization of inertness of noble gases, Clathrates; preparation and properties of XeF_2, XeF_4 and XeF_6; Bonding in noble gas compounds (Valence bond and MO treatment for XeF_2), Shapes of noble gas compounds (VSEPR theory).

Inorganic Chemistry – II Lab

Qualitative analysis

Qualitative analysis of mixtures containing not more than four radicals from among the following:

Basic Radicals: Silver, lead, mercury, bismuth, copper, cadmium, arsenic, antimony, tin, iron, aluminium, manganese, chromium, nickel, cobalt, zinc, calcium, strontium, barium, sodium, potassium

Acid Radicals: Chloride, bromide, iodide, bromate, iodate, silicate, fluoride, arsenite, arsenate, phosphate, nitrite, nitrate, sulphide, sulphite, thiosulphate, sulphate, borate, ferro/ferri-cyanide, chromate, dichromate

Insoluble Materials: Al_2O_3, Fe_2O_3, Cr_2O_3, SnO_2, $SrSO_4$, $BaSO_4$, CaF_2.

Course Name: Organic Chemistry – III

Course Code: BSCHCEMC302

Course Type: **CORE**	Course Details: CC-**6**		L-T-P: **4-0-4**	
Credit: **6**	Full Marks: **100**	CA Marks		ESE Marks	
		Practical	Theoretical	Practical	Theoretical
		30	**10**	**20**	**40**

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

Learning objectives:

1. *Will have knowledge about Nitrogen containing functional groups and their reactions in various aspects*

2. *Familiarization with polynuclear hydrocarbons and their reactions*
3. *Heterocyclic compounds and their reactions*
4. *Understanding reactions and reaction mechanism of nitrogen containing functional groups*
5. *Understanding the reactions and mechanisms of diazonium compounds*
6. *Understanding the structure and their mechanism of reactions of selected polynuclear hydrocarbons*
7. *Understanding the structure, mechanism of reactions of selected heterocyclic compounds*
8. *Name reactions, uses of various reagents and the mechanism of their action*
9. *Various organometallic chemistry in organic transformations*
10. *Hands on experience of various organic molecule identifications*

Syllabus:

Unit - I: Nitrogen Compounds

Preparation and important reactions of aliphatic and aromatic nitro compounds, nitriles and isonitriles; Amines: Basicity; Preparations: Gabriel's phthalimide synthesis, Carbylamine reaction, Mannich reaction, Hofmann bromoamide degradation, reductive amination; Properties: Hoffmann's exhaustive methylation, Hofmann-elimination reaction; Distinction between 1°, 2° and 3° amines with Hinsberg reagent and nitrous acid; nitrophenols, amionophenols, nitro anilines, amino carboxylic acids. Diazomethane, Diazonium salts: Preparation and synthetic applications.

Unit – II: Heterocyclic Compounds

Saturated heterocycles: Structures and synthetic approaches and reactivities of oxiranes, aziridines; oxaziranes, diaziridines and diazirines; oxitanes, azatidanes and thietanes.

Five-membered aromatic heterocycles: General synthetic approaches, properties and reactions of furans, pyrroles and thiophenes.

Six membered aromatic heterocycles: General synthetic approaches, properties and reactions of pyridine and its derivatives.

Condensed heterocycles: General synthetic approaches, properties and reactions of indole, quinoline and isoquinoline.

Unit – III: Polynuclear Hydrocarbons

Preparations, Properties and Reactions of naphthalene, phenanthrene and anthracene

Unit - IV: Rearrangements, Name Reactions & Organometallics

Rearrangements:

Rearrangement to electron-deficient carbon: Wagner-Meerwein rearrangement, pinacol rearrangement, dienone-phenol; Wolff rearrangement in Arndt-Eistert synthesis, benzil-benzilic acid rearrangement, Demjanov rearrangement, Tiffeneau–Demjanov rearrangement.

Rearrangement to electron-deficient nitrogen: rearrangements: Hofmann, Curtius, Lossen, Schmidt and Beckmann.

Rearrangement to electron-deficient oxygen: Baeyer-Villiger oxidation, cumene hydroperoxidephenol rearrangement and Dakin reaction.

Rearrangement in Aromatic system: Fries rearrangement and Claisen rearrangement.

Migration from nitrogen to ring carbon: Hofmann-Martius**,** Sommelet Houser**,** Fischer-Hepp, Bamberger, Orton and benzidine rearrangement.

Name Reactions

Birch, Von Richter, Houben-Hoesch, Arndt-Eistert homologation, HVZ, Hunsdiecker, Oppenaur, Sandmeyer, Stephen and Williamson's ether synthesis.

Organometallics

Preparation and reactions: Grignard reagent; Organolithiums; addition of Grignard and organolithium to carbonyl compounds; abnormal behavior of Grignard reagents; *ortho* lithiation of arenes; Gilman cuprates: substitution on -COX; conjugate addition by Gilman cuprates; Corey-House synthesis; Reformatsky reaction; Blaise reaction.

Organic Chemistry – III Lab

Identification with general reaction and tests of the following compounds:

a) Methyl alcohol, b) Ethyl alcohol, c) Acetone, d) Formic acid, e) Acetic acid, f) aniline, g) Nitro benzene, h) Tartaric acid, i) Succinic acid, j) Salicylic acid, k) Glucose, l) Resorcinol

Course Name: Physical Chemistry – II

Course Code: BSCHCEMC303

Course Type: CORE	Course Details: CC-7			L-T-P: **4-0-4**	
Credit: **6**	Full Marks: **100**	CA Marks		ESE Marks	
		Practical	Theoretical	Practical	Theoretical
		30	**10**	**20**	**40**

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

Learning objectives:

1. *First Law of thermodynamics and concepts.*
2. *Understand the concept of system, variables, heat, work, and their relations.*
3. *Concept of heat of reactions and use of equations in calculations of bond energy, enthalpy, etc.*
4. *Understand the basics of chemical kinetics: determination of order, molecularity, theories of reaction rates, determination of rate of opposing/parallel/chain reactions with suitable examples, application of steady state kinetics, Steady-state approximation.*
5. *Basic principle of laws of electrochemistry.*
6. *Concept of ion atmosphere.*
7. *Application of conductance measurement.*
8. *Adsorption – theory and significance.*
9. *Langmuir, Freundlich – adsorption isotherms, significance.*
10. *Understand the colloids and different types of electrokinetic phenomena, concept of micelles.*
11. *Concepts of electrical properties of molecules and different types of intermolecular forces.*
12. *Practical experience on kinetics and solubility product related experiments*

Syllabus:

Unit – I: Thermodynamics I

Basic formalism, concept of thermal equilibrium and zeroth law of thermodynamics, state and path functions, partial derivatives and cyclic rule, concept of heat and work, reversible and irreversible processes, graphical representation of work done.

First law, U and H as state functions, concept of C_P and C_V and their relations, Joule's experiment and its consequence, isothermal and adiabatic processes, calculations of *q*, *w*, *U* and *H* for reversible, irreversible and free expansion of gases (ideal and van der Waals) under isothermal and adiabatic conditions.

Thermochemistry: Kirchoff's equation, heat changes during physicochemical processes at constant P/V, bond dissociation energies, Born-Haber's cycle.

Unit – II: Chemical Kinetics –I

Introduction, reaction rate and extent of reaction, order and molecularity; kinetics of zero, first, second, fractional and pseudo-first order reactions; determination of order of reaction, opposing, consecutive and parallel reactions (first order), concept of steady state and rate determining step, chain reaction: elementary idea, illustrations with H_2-Br_2 and H_2-O_2 reactions. Temperature dependence of reaction rate, Arrhenius equation.

Unit – III: Electrochemistry

Conductance and its measurement, cell constant, specific and equivalent conductances, their variations with dilution for strong and weak electrolytes, molar conductance, transport number and determination by Hittorf methods, Moving Boundary methods, Kohlrausch's law, Walden's rule, ion conductance and ionic mobility, application of conductance measurement (determination of solubility product and ionic product of water), conductometric titrations.

Ion atmosphere, asymmetry and electrophoretic effects, Wien effect and Debye-Falkenhagen effect, Activity and activity coefficients of electrolyte/ion in solution, Debye-Hückel theory, Debye-Hückel limiting law (with derivation), solubility equilibrium and influence of common and indifferent ions.

Unit – IV: Interface & Dielectrics

Special feature of interfaces, physical and chemical adsorptions, Langmuir and Freundlich adsorption isotherms, surface excess and Gibbs adsorption isotherms, heterogeneous catalysis (single reactant).

Electrical double layers, zeta potential, overvoltage, Stern double layer (qualitative idea), Tyndall effect, electrokinetic phenomena (qualitative idea), colloids and electrolytes, micelle and reverse micelle, critical micelle constant (CMC).

Electrical properties of molecules, polarizability, induced and orientation polarization, Debye and Clausius-Mossotti equations (without derivation) and their applications.

Origin and types of intermolecular forces, different types of potential and their diagrams.

Physical Chemistry-II Lab

1. Kinetics of decomposition of H_2O_2 by potassium iodide.
2. Solubility/solubility product of Mg-carbonate in presence/absence of common ions and/or neutral electrolytes.

Course Name: Physical Chemistry & Inorganic Chemistry
Course Code: BSCHCEMGE301

Course Type: **GE**	Course Details: **GEC-3**		L-T-P: **4-0-4**	
Credit: **6**	Full Marks: **100**	CA Marks		ESE Marks	
		Practical	Theoretical	Practical	Theoretical
		30	**10**	**20**	**40**

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

Learning objectives:

1. *Basic concept of phase rule in a binary liquid mixture*
2. *Basic knowledge about colligative properties of solutions*
3. *Introduction on electrochemistry, electrochemical cell formation, electrode potentials*
4. *Concepts about conductance, transport number, limiting law*
5. *1st and 2nd order kinetics of chemicals reaction*
6. *Information about catalysis and catalyst*
7. *Some idea about acid-base chemistry*
8. *Concepts of ionic equilibria*

Syllabus:

Unit – I: Phase Equilibria and Colligative Properties

Phase rule equation (derivation excluded); phase diagram of water system, Miscibility (phenol-water) and distillation of completely miscible binary liquid mixtures; azeotropes, Steam distillation

Graphical approach of Raoult's law of vapour pressure and colligative properties: osmosis, lowering of freezing point, elevation of boiling point, experimental methods of determination of molecular weights of substances in dilute solutions, van't Hoff 'i' factor and abnormal behaviour of electrolytic solutions

Unit – II: Electrochemistry

Electrolytic conduction, transport number (experimental determination excluded), velocity of ions: specific, equivalent and molar conductances, determination of equivalent conductivity of solutions, Kohlrausch's law, strong and weak electrolytes, Ion atmosphere; electrophoretic and relaxation effects, Debye-Huckel theory (qualitative) and the limiting law.

Electrochemical cells, half-cells (with types and examples), Nernst equation and standard electrode potentials, standard cells

Unit – III: Chemical Kinetics

Order and molecularity of reactions, integrated rate laws (first and second order), average life period, concept of Arrhenius activation energy

Catalysis, autocatalysis, enzyme catalyst, catalyst poisons, promoters, elementary treatment of mechanism of catalysis.

Unit – IV: Chemical and Ionic Equilibrium

Conditions of spontaneity and equilibrium, degree of advancement and Le Chatelier principle; Van't Hoff isotherm, isobar and isochore

Ostwald dilution law, Henderson equation, neutralization and acid-base indicators, buffers, common ion effect, solubility product (application in analytical chemistry)

Inorganic Qualitative Practical (Lab)

Detection of three radicals by analysis of mixture containing not more than three radicals from the following list (insoluble salts excluded)

Silver, lead, mercury, bismuth, copper, cadmium, arsenic, antimony, tin, iron, aluminium, chromium, zinc, manganese, cobalt, nickel, calcium, strontium, barium, magnesium, sodium, potassium, ammonium and their oxides, hydroxides, chlorides, bromides, iodides, sulphates, sulphites, sulphides, thiosulphates, chromates, phosphates, nitrites, nitrates and borates.

Course Name: Industrial Chemistry
Course Code: BSCHCEMSE301

Course Type: **SEC (Theoretical)**	Course Details: **SEC-1**		L-T-P: 4-**0-0**	
Credit: 4	Full Marks: **50**	CA Marks		ESE Marks	
		Practical	Theoretical	Practical	Theoretical
		…….	**10**	…….	**40**

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

Learning objectives:

1. *Understanding to the chemistry of paints, varnishes and dyes*
2. *Preparation and uses of various compounds including $KMnO_4$, CaC_2, alloy steels etc.*
3. *Understanding the chemistry of ceramics*
4. *Concepts of corrosion: cause and prevention*
5. *Various fire-extinguishers and their chemical contents*

Syllabus:

Unit - I: Paints

Paints, Varnishes and Synthetic Dyes: Primary constituents of a paint, binders and solvents for paints. Oil based paints, latex paints, baked-on paints (alkyd resins). Constituents of varnishes. Formulation of paints and varnishes. Synthesis of Methyl orange, Congo red, Malachite green, Crystal violet.

Unit - II: Electrochemical and Electro-thermal Industries

Preparation and use of Potassium permanganate, hydrogen peroxide, synthetic graphite, calcium carbide, carborundum, alloy steels

Unit - III: Ceramics

Refractories, pottery, porcelain, glass, fibre glass

Unit - IV: Rusting of Iron and Steel

Cause and prevention of corrosion

Unit - V: Industrial Safety and Fire Protection

Flash point, fire extinguishers – foam, carbon dioxide, sprinkler system, inert gases.

Course Name: Pharmaceutical Chemistry
Course Code: BSCHCEMSE302

<table>
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50</td><td colspan="2">CA Marks</td><td colspan="2">ESE Marks</td></tr>
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<tr><td>………</td><td>10</td><td>………</td><td>40</td></tr>
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On completion of this course, the students will be able to understand:

Learning objectives:

1. *Understanding of different drug design and discoveries*
2. *Different classes of drugs and their examples*
3. *Some knowledge about aerobic and anaerobic fermentation chemistry*
4. *Some idea about production of various drug related components*

Syllabus:

Unit – I: Drugs & Pharmaceuticals

Drug discovery, design and development; Basic Retrosynthetic approach. Synthesis of the representative drugs of the following classes: analgesics agents, antipyretic agents, anti-inflammatory agents (Aspirin, paracetamol, lbuprofen); antibiotics (Chloramphenicol); antibacterial and antifungal agents (Sulphonamides; Sulphanethoxazol, Sulphacetamide, Trimethoprim); antiviral agents (Acyclovir), Central Nervous System agents (Phenobarbital, Diazepam), Cardiovascular (Glyceryl trinitrate), antilaprosy (Dapsone), HIV-AIDS related drugs (AZT- Zidovudine).

Unit – II: Fermentation

Aerobic and anaerobic fermentation. Production of (i) Ethyl alcohol and citric acid, (ii) Antibiotics; Penicillin, Cephalosporin, Chloromycetin and Streptomycin, (iii) Lysine, Glutamic acid, Vitamin B2, Vitamin B12 and Vitamin C.

SEMESTER – IV

Course Name: Inorganic Chemistry – III

Course Code: BSCHCEMC401

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<tr><td>30</td><td>10</td><td>20</td><td>40</td></tr>
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On completion of this course, the students will be able to understand:

Learning objectives:

1. *Coordination compounds – Crystal field theory, and some preliminary idea about Ligand Field Theory*
2. *Concept of Jahn-Teller Distortion and application to the Z-in and Z-out chemistry*
3. *Explanation about the origin of colour of complexes*
4. *Concepts of magnetic properties of the complexes*
5. *d- block chemistry including 1st, 2nd and 3rd row transition elements on their various oxidations state, magnetic properties, complex formation etc.*
6. *f-block chemistry including both lanthanides and actinides.*
7. *Concepts of Lanthanide contraction, abnormal electronic configuration and magnetic properties and their chemistry*
8. *Introductory idea about inorganic reaction mechanism, labile-inert complex, reaction mechanism on various substitution reaction, trans-/cis-effect and its consequences etc.*
9. *Hands on experience on the preparations of some inorganic complexes*

Syllabus:

Unit - I: Coordination Chemistry-II: Crystal Field Theory; Magnetochemistry: Origin of Colours in Transition Metal Compounds

Crystal field theory: Splitting of d-orbitals in different geometries (octahedral, tetrahedral and square planar), crystal field stabilization energy (CFSE), Jahn-Teller distortion, low-spin and high-spin complexes, pairing energy, factors affecting 10Dq value, critical 10 Dq value. Origin of colour in coordination complexes: L-S coupling, ground state terms, selection rules, Orgel diagrams, charge transfer spectra (preliminary idea), limitations of CFT, nephelauxetic effect, introduction to LFT, spectrochemical series.

Magnetochemistry: Different types (dia-, para-, ferro- and antiferro-magnetic), orbital and spin magnetic moment, spin only moments of d_n ions, super exchange and antiferromagnetic interactions (simple examples); stabilization of unusual oxidation states of metal centres

Unit - II: Chemistry of d and f Block Elements

d-Block elements: general comparison of 3d, 4d and 5d elements with special reference to electronic configuration, variable valency, ability to form coordination complexes, spectral magnetic catalytic properties

f-Block Elements: comparison of the general properties (e.g. electronic configuration, oxidation state, variation in atomic and ionic (3+) radii, complex formation, magnetic and spectral properties) of lanthanides and actinides, f-contraction, similarities between the later actinides and the later lanthanides, spectral properties (in comparison with the d-block elements), isolation and occurrence, use of the metals, principle of separation of lanthanides, chemistry of separation of Np, Pu and Am from U

Chemistry of some representative compounds: $K_2Cr_2O_7$, $KMnO_4$, Prussian blue, Turnbull's blue, $K_4[Fe(CN)_6]$, $K_2[Ni(CN)_4]$, H_2PtCl_6, $Na_2[Fe(CN)_5NO]$, Millon's Base, Ruthenium red, Magnus green salt, Reinecke's salt

Unit - III Inorganic Substitution Reaction Mechanism

Labile and inert complexes, various factors on reaction rate, substitution reaction on square planer complexes, tetrahedral, octahedral (preliminary concept), trans-effect, cis-effect (preliminary concept) in square planar complexes

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Inorganic Chemistry – III Lab

Preparation Chrome alum, Mohr's salt, Cuprommonium sulphate, Sodium nitroprusside, hexamine cobalt(III) chloride, tris(ethane 1,2-ammine) nickel(III) chloride

Preparation of acetylacetanato complexes of Cu^{2+}/Fe^{3+} (also find the λ_{max} of the prepared complex using instrument).

Course Name: Organic Chemistry – IV

Course Code: BSCHCEMC402

Course Type: **CORE**	Course Details: **CC-9**		L-T-P: **4-0-4**	
Credit: **6**	Full Marks: **100**	CA Marks	ESE Marks	
		Practical	Theoretical	Practical	Theoretical
		30	**10**	**20**	**40**

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

Learning objectives:

1. *Alkaloids and Terpenes*
2. *Classification, structure, mechanism of reactions of few selected alkaloids and terpenes*
3. *Understanding principle of UV-Vis spectroscopy, IR Spectroscopy, NMR spectroscopy, Mass spectrometry and their applications.*
4. *Various pericyclic reactions*
5. *Carbohydrate chemistry mostly monosaccharides and few examples of disaccharides and polysaccharides*

Syllabus:

Unit - I: Alkaloids & Terpenoids

Natural occurrence; Isolation; General structural features and their physiological properties, Hoffmann's exhaustive methylation, Emde's degradation, Structure elucidation and synthesis of piperine, ephedrine and coniine; Medicinal properties of nicotine, hygrine, quinine, and cocaine. Occurrence; Classification; Isoprene rule; Isolation; Elucidation of structure and synthesis of Citral, Nceral and α-Terpineol.

Unit - II: Organic Spectroscopy

UV Spectroscopy: Electromagnetic radiation, Lambert-Beer law, electronic transitions, λ_{max} & ε_{max}, chromophore, auxochrome, bathochromic, hypsochromic hyperchromic and hypochromic shifts. Effect of solvent on λ_{max} & ε_{max}; Application of electronic spectroscopy and Woodward-Fiser rules for calculating λ_{max} of acyclic and cyclic conjugated dienes and α, β–unsaturated carbonyl compounds.

IR Spectroscopy: Hooke's law, stretching and bending vibrations, characteristic and diagnostic stretching frequencies, factors affecting stretching frequencies (H-bonding, electronic factor, ring size), finger-print region, diagnostic bending frequencies for benzene and its *o*-, *m*- and *p*-isomers.

NMR (1H NMR) Spectroscopy: Principle, nuclear spin, NMR-active nuclei, chemically equivalent and nonequivalent protons; chemical shift, upfield and downfield shifts; shielding/deshielding of protons in systems involving C-C, C=O, C=C, benzene, cyclohexane; spin-spin splitting with reference to CH_3CH_2Br, CH_3CH2OH, Br_2CHCH_2Br; characteristic ^{1}H NMR signals for simple molecules.

Mass Spectrometry: Elementary idea and fragmentation rule in characterization of organic compounds.

Unit – III: Pericyclic reactions

Mechanism, stereochemistry, regioselectivity in case of

Electrocyclic reactions: FMO approach involving 4π- and 6π-electrons (thermal & photochemical) and corresponding cyclo-reversion reactions, Woodward-Hofmann selection rules.

Cycloaddition reactions: FMO approach, Diels-Alder reaction, Alder ene reaction, photochemical [2+2]cycloadditions.

Sigmatropic reactions: FMO approach, sigmatropic shifts and their order; [1,3]- and [1,5]-H shifts and [3,3]-shifts with reference to Claisen and Cope rearrangements.

Unit – IV: Carbohydrates

Monosaccharides: Aldoses up to 6 carbons; structure of D-glucose & D-fructose (configuration & conformation); ring structure of monosaccharides (furanose and pyranose forms): ring-size determination, Haworth representations and non-planar conformations; anomeric effect (including stereoelectronic explanation); mutarotation; epimerization; reactions (mechanisms in relevant cases): osazone formation, bromine-water oxidation, HNO_3 oxidation, selective oxidation of terminal –CH2OH of aldoses, reduction to alditols, Lobry de Bruyn-van Ekenstein rearrangement; stepping–up (Kiliani-Fischer method) and stepping–down (Ruff's & Wohl's methods) of aldoses; end-group-interchange of aldoses; acetonide (isopropylidene) and benzylidene protections; Configuration of (+) glucose.

Disaccharides: Concept of glycosidic linkages, structure of sucrose, inversion of cane sugar.

***Polysaccharides*:** Elementary idea about starch and cellulose.

Organic Chemistry – IV (Lab)

Quantitative analysis of organic compounds.

Estimation of: 1. Glucose by Fehling's solution, 2. Acetone, 3. Aniline

Course Name: Physical Chemistry – III

Course Code: BSCHCEMC403

Course Type: **CORE**	Course Details: **CC-10**			L-T-P: **4-0-4**	
Credit: **6**	Full Marks: **100**	CA Marks		ESE Marks	
		Practical	Theoretical	Practical	Theoretical
		30	**10**	**20**	**40**

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

Learning objectives:

1. Second Law of thermodynamics and concepts.

2. Understand the concept of entropy; reversible, irreversible processes.

3. Learn the application of thermodynamics: Joule Thompson effects, partial molar quantities.

4. Understanding about electrodes, EMF measurement, chemical cells and their function.

5. Learn the working of electrochemical cells, galvanic cell.

6. Qualitative idea about potentiometric titrations and their applications.

7. Understand the collision theory and transition state theory for any reaction.

8. Concepts of phases, components, degrees of freedom, Gibb's phase rule and its applications, construction of phase diagram of different systems, the application of phase diagram.

9. Understand phase equilibrium, criteria, CST, Duhem-Margules equation.

10. Concepts of four colligative properties, their interrelations and applications.

Syllabus:

Unit – I: Thermodynamics II & Application

Second law of thermodynamics and its need, Kelvin, Planck and Clausius statements and their equivalence, Carnot cycle and refrigerator, Carnot's theorem, thermodynamic scale of temperature.

Physical concept of entropy, Clausius inequality, entropy change of system and surroundings for various processes and transformations, entropy change during isothermal mixing of ideal gases, entropy and unavailable work, auxiliary state functions (G and A) and their variations with T, P and V, criteria of spontaneity and equilibrium.

Thermodynamic relations, Maxwell relations, thermodynamic equation of state, Gibbs-Helmholtz equation and its consequence, Joule-Thomson (J-T) experiment inversion temperature, J-T coefficient for a van der Waals gas, general heat capacity relations.

Additivity rule, partial molar quantities, chemical potential and its variation with T and P, Gibbs-Duhem equation, fugacity of gases and fugacity coefficient.

Unit – II: Electrochemical Cells

Electrochemical cells, half cells/electrodes with types and examples, cell reactions and thermodynamics of cell reactions, Nernst equation, standard cells, calomel, Ag/AgCl, quinhydrone and glass electrodes: features and applications, potentiometric titrations (acid base and redox), concentration cells (with and without transference), liquid junction potential.

Unit – III: Chemical kinetics –II

Collision theory of bimolecular reactions, unimolecular reactions, Lindemann theory, transition state theory, free energy and entropy of activation, pressure-dependence of rate constant, primary kinetic salt effect.

Types of catalyst, specificity and selectivity, Homogeneous catalysis, with reference to acid base and enzyme catalyses, heterogeneous catalysis.

Unit – IV: Phase Equilibria & Colligative Properties

Definition of phase, component and degree of freedom, phase rule and its derivation, phase diagram, phase equilibria for one-component system: water and carbon dioxide, first order phase transition and Clapeyron equation, Clausius-Clapeyron equation: derivation and applications.

Liquid-vapour equilibrium for two-component systems, Duhem-Margules equation, Henry's law, Konowaloff's rule, deviation from ideal behavior, azeotropic solution, liquid-liquid phase diagrams for phenol-water, triethylamine-water and nicotine-water systems, solid-liquid phase diagram, eutectic mixture, congruent and incongruent melting points, Nernst distribution law, solvent extraction.

ΔG, ΔS, ΔH and ΔV of mixing for binary solutions, vapour pressure of solution, ideal solutions, colligative properties, Raoult's law; ebullioscopy, cryoscopy and osmosis (thermodynamic treatment only): inter relationships and abnormal behavior in solution, van't Hoff *i*-factor.

Physical Chemistry-III Lab

1. Equilibrium constant of the reaction $KI + I_2 = KI_3$ by partition method.
2. Conductometric titrations of an acid or a base (acid may be monobasic/dibasic, and similarly for the base)
3. Potentiometric titrations of an acid or a base (acid may be monobasic/dibasic, and similarly for the base)

Course Name: Inorganic Chemistry & Organic Chemistry
Course Code: BSCHCEMGE401

Course Type: **GE**	Course Details: **GEC-4**			L-T-P: **4-0-4**	
Credit: **6**	Full Marks: **100**	CA Marks		ESE Marks	
		Practical	Theoretical	Practical	Theoretical
		30	**10**	**20**	**40**

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

Learning objectives:

1. *Characterize bonding between atoms, molecules, interaction and energetics*
2. *Hybridization and shapes of atomic, molecular orbitals, bond parameters, bond- distances.*
3. *Concepts of acids and bases*
4. *Electrolytes and electrolytic dissociation, salt hydrolysis*
5. *Salt hydrolysis (acid-base hydrolysis) and its application in chemistry.*
6. *Understanding redox reactions*
7. *Understanding the preparation methods of few organic compounds*

Syllabus:

Unit – I: Chemical Forces and Molecular Structure

Ionic bond, covalent bond (octet rule and expanded octet), dative bond, deformation of ions and Fajan's rules, Born-Haber cycle, hydrogen bond: intra- and intermolecular, bond polarity and dipole moment. Bond lengths, bond angles and qualitative description of shapes of some simple molecules like CO_2, SO_2, H_2O, $BeCl_2$, BF_3, NH_3, CH_4, C_2H_4, C_2H_2, C_6H_6.

Unit – II: Acids, Bases and Buffers

Different concept of acids and bases, ionic product of water, salt hydrolysis, pH and its colorimetric determination, Strengths of strong and weak acids and bases.

Unit – III: Oxidation and Reduction

Electronic concepts, oxidation number, ion-electron method of balancing equations, application of redox reactions, idea of standard potential and formal potential. Derivation of thermodynamic quantities of cell reactions (ΔG, ΔH and ΔS).

Unit – IV: Organic Synthesis

Preparation and synthetic uses of diethyl malonate, ethylacetoacetate and Grignard reagents

Preparation of TNT phenyl acetic acid, salicylic acid, cinnamic acid, sulphanilic acid, phenyl hydrazine, nitrophenols, nitroanilines, picric acid glycerol, allyl alcohol, citric acid.

Inorganic Quantitative (Lab)

a. Titration of Na_2CO_3 + $NaHCO_3$ mixture vs HCl using phenolphthalein and methyl orange indicators
b. To find the total hardness of water by EDTA titration
c. Titration of ferrous iron by $KMnO_4/K_2Cr_2O_7$
d. Titration of ferric iron by $KMnO_4/K_2Cr_2O_7$ using $SnCl_2$ reduction

Course Name: Mathematics and Statistics for Chemists
Course Code: BSCHCEMSE401

Course Type: **SEC(Theoretical)**	Course Details: **SEC-2**		L-T-P: 4-**0-0**	
Credit: 4	Full Marks: **50**	CA Marks	ESE Marks	
		Practical	Theoretical	Practical	Theoretical
		………	**10**	…….	**40**

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

Learning objectives:

1. Understand different mathematical functions.
2. Learn about mathematical probability and correlations.
3. Concepts of sampling and analysis of data.

Syllabus:

Unit - I: Introduction

Functions, limits, derivative, physical significance, basic rules of differentiation, maxima and minima, applications in chemistry, Error function, Gamma function, exact and inexact differential, Taylor and McLaurin series, Fourier series and Fourier Transform, Laplace transform, partial differentiation, rules of integration, definite and indefinite integrals.

Unit - II: Differential equations & Probability

Separation of variables, homogeneous, exact, linear equations, equations of second order, series solution method. Permutations, combinations and theory of probability

Unit - III: Vectors, matrices and determinants

Vectors, dot, cross and triple products, introduction to matrix algebra, addition and multiplication of matrices, inverse, adjoint and transpose of matrices, unit and diagonal matrices.

Course Name: Fuel Chemistry
Course Code: BSCHCEMSE402

Course Type: **SEC (Theoretical)**	Course Details: **SEC-2**		L-T-P: **4-0-0**	
Credit: 4	Full Marks: **50**	CA Marks		ESE Marks	
		Practical	Theoretical	Practical	Theoretical
		……..	**10**	………	**40**

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

Learning objectives:

1. *Concepts of different renewable and non-renewable energy sources*
2. *Understanding the Coal as a fuel*
3. *Fractionation of coal tar and coal liquification*
4. *Other non-petroleum fuels and their production and uses*
5. *Understanding of various petrochemicals and their uses*
6. *Concepts of lubricants and their various properties*

Syllabus:

Unit – I: Energy Sources

Review of energy sources (renewable and non-renewable). Classification of fuels and their calorific value. Coal: Uses of coal (fuel and nonfuel) in various industries, its composition, carbonization of coal. Coal gas, producer gas and water gas—composition and uses. Fractionation of coal tar, uses of coal tar bases chemicals, requisites of a good metallurgical coke, Coal gasification (Hydro gasification and Catalytic gasification), Coal liquefaction and Solvent Refining.

Unit – II: Petroleum and Petrochemical Industry

Composition of crude petroleum, Refining and different types of petroleum products and their applications. Fractional Distillation (Principle and process), Cracking (Thermal and catalytic cracking), Reforming Petroleum and non-petroleum fuels (LPG, CNG, LNG, bio-gas, fuels derived from biomass), fuel from waste, synthetic fuels (gaseous and liquids), clean fuels. Petrochemicals: Vinyl acetate, Propylene oxide, Isoprene, Butadiene, Toluene and its derivatives Xylene.

Unit – III: Lubricants

Classification of lubricants, lubricating oils (conducting and non-conducting) Solid and semisolid lubricants, synthetic lubricants. Properties of lubricants (viscosity index, cloud point, pore point) and their determination.

SEMESTER – V

Course Name: Organic Chemistry – V

Course Code: BSCHCEMC501

Course Type: Core	Course Details: CC-11		L-T-P: **4-0-4**	
Credit: **6**	Full Marks: **100**	CA Marks		ESE Marks	
		Practical	Theoretical	Practical	Theoretical
		30	**10**	**20**	**40**

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

Learning objectives:

1. Understandings of different types of biomolecules, e.g, amino acids. proteins, nucleic acids etc, synthesis and properties of these biomolecules.

2. Knowledge of structure of DNA

3. Concepts of reactions and mechanism of metabolism in human body system

4. Information and use of some pharmaceutical compounds

5. Knowledge of different types of organic synthesis

Syllabus:

Unit I: Biomolecules

Amino acids: Classification, physical properties, concept of isoelectric point and its determination, electrophoresis, synthesis with mechanistic details: Strecker, Gabriel, acetamido malonic ester, azlactone, Bücherer hydantoin, chemical properties (with mechanism): ninhydrin reaction, Dakin-West reaction; resolution of racemic amino acids; Estimation of amino acids by Sorensen formol titration.

Proteins: peptide linkage and its geometry; syntheses (with mechanistic details) of peptides using *N*-protection & C-protection, solid-phase peptide (Merrifield) synthesis; sequence of aminoacids in peptide: *C*-terminal and *N*-terminal unit determination (Edman, Sanger & 'dansyl' methods); partial hydrolysis; Concept of primary, secondary and tertiary structure of proteins, classification of proteins, denaturation of proteins.

Nucleic acids: pyrimidine and purine bases (only structure & nomenclature); nucleosides and nucleotides corresponding to DNA and RNA; mechanism for acid catalysed hydrolysis of nucleosides (both pyrimidine and purine types); comparison of alkaline hydrolysis of DNA and RNA; elementary idea of double helical structure of DNA (Watson-Crick Model); complimentary base–pairing in DNA.

Unit II: Bioenergetics

Introduction to metabolism (catabolism, anabolism). ATP: The source of cellular energy, ATP hydrolysis and free energy change. Electron transfer process in biological redox systems: NAD^+, FAD. Conversion of food to energy: Outline of catabolic pathways of carbohydrateglycolysis, fermentation, Krebs cycle; catabolic pathways of protein and fat; Caloric value of food, standard caloric content of food types.

Unit III: Pharmaceutical Compounds

Classification, structure and therapeutic uses of antipyretics: Paracetamol (with synthesis), Analgesics: Ibuprofen (with synthesis), Antimalarials: Chloroquine (with synthesis). An elementary treatment of Antibiotics and detailed study of chloramphenicol, Medicinal values of curcumin (haldi), azadirachtin (neem), vitamin C and antacid (ranitidine).

Unit IV: Synthetic Methodology

Features of organic synthesis, *Retrosynthetic analysis:* disconnections; concept of synthons and synthetic equivalents, donor and acceptor synthons; illogical electrophiles and nucleophiles, natural reactivity and*umpolung*; synthesis involving umpolung strategy, latent polarity in bifunctional compounds: consonant and dissonant polarity; interconversion and addition of functional groups (FGI and FGA); functional group removal (FGA); C-C disconnections and synthesis: one-group and two-group (1,2- to 1,5-dioxygenated compounds), reconnection (1,6-dicarbonyl. Synthesis involving enolates and enamines with special reference to diethyl malonate and ethyl acetoacetate; Robinson annelation; synthesis through protection of functional groups (alcohol, amine, carbonyl, acid) Strategy of ring synthesis*:* thermodynamic and kinetic factors; synthesis of large rings, application of high dilution technique. Concept and examples of cascade reaction.

Synthesis using second row elements

Concept of yilides, organic synthesis involving sulphur and phosphours.

Organic Chemistry – V Lab,

Preparation -

1. Condensation : *preparation of phthalimide*
2. Nitration : *nitration of nitro benzene and acetanilide*
3. Oxidation : *Oxidisation of benzyl alcohol*
4. Hydrolysis : *hydrolysis of amide*
5. Rearrangement reaction : *Benzil-benzilic acid rearrangement*

Course Name: Inorganic Chemistry – IV

Course Code: BSCHCEMC502

Course Type: Core	Course Details: CC-12		L-T-P: 4-**0-4**	
Credit: **6**	Full Marks: **100**	CA Marks		ESE Marks	
		Practical	Theoretical	Practical	Theoretical
		30	**10**	**20**	**40**

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

Learning objectives:

1. Concepts of redox potentials and redox titrations.

2. Understandings of radioactivity and stability of any nucleus.

3. Knowledge of radio carbon dating.

4. *Concepts of organometallic compounds, their preparations nomenclature and properties.*

Syllabus:

Unit-I: Redox Potential and Redox Equilibria

Some basic aspects of redox reactions, equivalent weights of oxidants and reductants, ion-electron method of balancing redox reactions, complimentary and noncomplimentary redox reactions, overpotential, electron and atom transfer in redox reactions,

Standard redox potentials, sign convention, Nernst equation, electrochemical series, formal potential and its importance in analytical chemistry; Redox potential: effect of complex formation, effect of precipitation, effect of P^H change, EMF Diagram (Latimer, Frost and Pourbaix), thermodynamic aspects of disproportionation and comproportionation reactions, redox potential and equilibrium constants, redox titration and redox indicators, function of Zimmermann Reinhardt (ZR) solution

Unit-II: Nuclear Chemistry

Nuclear Stability: neutron-proton ratio and Segre's chart, modes of decay and neutron-proton ratio, packing fraction, mass defect and nuclear binding energy, magic number; Radioactive decay, units of radioactivity, different modes of decay, half-life and average-life of radioelements, radioactive equilibrium, natural radioactive disintegration series, principles of determination of age of rocks and minerals, radio carbon dating, disintegration series (Naturally occurring), group displacement law, artificial radioactivity, types of nuclear reactions (n, p, α, d and γ), reaction cross-section, compound nucleus theory and nuclear reactions, nuclear fission, fusion reaction and spallation, nuclear energy and power generation, application of radioactivity in analytical chemistry

Radiation chemistry: Elementary ideas of radiation chemistry, radiolysis of water and aqueous solutions, unit of radiation chemical yield (G-value), radiation dosimetry (Fricke's dosimeter), units of radiation energy (Rad, Gray, Sievert)

Unit-III: Organometallic Compounds

Definition, a brief history, nomenclature, classification, importance of organometallic compounds as reagents, additives and catalysts, effective atomic number rule (18 electron rule), counting of electrons preparation, properties and bonding in - carbonyl, nitrosyl and cyanide complexes; IR-results as diagnostic tools in the identification of nature of bonding in such -acid complexes, metal-olefin complexes: Zeise's salt (preparation, structure and bonding), ferrocene (preparation, structure and reactions), heptacity of organometallic ligands and their examples, different types of reaction (elementary idea): oxidative addition, reductive elimination, insertion.

Inorganic Chemistry – IV Lab

Volumetric analysis: Redox titrations- permanganometry, dichromatometry, iodometry and iodimetry Volumetric analysis of mixtures involving not more than two different estimations: Fe + Cu, Fe + Cr, Fe + Ca, Ca + Ba, Ca + Mg etc.

Course Name: Green Chemistry

Course Code: BSCHCEMDSE501

Course Type: DSE	Course Details: DSEC-1 or 2		L-T-P: 5-**1-0**
		CA Marks	ESE Marks

Credit: **6**	Full Marks: **50**	Practical	Theoretical	Practical	Theoretical
		----	**10**	----	**40**

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

Learning objectives:

1. To inspire the students about the chemistry which is good for human health and environment.
2. To make students aware of how chemical processes can be designed, developed and run in a sustainable way.
3. To acquire the knowledge of the twelve principles of green chemistry and how to apply in green synthesis.
4. *To make students aware about the benefits of using green chemistry.*

Syllabus:

Unit - I: Introduction to Green Chemistry

What is Green Chemistry? Need for Green Chemistry. Goals of Green Chemistry. Limitations/ Obstacles in the pursuit of the goals of Green Chemistry

Unit – II: Principles of Green Chemistry and Designing a Chemical synthesis

Twelve principles of Green Chemistry with their explanations and examples and special emphasis on the following: Designing a Green Synthesis using these principles; Prevention of Waste/ byproducts; maximum incorporation of the materials used in the process into the final products, Atom Economy, calculation of atom economy of the rearrangement, addition, substitution and elimination reactions. Prevention/ minimization of hazardous/ toxic products reducing toxicity. risk = (function) hazard exposure; waste or pollution prevention hierarchy. Green solvents– supercritical fluids, water as a solvent for organic reactions, ionic liquids, fluorous biphasic solvent, PEG, solventless processes, immobilized solvents and how to compare greenness of solvents. Energy requirements for reactions – alternative sources of energy: use of microwaves and ultrasonic energy. Selection of starting materials; avoidance of unnecessary derivatization – careful use of blocking/protecting groups. Use of catalytic reagents (wherever possible) in preference to stoichiometric reagents; catalysis and green chemistry, comparison of heterogeneous and homogeneous catalysis, biocatalysis, asymmetric catalysis and photocatalysis.

Unit – III: Examples of Green Synthesis/ Reactions and some real world cases

1. Green Synthesis of the following compounds: adipic acid, catechol, disodium iminodiacetate (alternative to Strecker synthesis)
2. Microwave assisted reactions in water: Hofmann Elimination, methyl benzoate to benzoic acid, oxidation of toluene and alcohols; microwave assisted reactions in organic solvents Diels-Alder reaction and Decarboxylation reaction
3. Ultrasound assisted reactions: sonochemical Simmons-Smith Reaction (Ultrasonic alternative to Iodine)

Course Name: Environmental Chemistry

Course Code: BSCHCEMDSE502

Course Type: DSE	Course Details: DSEC-1 or 2		L-T-P: 5-**1-0**
		CA Marks	ESE Marks

Credit: **6**	Full Marks: **50**	Practical	Theoretical	Practical	Theoretical
		----	**10**	----	**40**

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

Learning objectives:

1. Concepts of different sphere and and layers of earths atmosphere.

2. To make students aware of different toxic chemicals and how they spoils the environment.

3. Knowledge of toxicity of different chemicals and impact on environment.

Syllabus:

Unit-I: The Atmosphere

Composition and structure of the atmosphere: troposphere, stratosphere, mesosphere and thermosphere, ozone layer and its role; major air pollutants : CO, SO_2, NO and particulate matters –their origins and harmful effects, problems of ozone layer depletion, green house effect, acid rain and photochemical smog, air pollution episodes, air quality standard, air pollution control measures: cyclone collector, electrostatic precipitator, catalytic converter, detection, collection and principles of estimation of CO, NOx, SO2, H2S and SPM in air samples

Unit-II: Aspects of Environmental Inorganic Chemistry

Atmospheric stability and temperature inversion, greenhouse effect, global warming and cooling, ozone depletion and involved chemical reactions, the disaster of endosulfan in kasargod in kerala, smog formation, acid rain, eutrophication in natural water bodies, Minamata disease, Bhopal disaster, hazard of nuclear disaster (Chernobyl and Fukushima Daiichi), nuclear disaster management

Unit-III: The Hydrosphere

Water pollutants: action of soaps and detergents, phosphates, industrial effluents, agricultural runoff, domestic wastes; thermal pollution radioactive pollution and their effects on animal and plant life, water pollution episodes, waste water treatment: chemical treatment and microbial treatment; water quality standards: DO, BOD, COD, TDS and hardness parameters, desalination of sea water: reverse osmosis, electro dialysis, detection and estimation of As, Hg, Cd, Pb, Cr, NH_4 and F , NO_3 , NO_2 in water sample

Unit-IV: The Lithosphere and Pollution control

Soil pollution and control measures, biochemical effects of As, Pb, Cd, Hg, Cr, and their chemical speciation, monitoring and remedial measures; noise pollution, agricultural and industrial pollution, green solution to various environmental hazards

Course Name: Solid State Chemistry

Course Code: BSCHCEMDSE503

Course Type: DSE	Course Details: DSEC-1 or 2		L-T-P: **5-1-0**	
Credit: **6**	Full Marks: **50**	CA Marks		ESE Marks	

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

Learning objectives:

1. Basic knowledge of structure of solids and crystal structure

2. Concepts of laws of crystallography and designation of crystal planes

3. Knowledge of different types of bonding in crystals.

4. Concepts of superconductor, semiconductors, transistors etc

Syllabus:

Unit-I: Basic Concepts and selected structure

Some basic crystal geometries: simples cube (sc), body centred cube (bcc), face centred cube (fcc), diamond cube (dc), close packing models: hexagonal close packing (hcp) (ABAB… type), cubic close packing (ccp) (ABCABC… type), tetrahedral and octahedral holes, packing efficiency Structural inferences (Simple) from crystallochemical parameters; Structure of Ionic Crystals: ABtype (i.e NaCl, CsCl and {ZnS,(sphelarite and wurtzite)}, AB_2 type (CaF_2, SiO_2 and TiO_2), Ilmenite and perovskite (ABO_3), spinel (AB_2O_4)

Unit-II: Crystallographic Basics

Crystal, Steno's Law, Hauy's Law (law of rational intercepts), law of constancy of symmetry, Weiss indices, Miller's indices, Unit cell, Bravis Lattice, Crystal systems, crystal class, Bragg's equation with derivation, methods of crystal analysis, application of Bragg's equation, crystal structure of sodium chloride and potassium chloride, Lattice vector and reciprocal lattice vector.

Unit-III: Chemical Bonding in Solids

Energetics of ionic bond formation and concept of lattice energy (thermodynamic basis), Born-Lande equation, Kapustinski equation, controlling factors of lattice energy. Ionic radii (Pauling's crystal and univalent radii, Shannon's crystal radii), Pauling's rules for ionic crystals, general properties of metals: free electron theory of metallic bonding (qualitative treatment), band theory and electrical properties of solids (qualitative idea), intrinsic and extrinsic semiconductor with examples from main group elements, alloys and intermetallic compounds: Hume-Rothery rules, electron compounds, basics in liquid crystals.

Unit-IV: Properties of Solids

Crystal defects: thermodynamics aspect of defects, stoichiometric and nonstoichiometric, point defects, Schottky and Frenkel, color centers, dislocations, conductor, semiconductor, insulator in the light of band theory, n–type, p–type, semiconductors, transistor, semiconductor Hall effect and Hall co-efficient; superconductivity in solids, ferroelectricity.

SEMESTER – VI

Course Name: Inorganic Chemistry – V

Course Code: BSCHCEMC601

<table>
<tr><td>Course Type: Core</td><td>Course Details: CC-13</td><td colspan="4">L-T-P: 4-0-4</td></tr>
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<tr><td>Practical</td><td>Theoretical</td><td>Practical</td><td>Theoretical</td></tr>
<tr><td>30</td><td>10</td><td>20</td><td>40</td></tr>
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On completion of this course, the students will be able to understand:

Learning objectives:

1. Students acquire knowledge of role of metal ions in our biological systems and mechanisms of action of drugs in our body system.

2. Basic knowledge of analytical chemistry

3. Concept of extraction and purification process of compounds

4. Knowledge of different chromatography techniques

5. Knowledge of Polymer chemistry

Syllabus:

Unit-I: Bioinorganic Chemistry

Essential metals: role of metal ions in biological systems (specially Na^+, K^+, Mg^{2+}, Ca^{2+}, $Fe^{3+/2+}$, $Cu^{2+/+}$, and Zn^{2+}) and in different metalloproteins and metalloenzymes, metal ion transport across biological membrane, Na+- ion pump, ionophores, biological functions of hemoglobin and myoglobin, cytochromes and ferredoxins, carbonate bicarbonate buffering system and carbonicanhydrase, biological nitrogen fixation, photosynthesis: photosystem-I and photosystem-II, metal dependent disease, detoxification by chelation therapy for Pb and As poisoning

Important metal complexes in medicines (Examples only), antimicrobial activity, antiarthritic gold complexes, anticancer compounds (Pt-complexes and metallocenes), lithium therapy in psychiatric mind disorder

Unit-II: Introduction to Analytical Chemistry

Errors in chemical analysis: accuracy, precision, determinate, indeterminate, systematic and random errors; source, effect and detection of systematic errors; distribution of random errors; standard deviation of calculated results- sum or difference, product or quotient, significant figures, rounding and expressing results of chemical computations.

Solvent extraction, distribution ratio, principle of solvent extraction, extraction equilibrium and effect of PH; application in analytical chemistry.

Chromatography

Techniques: Classification, principle and efficiency of the technique.

Mechanism of separation: adsorption, partition & ion exchange. Development of chromatograms: frontal, elution and displacement methods. Qualitative and quantitative aspects
of chromatographic methods of analysis using LC, TLC.

Unit-III Catalytic Inorganic Reaction

Wilkinson, Zigler-Natta catalyst

Unit-IV Polymer

Polymers: Basic concept, structure and types of plastics, polythene, polystyrene, phenol-formaldehydes, PVC; manufacture, Number and weight average molecular weights of polymers – significance, physical properties and uses of natural rubber, synthetic rubber, synthetic fibres: Nylon-66, polyester.

Inorganic Chemistry –V Lab

1. Complexometric Titration:

$CaCO_3$ and $MgCO_3$ in mixture; Mg2+ and Zn2+ in mixture.

2. Gravimetric Analysis:

(i) Estimation of nickel (II) using Dimethylglyoxime as the precipitant.

(ii) Estimation of copper as CuSCN.

(iii) Estimation of iron as Fe_2O_3 after precipitating iron as $Fe(OH)_3$ and Heating at elevated temperature etc

3. Ion-exchanger: Cation content of a sample by cation exchanger

4. Solvent extraction

Course Name: Physical Chemistry – IV

Course Code: BSCHCEMC602

Course Type: Core	Course Details: CC-14		L-T-P: **4-0-2**	
Credit: **6**	Full Marks: **100**	CA Marks		ESE Marks	
		Practical	Theoretical	Practical	Theoretical
		30	**10**	**20**	**40**

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

Learning objectives:

1. Understand the equilibrium on the basis of thermodynamic parameters.

2. Understand the Le Chatelier's principle from thermodynamics.

3. Concepts of thermodynamic probability and relation with entropy.

4. Calculation of entropy using 3rd law of thermodynamics.

5. Concepts of partition functions.

6. Understanding the symmetry and group theory.

7. Learn about limitations of classical mechanics and solution in terms of quantum mechanics for atomic/molecular systems.

8. Develop an understanding of quantum mechanical operators, quantization, probability distribution, uncertainty principle.

9. Knowledge of the laws of absorption of light energy by molecules and the subsequent photochemical reactions.

10. Interpret rotational and vibrational spectra and know about their application.

Syllabus:

Unit – I: Chemical Equilibrium

Thermodynamic condition of equilibrium, degree of advancement of reaction and Le Chatelier's principle, Van't Hoff isotherm, isobar and isochore.

Unit – II: Statistical Thermodynamics & Third Law

Thermodynamic probability, entropy and probability, residual entropy, calculation of absolute entropy of molecules. Boltzmann distribution formula (with derivation), application to barometric distribution, partition function and thermodynamic properties (U, H & P), Einstein's theory of heat capacity of solids and its limitations.

Nernst heat theorem and its implications, approach to zero Kelvin, Planck's formulation of third law and absolute entropies.

Unit – III: Symmetry & Group Theory

Introduction, symmetry elements and operations with illustrations, symmetry elements and physical properties, group and symmetry group, group multiplication table, point group.

Unit – IV: Quantum Chemistry

Black body radiation, Planck's radiation law, photoelectric effect, Wilson-Sommerfeld quantization rule, application to Bohr atom, harmonic oscillator, rigid rotator and particle in 1-d box, de Broglie relation and energy quantization in Bohr atom and box, Heisenberg uncertainty principle, Bohr's correspondence principle and its applications to Bohr atom and particle in 1-d box.

Elementary concept of operators, eigenfunctions and eigenvalues, linear operators, commutation of operators, expectation value, hermitian operator, properties, Schrödinger's time independent equation, acceptability of wave function, probability interpretation of wave function.

Particle in a box, setting up of Schrödinger's equation of 1-d box, its solution and application, degeneracy.

Unit – V: Photochemistry & Spectroscopy

Primary photophysical processes, potential energy diagram, Franck-Condon principle and vibrational structure of electronic spectra, bond dissociation, decay of excited state by radiative and nonradiative paths, fluorescence and phosphorescence, Jablonsky diagram, laws of photochemistry, quantum yield, photochemical equilibrium, photosensitized reactions, kinetics of HI decomposition.

Alkali metal spectra, multiplicity of spectral lines, idea of spin quantum number, physical idea of spin orbit coupling.

Rotational spectroscopy of diatomic molecules, rigid rotator model, characteristic features (spacing and intensity).

Vibrational spectroscopy of diatomic molecules, Simple Harmonic Oscillator (SHO) model.

Physical Chemistry-IV Lab

1. Kinetics of saponification of ester by conductometric method.
2. Conductometric verification of Ostwald dilution law
3. Colorimetric determination of pK_{in} of methyl red

Course Name: Chemistry of Nanomaterials

Course Code: BSCHCEMDSE601

Course Type: DSE	Course Details: DSEC-3 or 4		L-T-P: 5-**1-0**	
Credit: **6**	Full Marks: **50**	CA Marks	ESE Marks	
		Practical	Theoretical	Practical	Theoretical
		----	**10**	----	**40**

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

Learning objectives:

1. Basic concepts of nanomaterials and their activity.

2. Knowledge of synthesis of nanomaterials

3. Concepts of some special types of nanomaterials

4. Charecterisations of nanomaterials by using different instrumental techniques

Syllabus:

Unit-I: Basic Concepts on Nanomaterials

The scope and challenges of nanomaterials chemistry, the nanoscale and colloidal systems, fundamentals of surface and interfacial chemistry, chemical potential and surface curvature, surface energy and stabilization of nanoscale materials, electrostatic stabilization, interaction between two particles (DLVO theory), steric stabilization

Unit-II: Synthesis and Fabrication of Nanomaterials

Top down and bottom up techniques, zero-dimensional nanomaterials: nanoparticles, synthesis of metallic, semiconducting and oxide nanoparticles, one-dimensional nanostructures: nanowire and nanorods, fundamentals of VLS and SLS growth, two-dimensional nanostructures: thin films, physical and chemical vapor deposition (PVD and CVD), Diamond films, sol-gel films

Unit-III: Special Nanomaterials

Graphene, Carbon fullerenes (detailed on bonding and structure), carbon nanotubes: classification and physical characteristics, porous materials: micro and mesoporous materials, core-shell structures, quantum dot, metal-polymer structures, organic-inorganic hybrids, Metal-Organic framework (MOF), intercalation compounds, nanocomposites

Unit-IV: Characterization, Properties and Applications of Nanomaterials

X-ray Diffraction (XRD), Scherrer's Formula, scanning and tunneling electron Microscopy (preliminary idea), size dependent properties: Electrical, optical, catalytic and magnetic; melting point and lattice constants, nanobots, nanocatalysis, catalysis by gold nanoparticles, biological applications of nanoparticles

Course Name: Dynamic Stereochemistry

Course Code: BSCHCEMDSE602

Course Type: DSE	Course Details: DSEC-3 or 4		L-T-P: **5-1-0**
		CA Marks	ESE Marks

Credit: **6**	Full Marks: **50**	Practical	Theoretical	Practical	Theoretical
		----	**10**	----	**40**

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

Learning objectives:

1. Knowledge of stereoselective and stereospecific reactions

2. Concepts of stereochemical aspects of some organic reactions

3. Knowledge of conformation and reactivity for alicyclic compounds

4. Knowledge of stereochemical change of substitution, elimination and NGP reactions

Syllabus:

Unit-I: General Introduction

Regioselective, regio specific and chemoselective reactions; stereo-selectivity and stereospecificity; Stereoseleactive reactions : Classification, terminology and principles;

Unit-II: Synthetic Approach

Asymmetric synthesis and Asymmetric Induction; Diastereo selective synthesis : Asymmetric synthesis with chiral substrates, cram's rule – its application and deviation, Felkin-Anh Model Prelog's rule, Enantio Selective synthesis.

Unit-III: Stereochemical Aspects of a few Organic Reactions

Polar addition reactions to alkene, Prevost and woodward Hydroxylation, Hydroxylation by OsO_4 followed by reductive cleavage, Catalytic reductions of alkenes and alkynes, Nucleophilic substitution on saturated carbon, E_1 and E_2 reaction, stereoconvergent Elimination, stereochemical aspects of a few Molecular rearrangement – Pinacol rearrangement, Beckmann rearrangement, Claisen rearrangement and Cope rearrangement.

Unit-IV: Alicyclic system

Conformation and Reactivity in cyclohexanes; Steric effect and steroelectronic effect; Neighbouring group effects, effects of conformation on rearrangement and transannular reactions in alicyclic system; Diastereo selection in cyclic system. Reactions of cyclohexane derivatives; Hydrolysis of ester of cyclohexane carboxylic acids, Esterification Reaction of cyclohexane carboxylic acids, S_N^1, S_N^2, E_1, E_2, NGP, reactions. Hydride reduction of cyclohexanones to cyclohexanols, oxidation of cyclohexanols with Chromic acid, Merged substitution – elimination reaction, Reaction of 2-Aminocyclohexanol by Nitrous acid, Pinacol-pinacolone rearrangement in cyclohexanediols.

Course Name: Quantum Chemistry & Spectroscopy

Course Code: BSCHCEMDSE603

Course Type: DSE	Course Details: DSEC-3 or 4			L-T-P: 5-**1**-**0**	
Credit: **6**	Full Marks: **50**	CA Marks		ESE Marks	
		Practical	Theoretical	Practical	Theoretical
		----	**10**	----	**40**

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

Learning objectives:

1. Learn about limitations of classical mechanics and solution in terms of quantum mechanics for atomic/molecular systems.

2. Develop an understanding of quantum mechanical operators, quantization, probability distribution, uncertainty principle.

3. Knowledge of spectral lines of atoms in the light of quantum mechanics.

4. Some basic concepts of different types of molecular spectra such as vibrational, rotational, Raman, NMR, Mossbauer.

Syllabus:

Unit – I: Quantum Mechanics

Summarization of the results of some experiments – black-body radiation, photoelectric effect, Davison and Germer experiment, Franck-Hertz experiment, identification of classical and quantum systems, Bohr's correspondence principle with examples; postulates of quantum mechanics, properties of wave functions, operators and related theorems

Degeneracy; Schrödinger equation, energy-eigenvalue equation, expectation value, eigenvalue and spread of observation, definition of uncertainty;

Free particle system – position, momentum, energy and uncertainity relation, motion of three dimension, degeneracy, potential barrier, tunnelling Vibrational motion of a particle, classical mechanical treatment, quantum mechanical treatment and their comparison Rotational motion of a particle – Schrodinger equation and wave function, spherical angular coordinates, complete wave function (spherical harmonics) Physical interpretation

Elementary discussion of the H-atom solution

Unit – II: Atomic structure

Quantum numbers, orbital and spin angular momenta of electrons, Stern-Gerlach experiment, vector atom model, term symbols (one and two optical electron systems), normal and anomalous Zeeman effect, Paschenback effect

Unit – III: Molecular Spectroscopy

Electromagnetic spectrum and molecular processes associated with the regions

Rotational spectra: classification of molecules into spherical, symmetric and asymmetric tops; diatomic molecules as rigid rotors – energy levels, selection rules and spectral features, isotope effect, intensity distribution, effect of non-rigidity on spectral features

Vibrational spectra of diatomics: potential energy of an oscillator, Harmonic Oscillator approximation, energy levels and selection rules, anharmonicity and its effect on energy levels and spectral features: overtones and hot bands, vibration-rotation spectra of diatomics: origin; selection rules; P, Q and R branches

Raman spectra: origin, selection rules, rotational and vibrational Raman spectra of diatomics

NMR spectra: theory, relaxation process, instrumentation, chemical shift and shielding, factors contributing to magnitude of shielding, spin interactions – its origin, equivalent protons, qualitative idea of energy levels of AX and A2 systems, a few representative examples

Mossbauer Spectra: Origin, Chemical shift, Quadruple effect

Recommended Books

Inorganic Chemistry

1. R. L. Dutta and G. S. De, Inorganic Chemistry, Pt – I, 7th Edn, 2013, The New Book Stall, 2013.
2. R. L. Dutta, Inorganic Chemistry, Pt –II, 5th Edn, 2013, The New Book Stall, 2006.
3. R. Sarkar, General and Inorganic Chemistry, Pt- I, II, 2nd Edn, Books & Allied (P) Ltd, 2009.
4. A. K. Das, Fundamental Concepts of Inorganic Chemistry, (Vol. 1-3), 2nd Edn, CBS Publisher, 2012.
5. A. K. Das, Fundamental Concepts of Inorganic Chemistry, (Vol. 4-7), CBS Publisher, 2014.
6. G. Wulfsberg, Inorganic Chemistry, Viva Books Private Ltd., New Delhi, 2001.
7. D. F. Shriver, P. W. Atkins and C. H. Langford, Inorganic Chemistry, Oxford University Press, New York, 1990.
8. B. Douglas, D. McDaniel and J. Alexander, Concepts and Models of Inorganic Chemistry, 3rd Edn, John Wiley and Sons, Inc., New York, 2001.
9. G. E. Rodger, Inorganic and Solid State Chemistry, Cengage Learning, 2002.
10. J. E. Huheey, E. A. Keiter and R. L. Keiter, Inorganic Chemistry: Principles of Structure and Reactivity, 4th Edn, Pearson Education, India, 2006.
11. A. Das and G. N. Mukherjee, Elements of Bioinorganic Chemistry, 2nd Edn, U. N. Dhur and Sons, Kolkata, 2002.
12. S. J. Lippard and J. M. Berg, Principles of Bioinorganic Chemistry, 1st Edn, Panima Publishing, 1995.
13. N. N. Greenwood and A. Earnshaw, Chemistry of the Elements, 2nd Edn, Elsevier, India, 2005.
14. G. L. Miessler and D. A. Tarr, Inorganic Chemistry, 3rd Edn, Pearson Education, India, 2004.
15. J. D. Lee, Concise Inorganic Chemistry, 5th Edn, Oxford University Press, 1999.
16. F. A. Cotton, G. Wilkinson, C. M. Murillo and M. Bochmann, Advanced Inorganic Chemistry, 6th Edn, John Wiley and Sons, Inc., New York, 1999.
17. J. J. Katz, G. T. Seaborg and L. R. Morss (Eds), The Chemistry of the Actinide Elements, Vols I and II, 2nd Edn, Springer Verlag Gmbh, 1986.
18. D. M. Adams, Inorganic Solids, Wiley, New York, 1992.
19. F. Basolo and R. G. Pearson, Mechanism of Inorganic Reactions, 2nd Edn, Wiley, 1967.
20. R. B. Jordan, Reaction Mechanisms of Inorganic and Organometallic Systems, Oxford University Press, 1998.
21. R. H. Crabtree, The Organometallic Chemistry of Transition Metals, 2nd Edn., John Wiley, 1994.
22. G. O. Spessard and G. L. Miessler, Organometallic Chemistry, 2nd Edn, Oxford University Press, USA, 2009.
23. A. G. Sharpe, Inorganic Chemistry, 3rd Edn, Pearson Education, New delhi, 2004.
24. J. W. Steed and J. L. Atwood, Supramolecula Chemistry, 22nd Edn, Wiley, 2009.
25. A. K. Das, Bioinorganic Chemistry, 2nd Edn, Books & Allied (P) Ltd, Kolkata, 2004.
26. D. Banerjea, Inorganic Chemistry: A Modern Treatise, Asian Books Private Ltd, 2012.
27. A. I. Vogel, A Text Book of Quantitative Inorganic Analysis, 3rd Edn, Longmans, 1961.
28. I. M. Kolthoff, P. J. Elving and E. B. Sandell, Treatise on Anlytical Chemistry, Pt-I, II, III, The Interscience Encyclopedia, Inc., New York. 1959.
29. D. Harvey, Modern Analytical Chemistry, McGraw-Hill, New York, 2000.
30. D. A. Skoog, Principle of Instrumental Analysis, 3rd Edn, Saunders College Publishing, New York, 1985.
31. G. D. Christian, Analytical Chemistry, 5th Edn. John Wiley, New York, 1994.

32. H. J. Arnikar, Essentials of Nuclear Chemistry, 4th Edn Reprint, New Age International (P) Ltd Publications, New Delhi, 2001.
33. D. A. Skoog, D. M. West and F. J. Holley, Fundamentals in Analytical Chemistry, 5th Edn, Saunders, Philadelphia, 1988.
34. S. Lindsay and J. Barnes, High Performance Liquid Chromatography, John Wiley, New York, 1992.
35. D. G. Peters, J. M. Hayes and G. M. Hieftje, Chemical Separations and Measurements: Theory and Practice of Analytical Chemistry, Saunders, Wiley Interscience, New York, 1974.
36. S. M. Khopkar, Basic Concepts of Analytical Chemistry, Wiley Eastern Ltd., New Delhi, 1998.
37. A. L. Underwood and R. A. Day, Quantitative Analysis 6th Edn, Prentice-Hall, 2009.

Organic Chemistry

1. W. J. I. Noble, Highlights of Organic Chemistry, Mercel Dekker, 1974.
2. E.L. Eliel, S.H. Wilen and L.N. Mander, Stereochemistry of Organic Compounds, John Wiley & Sons, New York, 1994.
3. S. Sengupta, Basic Stereochemistry of Organic Molecules, 2009.
4. D. Nasipuri, Stereochemistry of Organic Compounds, 2nd Edn., Wiley Eastern, New Delhi, 1993.
5. D. L. Nelson, A. Lehninger, M. Cox, Principles of Biochemistry, 52nd Edn, W.H. Freeman & Company, 2008.
6. W. Kemp, Organic Spectroscopy, 3rd Edn., McMillan, Hong Kong, 1991.
7. D. H. Williams and I. Fleming, Spectroscopic Methods in Organic Chemistry, 5th Edn., Tata McGraw-Hill, New Delhi, 2005.
8. J. R. Dyer, Applications of Absorption Spectroscopy of Organic compounds, 2nd print Prentice_Hall, New Jersey, 1971. 10
9. J. March, Advanced Organic Chemistry: Reactions, Mechanisms and Structure, 5th Edn., John Wiley, New York, 1999.
10. S. P. McManus, Organic Reactive Intermediates, Academic Press, New York, 1973.
11. F.A. Carey and R.J. Sundberg, Advanced Organic Chemistry Part A and Part B, 4th Edn., Plenum Press, New York, 2001.
12. T. L. Gilchrist and C. W. Rees, Carbenes, Nitrenes and Arynes, Nelson, New York, 1973.
13. T. H. Lowry and K.C. Richardson, Mechanism and Theory in Organic Chemistry, 3rd Edn., Harper and Row, New York, 1998.
14. D. L. Nelson and M.M. Cox, Lehninger: Principles of Biochemistry, W.H. Freeman Co, London, 2005.
15. H. Neurath, The Proteins: Composition, Structure and Function, Vols. 1-5, Academic Press, New York, 1963.
16. T. W. G. Solomons, Organic Chemistry,
17. G. M. Loudon, Organic Chemistry
18. E. A. Davidson, Carbohydrate Chemistry, Holt, Rinehart and Winston, New York1967.
19. J. Kennedy, Carbohydrate Chemistry, Clarendon Press, Oxford, 1988.
20. J. Clayden, N. Greeves, S. Warren, Organic Chemistry, 2nd Ed., (2012), Oxford University Press.
21. S. H. Pine, Organic Chemistry (Fifth Edition), Mc Graw Hill, (2007).
22. I. Fleming, Frontier Orbitals and Organic Chemical Reactions, John Wiley, 1980.
23. W. Caruthers, Modern Methods of Organic Synthesis, 3rd Edn., Low Price Edition, Cambridge University Press, 1996.
24. H. O. House, Modern Synthetic Reactions, 2nd Edn., Benjamin, 1971.

25. P. Sykes: A Guide to Mechanism in Organic Chemistry.
26. J. A. Joule and K. Mills: Heterocyclic Chemistry (4^{th} Edn).
27. T. L. Gilchirst, Heterocyclic Chemistry, 3^{rd} Edn, Pearson, 2005.
28. R. N. Morrison, R. N. Boyd, Organic Chemistry, 6th Edn., Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
29. R. O. C. Norman and J. M. Coxon: Principle of organic synthesis
30. I. L. Finar, Organic Chemistry, Vol I, 6th Edn., Addison Wesley Longmann, London, 1998.
31. I. L. Finar, Organic Chemistry, Vol II, 5th Edn., ELBS, London, 1995.
32. Gareth Thomas, Medicinal Chemistry, Wiley, 2^{nd} Edn
33. Asim Kr. Das, Environmental with Green Chemistry, Books & Allied (P) Ltd, 2004
34. S. Warren, Organic Synthesis: The Disconnection Approach, 1^{st} Edn, Wiley, 2012.
35. Ahluwalia, Green Chemistry Environmentally Benign Reactions, Ane Books-New Delhi, 2012.

Physical Chemistry

1. G. W. Castellan, Physical Chemistry, Narosa Publishing House, Calcutta, 1995.
2. Ira N. Levine, Physical Chemistry, PHI Learning Pvt. Ltd.
3. R. A. Alberty and R. J. Silbey, Physical Chemistry, John Wiley and Sons, Inc., New York, 1995.
4. G. K. Vemulapally, Physical Chemistry, Prentice-Hall of India Pvt. Ltd., New Delhi, 2006.
5. S. Glasstone, Text Book of Physical Chemistry, Macmillan and Company Ltd., London, 1951.
6. T. Engel and P. Reid, Physical Chemistry, Pearson Education, New Delhi, 2006.
7. D. A. McQuarrie and J. D. Simon, Physical Chemistry: A Molecular Approach, Viva Books Private Limited.
8. H. Chatterjee, Physical Chemistry (Vol. I-III), Platinum
9. V. Kireev, Physical Chemistry, Mir Publishers, Moscow, 1979.
10. E. N. Yeremin, Fundamentals of Chemical Thermodynamics, Mir Publishers, Moscow, 1986.
11. P. C. Rakshit (Revised by S.C. Rakshit), Physical Chemistry, Sarat Book Distributers, Kolkata.
12. P. W. Atkins & Julio De Paula, Physical Chemistry, Eighth Edition, Oxford University Press, Oxford
13. P. W. Atkins, J. De Paula, Physical Chemistry (Tenth Edition), Oxford University Press, 2014.
14. S. N. Mukherjee, Introduction to Physical Chemistry, Art Union, Calcutta.
15. R.G. Mortimer, Physical Chemistry, Third Edition, Elsevier Academic Press.
16. P. Monk, Physical Chemistry Understanding our Chemical World, John Wiley & Sons Ltd.
17. K.L. Kapoor, A Text Book of Physical Chemistry (Vol. 1 – 5), Macmillan India Limited, New Delhi.
18. S. Pahari, Physical Chemistry (Vol. 1 & 2), New Central Book Agency (P) Ltd.
19. Berry, Rice & Ross, Physical Chemistry, Oxford University Press.
20. K. L. Chugh & S. L. Agnish, A Text Book of Physical Chemistry (Vol 1 – 3), Kalyani Publishers.
21. K. J. Laidler, Chemical Kinetics, Pearson, New Delhi, 2014.
22. W. J. Moore, Physical Chemistry, Longman Green and Co. Ltd., 1953.
23. Pahari and Pahari, Problems on Physical Chemistry, New Central Book Agency (P) Ltd.
24. A. Ghoshal, Numerical Problems on Physical Chemistry, Books and Allied (P) Ltd.
25. K. K. Rohatgi-Mukherjee, Fundamentals of Photochemistry, New Age International (P) Limited, Publishers, India, 2007.
26. C. N. Banwell and E. M. McCash, Fundamentals of Molecular Spectroscopy, Tata McGraw Hill Publishing Company Limited, New Delhi, 1994.
27. J. M. Hollas, Modern Spectroscopy, Fourth Edition, John Wiley & Sons.

28. J. E. House, Fundamentals of Quantum Chemistry, Second Edition, Elsevier Academic Press.
29. P. Atkins & R. Friedman, Molecular Quantum Mechanics, Fourth Edition, Oxfor University Press.
30. Ira N. Levine, Quantum Mechanics, PHI Learning Pvt. Ltd., New Delhi, 2012
31. R. K. Prasad, Quantum Chemistry, New Age International (P) Limited, Publishers.
32. M. Chandra, Atomic Structure and Chemical Bond Including Molecular Spectroscopy, Tata Mc Graw Hill Publishing Company Limited.
33. B. K. Sen, Quantum Chemistry including Spectroscopy, Kalyani Publishers
34. A. K. Chandra, Introductory Quantum Chemistry, Tata McGraw Hill Publishing Company Limited.
35. A.K. Mukherjee & B. C. Ghosh, Group Theory in Chemistry, Universities Press, 2018
36. S. C. Rakshit, Molecular Symmetry Group and Chemistry, Sarat Book House
37. F. A. Cotton, Chemical Applications of Group Theory, Wiely-India, New Delhi, 2003.
38. A. Vincent, Molecular Symmetry and Group Theory, John Wiley and Sons, New York, 1988.
39. R. Ameta, Symmetry and Group Theory in Chemistry, New Age International Publishers, Kolkata, 2013.

Practical

1. J. C. Ghosh, Experiments in Physical Chemistry, Bharati Bhawan Publishers and Distributors, Patna, 1994
2. Ghoshal, Mahapatra & Nad , An Advanced Course in Practical Chemistry, New Central Book Agency (P) Ltd.
3. S. K. Maity and N. K. Ghosh, Physical Chemistry Practical, New Central Book Agency (P) Ltd.
4. M. J. K. Thomas, J. Mendham, R. C. Denney, J. D. Barnes, Vogel's Quantitative Chemical Analysis, 6th Edn, Pearson Higher Education, 2000.
5. G. Svehla, Vogels Qualitative Inorganic Analysis, 7th Edn, Dorling Kindersley (RS) 2006.
6. A. K. Nad, B. Mahapatra & A. Ghosal, An Advanced Course in Practical Chemistry, New Central, 2007.
7. Vogel’s Text Book of Practical Organic Chemistry (5th Edn).
8. Mann and Saunders, Practical Organic Chemistry.

Skill Enhancement Course

1. G. L. Patrick, Introduction to Medicinal Chemistry, Oxford University Press, UK, 2013.
2. H. Singh & V.K. Kapoor, Medicinal and Pharmaceutical Chemistry, Vallabh Prakashan, Pitampura, New Delhi, 2012.
3. E.Stocchi, Industrial Chemistry, Vol-I, Ellis Horwood Ltd. UK 1990.
4. Jain, P.C. & Jain, M. Engineering Chemistry Dhanpat Rai & Sons, Delhi.
5. B.K. Sharma & H.Gaur, Industrial Chemistry, Goel Publishing House, Meerut 1996.
6. B.K. Sharma & H. Gaur, Industrial Chemistry, Goel Publishing House, Meerut 1996.
7. E. Steiner,The Chemical Maths Book, Oxford University Press (1996).
8. D. B. Hibbert & J. J. Gooding, Data analysis for chemistry. Oxford University Press (2006).
9. B. S. Grewal, Higher Engineering Mathematics, Khanna Publishers, 43rd Edition.
10. Erwin Kreyszig, Advanced Engineering Mathematics, Wiley, 10th Edition.

Generic Elective Courses

1. A. Sangal, Advanced Organic Chemistry, Vol. 1, Krishna Prakashan Media (P) Ltd, Meerut, India, 2012.
2. S. R. Palit, Elementary Physical Chemistry; Book Syndicate Private Limited.

3. P. C. Rakshit, Physical Chemistry; Sarat Book Distributers.
4. Dr. A. K. Mondal, Degree Bhouto O Sadharan Rasayan; Sarat Book Distributers.
5. A. Ghoshal, Sadharan O Bhouto Rasayan;: Books and Allied (P) Ltd.
6. S. Ekambaram, General Chemistry; Pearson.
7. G. K. Mukherjee & J. Das, Ajaibo Rasayan, Books & Allied Pvt. Ltd.
8. R. L. Dutta and G. S. De, Inorganic Chemistry, Part – I, The New Book Stall, 7th Edn, 2013.
9. R. L. Dutta, Inorganic Chemistry, Part –II, The New Book Stall, 5th Edn, 2006.
10. P. K. Dutt, General and Inorganic Chemistry, (Vol- I & II).
11. S. N. Poddar & S. Ghosh, General & Inorganic Chemistry (Vol I & II) , Book Syndicate Pvt Ltd.
12. S. Sengupta, Organic Chemistry.
13. A. Bahl and B.S. Bahl, Organic Chemistry, S. Chand Publications.
14. Bhal, B.S.Bhal & G.D. Tuli Essentials of Physical Chemistry, S. Chand Publications.
15. R. K. Bansal, Organic Chemistry.
16. A. K. Das, Environmental Chemistry With Green Chemistry.
17. A. Kar, Medicinal Chemistry
18. Sriram & Yogeswari, Medicinal Chemistry.
19. G. A. Ozin and A. C. Arsenult, Nanochemistry: A Chemical Approach to Nanomaterials.
20. C. N. R. Rao, A. Muller and A. K. Cheetham, Nanomaterial Chemistry: Recent Development and New Directions.
21. G. L. Patrick, Introduction to Medicinal Chemistry, Oxford University Press, UK, 2013.
22. H. Singh & V.K. Kapoor, Medicinal and Pharmaceutical Chemistry, Vallabh Prakashan, Pitampura, New Delhi, 2012.
23. E.Stocchi, Industrial Chemistry, Vol-I, Ellis Horwood Ltd. UK 1990.
24. Jain, P.C. & Jain, M. Engineering Chemistry Dhanpat Rai & Sons, Delhi.
25. B.K. Sharma & H.Gaur, Industrial Chemistry, Goel Publishing House, Meerut 1996.