Program Outcome and Course Outcomes of the Courses offered by Department of Chemistry, Durgapur Government College; as specified in the prescribed syllabus of the affiliating University

Department of Chemistry, Durgapur Government College, offers undergraduate and post-graduates programmes in chemistry in accordance to the prescribed curriculum of Kazi Nazrul University. The Program Outcome has been mentioned in the precribed University Syllabus along with the Course Outcome/Objectives.

PROGRAMMES OFFERED BY DEPARTMENT OF CHEMISTRY, DURGAPUR GOVERNMENT COLLEGE (ACADEMIC SESSION: 2023-2024)

- B.Sc. Honours in Chemistry (4 Year Degree Programme under NCCF): offered to students admitted in 2023
- B.Sc. (Undergraduate) in Chemistry (3 Year Degree Programme under NCCF); offered to students admitted in 2023
- B.Sc. Honours in Chemistry (3 Years Degree Programme under LOCF); offered to students admitted in 2022 and 2021
- B.Sc. Honours in Chemistry (3 Years Degree Programme under LOCF); offered to students admitted in 2022 and 2021
- M.Sc. in Chemistry with Organic Chemistry and Physical Chemistry Specialization; offered to students admitted in 2022 and 2023

Courses Offered during the academic session 2023-2024 by Department of Chemistry

Program Name	Course code	Course Name	Year of introduction
B.Sc. Honours in Chemistry and B.Sc. Undergraduate in Chemistry	BSCHCEMMJ101	General Chemistry-I	2023
B.Sc. Honours in Botany, B.Sc. Honours in Zoology, B.Sc. Honours in Geology, B.Sc. Undergraduate in Botany, B.Sc. Undergraduate in Zoology	BSCCEMMN101	General Chemistry-I	2023
B.Sc. Honours in Chemistry and B.Sc. Undergraduate in Chemistry	BSCCEMSE101	Industrial Chemistry (SEC-1)	2023
B.Sc. Honours in Chemistry and B.Sc. Undergraduate in Chemistry	BSCHCEMMJ201	General Chemistry-II	2024
B.Sc. Honours in Botany, B.Sc. Honours in Zoology, B.Sc. Honours in Geology, B.Sc. Undergraduate in Botany, B.Sc. Undergraduate in Zoology	BSCCEMMN201	General Chemistry-II	2024
B.Sc. Honours in Chemistry and B.Sc. Undergraduate in Chemistry	BSCCEMSE201	Pharmaceutical Chemistry (SEC-2)	2024
B.Sc. Honours in Botany, B.Sc. Honours in Zoology, B.Sc. Honours in Mathematics, B.Sc. Undergraduate in Botany, B.Sc. Undergraduate in Zoology , B.Sc. Undergraduate in Mathematics	MDC213	Chemical Science	2024
B.Sc. Honours in Chemistry	BSCHCEMC301	Inorganic Chemistry - II	2017
B.Sc. Honours in Chemistry	BSCHCEMC302	Organic Chemistry - III	2017
B.Sc. Honours in Chemistry	BSCHCEMC303	Physical Chemistry - II	2017
B.Sc. Honours in Chemistry	BSCHCEMSE302	Pharmaceutical Chemistry	2017
B.Sc. Honours in Chemistry	BSCHCEMC401	Inorganic Chemistry - III	2018
B.Sc. Honours in Chemistry	BSCHCEMC402	Organic Chemistry - IV	2018

Program Outcome and Course Outcomes of the Courses offered by Department of Chemistry, Durgapur Government College; as specified in the prescribed syllabus of the affiliating University

Program Name	Course code	Course Name	Year of introduction
B.Sc. Honours in Chemistry	BSCHCEMC403	Physical Chemistry - III	2018
B.Sc. Honours in Chemistry	BSCHCEMSE402	Fuel Chemistry	2018
B.Sc. Honours in Chemistry	BSCHCEMC501	Organic Chemistry - V	2018
B.Sc. Honours in Chemistry	BSCHCEMC502	Inorganic Chemistry - IV	2018
B.Sc. Honours in Chemistry	BSCHCEMDSE501	Green Chemistry	2018
B.Sc. Honours in Chemistry	BSCHCEMDSE502	Environmental Chemistry	2018
B.Sc. Honours in Chemistry	BSCHCEMC601	Inorganic Chemistry - V	2019
B.Sc. Honours in Chemistry	BSCHCEMC602	Physical Chemistry - IV	2019
B.Sc. Honours in Chemistry	BSCHCEMDSE601	Chemistry of Nanomaterials	2019
B.Sc. Honours in Chemistry	BSCHCEMDSE602	Dynamic Stereochemistry	2019
B.Sc. Honours in Mathematics, B.Sc. Honours in Physics, B.Sc. Honours in Geology	BSCHCEMGE301	Physical Chemistry & Inorganic Chemistry	2017
B.Sc. Honours in Mathematics, B.Sc. Honours in Physics	BSCHCEMGE401	Inorganic Chemistry & Organic Chemistry	2018
B.Sc. Program in Chemistry, B.Sc. Program in Botany, B.Sc. Program in Zoology, B.Sc. Program in Mathematics	BSCPCEMC301	Physical Chemistry & Inorganic Chemistry	2017
B.Sc. Program in Chemistry, B.Sc. Program in Botany, B.Sc. Program in Zoology, B.Sc. Program in Mathematics	BSCPCEMC401	Inorganic Chemistry & Organic Chemistry	2018
B.Sc. Program in Chemistry, B.Sc. Program in Botany, B.Sc. Program in Zoology, B.Sc. Program in Physics	BSCPCEMDSE501	Applied Chemistry	2018
B.Sc. Program in Chemistry, B.Sc. Program in Botany, B.Sc. Program in Zoology, B.Sc. Program in Physics	BSCPCEMDSE502	Quantum Chemistry, Spectroscopy & Photochemistry	2018
B.Sc. Program in Chemistry, B.Sc. Program in Botany, B.Sc. Program in Zoology, B.Sc. Program in Physics	BSCPCEMDSE601	Chemistry of Bio-molecules & Chemotherapy	2019
B.Sc. Program in Chemistry	BSCPCEMSE301	Industrial Chemistry	2017
B.Sc. Program in Chemistry	BSCPCEMSE401	Chemistry of Cosmetics & Perfumes	2018
B.Sc. Program in Chemistry	BSCPCEMSE501	Pharmaceutical Chemistry	2018
B.Sc. Program in Chemistry	BSCPCEMSE601	Fuel Chemistry	2019
M.Sc. in Chemistry	MSCCHEMC101	Inorganic Chemistry General - I	2016
M.Sc. in Chemistry	MSCCHEMC102	Organic Chemistry General - I	2016
M.Sc. in Chemistry	MSCCHEMC103	Physical Chemistry General - I	2016
M.Sc. in Chemistry	MSCCHEMC104	Analytical Chemistry General - I	2016
M.Sc. in Chemistry	MSCCHEMC105	Inorganic Chemistry General: Practical	2016

Program Outcome and Course Outcomes of the Courses offered by Department of Chemistry, Durgapur Government College; as specified in the prescribed syllabus of the affiliating University

Program Name	Course code	Course Name	Year of introduction
M.Sc. in Chemistry	MSCCHEMC106	Organic Chemistry General: Practical	2016
M.Sc. in Chemistry	MSCCHEMC201	Inorganic Chemistry General - II	2017
M.Sc. in Chemistry	MSCCHEMC202	Organic Chemistry General - II	2017
M.Sc. in Chemistry	MSCCHEMC203	Physical Chemistry General - II	2017
M.Sc. in Chemistry	MSCCHEMC204	Analytical Chemistry General - II	2017
M.Sc. in Chemistry	MSCCHEMC205	Physical Chemistry General: Practical	2017
M.Sc. in Chemistry	MSCCHEMC206	Analytical Chemistry General	2017
M.Sc. in Chemistry	MSCCHEMC301	Advanced Inorganic Chemistry General	2017
M.Sc. in Chemistry	MSCCHEMC302	Advanced Organic Chemistry General	2017
M.Sc. in Chemistry	MSCCHEMC303	Advanced Physical Chemistry General	2017
M.Sc. in Chemistry	MSCCHEMMJE302	Organic Chemistry Major I	2017
M.Sc. in Chemistry	MSCCHEMMJE303	Physical Chemistry Major I	2017
M.Sc. in Chemistry	MSCCHEMC304	Advanced Chemistry General	2017
M.Sc. in Chemistry	MSCCIIEMMJE305	Organic Chemistry Major: Practical I	2017
M.Sc. in Chemistry	MSCCHEMMJE306	Physical Chemistry Major: Practical I	2017
M.Sc. in Chemistry	MSCCHEMC401	Advanced Analytical Chemistry	2018
M.Sc. in Chemistry	MSCCHEMMJE402	Organic Chemistry Major II	2018
M.Sc. in Chemistry	MSCCHEMMJE403	Physical Chemistry Major II	2018
M.Sc. in Chemistry	MSCCEIEMMJE405	Organic Chemistry Major III	2018
M.Sc. in Chemistry	MSCCHEMMJE406	Physical Chemistry Major III	2018
M.Sc. in Chemistry	MSCCHEMMJE408	Organic Chemistry Major Practical II	2018
M.Sc. in Chemistry	MSCCHEMMJE409	Physical Chemistry Major Practical II	2018
M.Sc. in Chemistry	MSCCHEMC403	Organic Chemistry Term Paper Project	2018

Learning Outcome Based Curriculum (LOCF)

for

B.Sc. (Honours in Chemistry)

UndergraduateProgramme(CBCS)

w.e.f.AcademicSession2020-21

KaziNazrulUniversity
Asansol,WestBengal

PARTI

INTRODUCTION

Learning Outcomes basedCurriculum Framework (LOCF) for ChemistryunderCBCS

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-orientedscenario.
2. To develop the curriculum for fosteringdiscovery-learning.
3. To equip the students in solving the practical problems pertinent toIndia
4. To adopt recent pedagogical trends in education including e-learning, flipped class, hybrid learning andMOOCs
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 ChemistryProgramme:

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 inChemistry:

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 LearningOutcomes:

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 andanalysis.

(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 separationtechnology.

(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 oralpresentation.

(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 andconcepts.

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

(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 projectoperation.

2.iv Course LearningOutcomes:

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 andIndustry.

2.v Teaching LearningOutcomes:

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 andWorkshops
v. Peer teaching andlearning
vi. Questionpreparation
vii. Practicum, and project-basedlearning
viii. Substantial laboratory-based practical component andexperiments
ix. Open-ended projectwork,
x. Technology-enabled learning

3. Attributes of a ChemistryGraduate:

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-boundrevisions.

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 wideraudience

c. **Critical thinking:** Chemistry graduates are expected to know basics of cognitive biases, mental models, logical fallacies, scientific methodology and constructing cogent scientificarguments.

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 emotionalmanagement.

e. **Problem-solving:** Graduates are expected to be equipped with problem-solving philosophical approaches that are pertinent across thedisciplines;

f. **Analytical reasoning:** Graduates are expected to acquire formulate cogent arguments and spot logical flaws, inconsistencies, circular reasoningetc.

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 logicaldeduction.

h. **Teamwork:** Graduates are expected to be team players, with productive co-operations involving members from diverse socio-culturalbackgrounds.

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 soon.

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 soon.

4. QualificationDescriptors:

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 professionaldevelopment.

(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. AssessmentMethods:

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 surprisetests),
- Closed-book and open-booktests,
- Problem-solvingexercises,
- Practical assignments and laboratoryreports,
- Observation of practicalskills,
- Individual and group project reports,
- Efficient delivery using seminarpresentations,
- *Viva voce* interviews are majorly adopted assessment methods for this curricullum.

B.Sc. (Honours) in Chemistry

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

<table>
<tr><td>Course Type: Core (Theoretical)</td><td colspan="3">Course Details: GEC-1</td><td colspan="2">L-T-P: 5-1-0</td></tr>
<tr><td rowspan="2">Credit: 6</td><td rowspan="2">Full Marks: 50</td><td colspan="2">CA Marks</td><td colspan="2">ESE Marks</td></tr>
<tr><td>Practical</td><td>Theoretical</td><td>Practical</td><td>Theoretical</td></tr>
</table>

		……	**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

<table>
<tr><td colspan="2">Course Type: CORE</td><td colspan="2">Course Details: CC-3</td><td colspan="2">L-T-P: 4-0-4</td></tr>
<tr><td rowspan="3">Credit: 6</td><td rowspan="3">Full Marks: 100</td><td colspan="2">CA Marks</td><td colspan="2">ESE Marks</td></tr>
<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>
</table>

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.

Syllabus:

Unit – I: Chemistry of Halogenated Hydrocarbons

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

Aryl halides: Preparation, including preparation from diazonium salts. nucleophilic aromaticsubstitution; 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

<table>
<tr><td>Course Type: GE</td><td colspan="2">Course Details: GEC-2</td><td colspan="3">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>
</table>

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 colspan="3">Course Details: CC-5</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**
		CA Marks	ESE Marks

Credit: **6**	Full Marks: **100**	Practical **30**	Theoretical **10**	Practical **20**	Theoretical **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, dienonephenol; 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

<table>
<tr><td>Course Type: CORE</td><td colspan="2">Course Details: CC-7</td><td colspan="2">L-T-P: 4-0-4</td></tr>
<tr><td rowspan="3">Credit: 6</td><td rowspan="3">Full Marks: 100</td><td colspan="2">CA Marks</td><td colspan="2">ESE Marks</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. *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. *1^{st} and 2^{nd} 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*

<u>Syllabus:</u>

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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<tr><td>………</td><td>10</td><td>………</td><td>40</td></tr>
</table>

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

<table>
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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. *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 1^{st}, 2^{nd} and 3^{rd} 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*

<u>**Syllabus:**</u>

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

<table>
<tr><td>Course Type: CORE</td><td colspan="3">Course Details: CC-10</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. 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

<table>
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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. 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 itsdetermination, electrophoresis, synthesis with mechanistic details: Strecker, Gabriel, acetamidomalonic ester, azlactone, Bücherer hydantoin, chemical properties (with mechanism): ninhydrinreaction, Dakin-West reaction; resolution of racemic amino acids; Estimation of amino acids bySorensen formol titration.

Proteins: peptide linkage and its geometry; syntheses (with mechanistic details) of peptidesusing *N*-protection & C-protection, solid-phase peptide (Merrifield) synthesis; sequence ofaminoacids 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 andnucleotides corresponding to DNA and RNA; mechanism for acid catalysed hydrolysis ofnucleosides (both pyrimidine and purine types); comparison of alkaline hydrolysis of DNA andRNA; 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, ATPhydrolysis 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**	
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. *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**	
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. 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	
		Practical	Theoretical	Practical	Theoretical
		---	**10**	----	**40**

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, pointdefects, 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 colspan="3">Course Details: CC-13</td><td colspan="2">L-T-P: 4-0-4</td></tr>
<tr><td rowspan="3">Credit: 6</td><td rowspan="3">Full Marks: 100</td><td colspan="2">CA Marks</td><td colspan="2">ESE Marks</td></tr>
<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>
</table>

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

<table>
<tr><td>Course Type: DSE</td><td colspan="2">Course Details: DSEC-3 or 4</td><td colspan="3">L-T-P: 5-1-0</td></tr>
<tr><td rowspan="3">Credit: 6</td><td rowspan="3">Full Marks: 50</td><td colspan="2">CA Marks</td><td colspan="2">ESE Marks</td></tr>
<tr><td>Practical</td><td>Theoretical</td><td>Practical</td><td>Theoretical</td></tr>
<tr><td>----</td><td>10</td><td>----</td><td>40</td></tr>
</table>

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, 7^{th} Edn, 2013, The New Book Stall, 2013.
2. R. L. Dutta, Inorganic Chemistry, Pt –II, 5^{th} Edn, 2013, The New Book Stall, 2006.
3. R. Sarkar, General and Inorganic Chemistry, Pt- I, II, 2^{nd} Edn, Books & Allied (P) Ltd, 2009.
4. A. K. Das, Fundamental Concepts of Inorganic Chemistry, (Vol. 1-3), 2^{nd} 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.
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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, 4^{th} Edn, Pearson Education, India, 2006.
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21. R. H. Crabtree, The Organometallic Chemistry of Transition Metals, 2nd Edn., John Wiley, 1994.
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24. J. W. Steed and J. L. Atwood, Supramolecula Chemistry, 22^{nd} Edn, Wiley, 2009.
25. A. K. Das, Bioinorganic Chemistry, 2^{nd} 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.
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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.
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3. S. Sengupta, Basic Stereochemistry of Organic Molecules, 2009.
4. D. Nasipuri, Stereochemistry of Organic Compounds, 2nd Edn., Wiley Eastern, New Delhi, 1993.
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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).
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31. I. L. Finar, Organic Chemistry, Vol II, 5th Edn., ELBS, London, 1995.
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34. S. Warren, Organic Synthesis: The Disconnection Approach, 1^{st} Edn, Wiley, 2012.
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3. E.Stocchi, Industrial Chemistry, Vol-I, Ellis Horwood Ltd. UK 1990.
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16. A. K. Das, Environmental Chemistry With Green Chemistry.
17. A. Kar, Medicinal Chemistry
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Learning Outcome Based Curriculum (LOCF)

for

B.Sc. (Program in Chemistry)

UndergraduateProgramme(CBCS)
w.e.f.AcademicSession2020-21

KaziNazrulUniversity
Asansol,WestBengal

PARTI

INTRODUCTION

Learning Outcomes basedCurriculum Framework (LOCF) for ChemistryunderCBCS

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-orientedscenario.
2. To develop the curriculum for fosteringdiscovery-learning.
3. To equip the students in solving the practical problems pertinent toIndia
4. To adopt recent pedagogical trends in education including e-learning, flipped class, hybrid learning andMOOCs
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. (Program) 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 ChemistryProgramme:

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 inChemistry:

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 LearningOutcomes:

The student graduating with the Degree B.Sc (Program) 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 andanalysis.

(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 separationtechnology.

(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 oralpresentation.

(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 andconcepts.

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

(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 projectoperation.

2.iv Course LearningOutcomes:

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	CC2	CC 3	CC 4
Core competency	√	√	√	√
Critical thinking	√	√	√	√
Analytical reasoning	√	√	√	√
Research skills	√	√	√	√
Teamwork	√	√	√	√

Discipline Specific Elective (DSE):

Programme Outcomes	DSE 1	DSE 2	DSE 3	DSE 4
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	√	√	√	√

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 andIndustry.

2.v Teaching LearningOutcomes:

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 andWorkshops
v. Peer teaching andlearning
vi. Questionpreparation
vii. Practicum, and project-basedlearning
viii. Substantial laboratory-based practical component andexperiments
ix. Open-ended projectwork,
x. Technology-enabled learning

3. Attributes of a ChemistryGraduate:

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-boundrevisions.
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 wideraudience

c. **Critical thinking:** Chemistry graduates are expected to know basics of cognitive biases, mental models, logical fallacies, scientific methodology and constructing cogent scientificarguments.

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 emotionalmanagement.

e. **Problem-solving:** Graduates are expected to be equipped with problem-solving philosophical approaches that are pertinent across thedisciplines;

f. **Analytical reasoning:** Graduates are expected to acquire formulate cogent arguments and spot logical flaws, inconsistencies, circular reasoningetc.

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 logicaldeduction.

h. **Teamwork:** Graduates are expected to be team players, with productive co-operations involving members from diverse socio-culturalbackgrounds.

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 soon.

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 soon.

4. QualificationDescriptors:

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 professionaldevelopment.

(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. AssessmentMethods:

Academic performance in various courses i.e. core, discipline electives, DSE 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 surprisetests),
- Closed-book and open-booktests,
- Problem-solvingexercises,
- Practical assignments and laboratoryreports,
- Observation of practicalskills,
- Individual and group project reports,
- Efficient delivery using seminarpresentations,
- *Viva voce* interviews are majorly adopted assessment methods for this curricullum.

B.Sc. (Program) in Chemistry

Credit Distribution in Chemistry (Programme):

Sem	Core Course (12) of 6 Credits each	AEC (2) of 4/2 Credits each	GE of 6 Credits each	DSE (6) of 6 Credits each	SEC (4) of 2 Credits each
I	Core 1	AECC1(Elective)			
	Core 2				
	Core 3				
II	Core 4	AECC2(Elective)			
	Core 5				
	Core 6				
III	Core 7				SEC 1
	Core 8				
	Core 9				
IV	Core 10				SEC 2
	Core 11				
	Core 12				
V				DSEC-1(1)	SEC 3
				DSEC-2(1)	
				DSEC-3(1)	
VI				DSEC-1(2)	SEC 4
				DSEC-2(2)	
				DSEC-3(2)	
No of credits	72	4 + 4	0	36	16
Total credits	132				

SEMESTER-I

Course Name: Basics in Organic and Inorganic Chemistry

Course Code: BSCPCEMC101

Course Type: **Core (Theoretical)**	Course Details: CC-**1(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: Elementary Physical Chemistry & Organic Chemistry

Course Code: BSCPCEMC201

<table>
<tr><td>Course Type: CORE</td><td colspan="3">Course Details: CC-1(2)</td><td colspan="2">L-T-P: 4-0-4</td></tr>
<tr><td rowspan="3">Credit: 6</td><td rowspan="3">Full Marks: 100</td><td colspan="2">CA Marks</td><td colspan="2">ESE Marks</td></tr>
<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>
</table>

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: Physical Chemistry & Inorganic Chemistry

Course Code: BSCPCEMC301

Course Type: **CORE**	Course Details: **CC-1(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. *1^{st} and 2^{nd} 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: BSCPCEMSE301

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.

SEMESTER – IV

Course Name: Inorganic Chemistry & Organic Chemistry

Course Code: BSCPCEMC401

Course Type: **CORE**	Course Details: **CC-1(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:Chemistry of Cosmetics & Perfumes

Course Code: BSCPCEMSE401

<table>
<tr><td>Course Type: SEC</td><td colspan="3">Course Details: SEC-2</td><td colspan="2">L-T-P: 4-0-0</td></tr>
<tr><td rowspan="3">Credit: 4</td><td rowspan="3">Full Marks: 50</td><td colspan="2">CA Marks</td><td colspan="2">ESE Marks</td></tr>
<tr><td>Practical</td><td>Theoretical</td><td>Practical</td><td>Theoretical</td></tr>
<tr><td>----</td><td>10</td><td>----</td><td>40</td></tr>
</table>

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

Learning objectives:

1. Basic concepts of cosmetics and perfumes

2. Some examples of cosmetics and perfumes

3. *Knowledge of preparation of these compounds*

Syllabus:

Preparation and Use of Cosmetics & Perfumes

A general study including preparation and uses of the following: Hair dye, hair spray, shampoo, suntan lotions, face powder, lipsticks, talcum powder, nail enamel, creams (cold, vanishing and shaving creams), antiperspirants and artificial flavours. Essential oils and their importance in cosmetic industries with reference to Eugenol, Geraniol, sandalwood oil, eucalyptus, rose oil, 2-phenyl ethyl alcohol, Jasmone, Civetone, Muscone.

SEMESTER – V

Course Name:Applied Chemistry

Course Code: BSCPCEMDSE501

Course Type: DSE	Course Details: DSEC-1(1) or 2(1) or 3(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. *Basic concepts of analytical chemistry and its application.*
2. *To inspire the students about the chemistry which is good for human health and environment.*
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.*
5. *Knowledge of Colloids and Macromolecular chemistry*

Syllabus:

Unit – I: Analytical Chemistry

(a) Accuracy and precision in analysis, types of errors, data analysis and curve fitting (linear Y = mX + C type), numerical problems, mean, mode and variant

(b) Principles of acid-base titration, use of indicators and indicator constant, titration of Na_2CO_3 + $NaHCO_3$ mixture vs HCl using different indicators, estimation of mixture of strong and weak acids, qualitative discussion of salt hydrolysis (no derivation)

(c) Single electrode potential and emf of a chemical cell, principles of redox titration, use of redox potentials, iodometry, iodimetry, use of $K_2Cr_2O_7$ and $KMnO_4$ as oxidant (acid, neutral and alkaline media)

Unit – II: Basic Principles of Green Chemistry

Tools of green chemistry including the use of alternative feed stocks or starting materials, reagents, solvents, target molecules, and catalysts (homogeneous, heterogeneous and biocatalysis), green chemistry as the alternative chemistry for protection of environment.

Unit – III: Colloidal State

General classification, general methods of preparation of lyophobic colloids and general properties of colloids, ideas of coagulation, peptization, protective colloids, dialysis, gold number, isoelectric point, Brownian motion

Unit – IV: Macromolecular Chemistry

Introduction, definition of macromolecules, natural and synthetic polymers, monomers, polymers, degree of polymerization, simple idea of polymer structure: homopolymer (linear, branched, cross-linked) and copolymer (random, block, graft), polymerization reaction step (growth, addition, ring opening), importance of polymers both natural and synthetic

Number and weight average molecular weights of polymers – significance, structure and use of natural rubber, synthetic rubber (neoprene), synthetic fibres (Nylon 66, poly ester), plastics like polyethylene and PVC, macromolecules and environment.

Course Name: Quantum Chemistry, Spectroscopy & Photochemistry

Course Code: BSCPCEMDSE502

Course Type: DSE	Course Details: DSEC-1(1) or 2(1) or 3(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. 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, NMR.

Syllabus:

Unit – I: 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

Stationary Schrödinger equation for the H-atom in polar coordinates, separation of radial and angular parts

Unit – II: Photochemistry

Absorption, Lambert-Beer's law, photochemical laws, primary photophysical processes, potential energy diagram, Franck-Condon principle, fluorescence and phosphorescence, Jablonsky diagram, Laws of photochemistry, quantum yield, kinetics of HI decomposition, H_2-Br_2 reactions

Unit – III: Spectroscopy

Alkali metal spectra, multiplicity of spectral lines

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

Vibrational spectroscopy of diatomic molecules, Simple Harmonic Oscillator (SHO) model; vibration rotation spectra, applications

NMR spectra, nuclear spin, Larmour precision, chemical shift, spin-spin interaction

Course Name: Pharmaceutical Chemistry

Course Code: BSCPCEMSE501

<table>
<tr><td>Course Type: SEC</td><td>Course Details: SEC-3</td><td colspan="2"></td><td colspan="2">L-T-P: 4-0-0</td></tr>
<tr><td rowspan="3">Credit: 4</td><td rowspan="3">Full Marks: 50</td><td colspan="2">CA Marks</td><td colspan="2">ESE Marks</td></tr>
<tr><td>Practical</td><td>Theoretical</td><td>Practical</td><td>Theoretical</td></tr>
<tr><td>----</td><td>10</td><td>----</td><td>40</td></tr>
</table>

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:

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).

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 – VI

Course Name:Chemistry of Biomolecules & Chemotherapy

Course Code: BSCPCEMDSE601

<table>
<tr><td>Course Type: DSE</td><td>Course Details: DSEC-1(2) or 2(2) or 3(2)</td><td colspan="2"></td><td colspan="2">L-T-P: 5-1-0</td></tr>
<tr><td rowspan="3">Credit: 6</td><td rowspan="3">Full Marks: 50</td><td colspan="2">CA Marks</td><td colspan="2">ESE Marks</td></tr>
<tr><td>Practical</td><td>Theoretical</td><td>Practical</td><td>Theoretical</td></tr>
<tr><td>----</td><td>10</td><td>----</td><td>40</td></tr>
</table>

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, etc, synthesis and properties of these molecules.

2. Activity of enzymes in biological systems

3. Basic concepts of chemotherapy

4. Knowledge of synthesis of different drug molecules

Syllabus:

Unit – I: Carbohydrate Chemistry

Classification, Structure and configuration of D- arabinose, D – ribose, D- glucose, D – fructose and Sucrose (Fischer and Haworth projection) : Structure determination of D- glucose : Epimers and Anomers ;MutarotationOsazone formation, Oxidation and reduction of D – glucose ; Stepping up and stepping down of monosaccharides ; Conversion of aldose to ketose and vice – versa ; Elementary idea about starch and cellulose.

Unit - II: Amino acids and Protein

Essential and non-essential amino acid ; Synthesis of glycine and alanine ; Isoelectric point ; Detection of amino acid (Ninhydrin reaction) Classification of Protein , Geometry of peptide Linkage elementary idea about primary and secondary structure of protein ; Denaturation of proteins .

Unit – III: Heterocyclic Compound and Nucleic acids

Structures of furan, pyrrole, thiophene, Pyridine, Pyrimidine, Pyrimidine derivatives like uracil, thymine andcytosine, purine and purine derivatives like adenine, guanine & uric acid ; Reactivity and basicity comparison between pyrrole and pyridine, Synthesis of uric acid from barbituric acid. Nucleosides, nucleotides, Nucleic acid, Structural component of RNA and DNA ; Secondary structure of DNA (Watson and Crick Model) .

Unit - IV: Enzymes and Biochemical Process

Definition of terms : enzymes, Cofactors, Coenzymes, Prosthetic groups Metalloenzymes, Metabolism (Catabolism and Anabolism) ; Nomenclature and Classification of enzymes ; Characteristics of enzymes ; Biochemical process : i) Conversion of pyruvate to acetyl CoA ; ii) glycolytic degradation of D – glucose into lactic acid.

Unit - V: Chemotherapy

Meaning of Chemotherapy, definition of drug, side effects, secondary effects and toxic effects of drugs ; preparation and uses of the drugs : Paracetamol, Aspirin, Sulphadiazine, Phenobarbitol and Metronidiazole.

Course Name:Advanced Inorganic Chemistry

Course Code: BSCPCEMDSE602

<table>
<tr><td>Course Type: DSE</td><td>Course Details: DSEC-1(2) or 2(2) or 3(2)</td><td colspan="2">L-T-P: 5-1-0</td><td></td></tr>
<tr><td rowspan="3">Credit: 6</td><td rowspan="3">Full Marks: 50</td><td colspan="2">CA Marks</td><td colspan="2">ESE Marks</td></tr>
<tr><td>Practical</td><td>Theoretical</td><td>Practical</td><td>Theoretical</td></tr>
<tr><td>----</td><td>10</td><td>----</td><td>40</td></tr>
</table>

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

Learning objectives:

1. *Coordination compounds – Concepts of double salts and complex salts, Werner theory*
2. *Knowledge of main group elements, electronic configurations, their properties abundance in nature reactions etc.*
3. *d- block/transition elements , some compounds, their preparations properties etc.*

Syllabus:

Unit – I: Coordination Chemistry

Double and complex salts, Werner's theory, ligands, coordination number, inner metallic complexes, chelate effect, different types of isomerism, IUPAC nomenclature.

Unit – II: Chemistry of Main Group Elements

A comparative study of the elements belonging to a particular group to be made in brief on the basis of their electron distribution and position in the periodic table. Structures (excluding stereochemistry) and properties of important compounds mentioned to be explained.

Group 1: Hydrogen – isotopes and binary hydrides, lithium and its similarities and differences from other alkali metals, diagonal relationship with magnesium, lithium aluminium hydride,

Group 2: Calcium, stroncium and barium, hydrolith, calcium cyanamide, gypsum and plaster of paris.

Group 12: Zinc, cadmium and mercury. Nesslar's reagent, Millon's base.

Group 13: Diborane, boron trifluoride, sodium borohydride, inorganic benzene.

Group 14: Carbon, silicon, tin and lead, carbide, silicon carbide, silica, sodium silicate. Silica gel, hydrofluorosilicic acid, silicon tetra chloride, glass, fullerene.

Group 15: Nitrogen, phosphorus, arsenic, antimony and bismuth, hydrazine, hydrazoic acid, hydroxyl amine, hyponitrous acid, phosphorus oxyacids (H_3PO_2, H_3PO_3, H_3PO_4, $H_4P_2O_7$ and HPO_3), sodium bismuthate.

Group 16: Oxygen and sulphur, composition and structure of ozone, oxyacids of sulphur (H_2SO_3, H_2SO_4, $H_2S_2O_3$,$H_2S_2O_8$), persulphate

Group 17: Fluorine, chlorine, bromine and iodine, oxides and oxyacids of chlorine, isolation of fluorine.

Group 18: Rare gases (isolation and uses) with special reference to general fluorides (structure)

Unit – III: Transition Metals

Groups 6 and 7: Chromium, manganese, K_2CrO_4, $K_2Cr_2O_7$, CrO_2Cl_2, $KMnO_4$, chrome alum.

Groups 8, 9 and 10: Iron, cobalt and nickel, principles of isolation of Ni (excluding details), composition and uses of alloys, steels, rusting of iron, galvanization and tin plating.

Group 11: Cu, Ag, Au, principles of Ag and Au isolation

Course Name: Fuel Chemistry
Course Code: BSCPCEMSE601

Course Type: **SEC (Theoretical)**	Course Details: **SEC-4**			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*

<u>Syllabus:</u>

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.

Recommended Books

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 SadharanRasayan; Sarat Book Distributers.
5. A. Ghoshal, Sadharan O BhoutoRasayan;: Books and Allied (P) Ltd.
6. S. Ekambaram, General Chemistry; Pearson.
7. G. K. Mukherjee & J. Das, AjaiboRasayan, Books & Allied Pvt. Ltd.
8. R. L. Dutta and G. S. De, Inorganic Chemistry, Part – I, The New Book Stall, 7thEdn, 2013.
9. R. L. Dutta, Inorganic Chemistry, Part –II, The New Book Stall, 5thEdn, 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.

Syllabus of 3-Year Degree/4-Year Honours in Chemistry

Based on National Curriculum and Credit Framework for Undergraduate Programme
With effect from 2023-24

KaziNazrulUniversity

Asansol,WestBengal

SEMESTER – I

COURSE TYPE: MAJOR

COURSE NAME: GENERAL CHEMISTRY–I

COURSE CODE: BSCCEMMJ101

Course Type: **MAJOR**	Course Details: MJC-1			L-T-P: **3-0-4**	
Credit: **5** **3 (Theory) + 2(Practical)**	Full Marks: **100**	CA Marks		ESE Marks	
		Practical	Theoretical	Practical	Theoretical
		30	**15**	**20**	**35**

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

Learning objectives:

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

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

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

4. Identity of given element, relative size, charges of proton, neutron and electrons, and their assembly to formdifferent atoms.

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

6. Characterize bonding between atoms, molecules, interaction and energetics hybridization and shapes ofatomic, molecular orbitals, bond parameters, bond- distances and energies.

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

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

9. Understanding hybridization and geometry of atoms, 3-D structure of organic molecules, identifying chiralcenters.

10. Electrophile, nucleophiles, free radicals, electronegativity, resonance, and intermediates along the reactionpathways.

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

Syllabus:

1. **AtomicStructure (8 Lectures)**

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. 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'srule of maximum multiplicity, Aufbau's principle and its limitations, Variation of orbital energy with atomic number.

2. PeriodicTable (7 Lectures)

Effective nuclear charge, shielding or screening effect, Slater rules,variation of effective nuclear charge in periodic table. Ionization enthalpy, Successive ionization enthalpies and factors affecting ionization energy. Applications of ionization enthalpy. Electron gain enthalpy, trends of electron gain enthalpy. Electronegativity, Pauling, Mullikan, Allred-Rochow scales, electronegativity and bond order, partial charge, hybridization, group electronegativity. Sanderson electron density ratio.

3. Chemical Bonding (10 Lectures)

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, BF_3 (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. Metallic Bond: Qualitative idea of free electron model, Semiconductors, Insulators.

4. Basics of Organic Chemistry (20 Lectures)

Organic Compounds: Classification and nomenclature, concept of hybridization, orbital pictures of bonding and shapes of molecules, calculation of formal charges and double bond equivalent.

Electronic displacements: Inductive effect, electromeric effect, resonance, hyperconjugation, mesomeric effect, bond polarizability, steric effect, steric inhibition of resonance.

Reactive intermediates: Method of generation, shape and relative stability of carbocations, carbanions, free radicals, carbenes, nitrenes, arynes, energy profile diagrams, electrophilic/ nucleophilic behaviour of reactive intermediates (elementary idea).

Introduction to organic reactions: Electrophiles and nucleophiles, hemolytic and heterolytic bond cleavage, homogenic and heterogenic bond formation, addition, elimination (E_1, E_2, E_{1CB}etc.) and substitution (SN^1, SN^2, SN^ietc.) reactions, curly arrow rules in representation of mechanistic steps.

Stereochemistry: Concept of asymmetry; Stereoisomerism; Conformations and configurations; Flying-wedge, Fischer, Sawhorse and Newman projection formulae and their inter conversions; nomenclature D/L, R/S, E/Z

Practical:
Qualitative analysis of organic special element N, S, Cl, Melting point, Functional group detection $-NH_2$, $-NO_2$, $-CONH_2$, phenolic-OH, -COOH,>C=O, -CHO and derivative preparation.

Recommended Books :

1. R. L. Dutta and G. S. De, Inorganic Chemistry, Pt – I, 7th Edn, 2013, The New Book Stall, 2013.
2. R. Sarkar, General and Inorganic Chemistry, Pt- I, 2nd Edn, Books & Allied (P) Ltd, 2009.
3. A. K. Das, Fundamental Concepts of Inorganic Chemistry, (Vol. 1-3), 2nd Edn, CBS Publisher, 2012.
4. D. F. Shriver, P. W. Atkins and C. H. Langford, Inorganic Chemistry, Oxford University Press, New York, 1990.
5. J. E. Huheey, E. A. Keiter and R. L. Keiter, Inorganic Chemistry: Principles of Structure and Reactivity, 4th Edn, Pearson Education, India, 2006.

6. N. N. Greenwood and A. Earnshaw, Chemistry of the Elements, 2nd Edn, Elsevier, India, 2005.
7. J. D. Lee, Concise Inorganic Chemistry, 5th Edn, Oxford University Press, 1999.
8. F. A. Cotton, G. Wilkinson, C. M. Murillo and M. Bochmann, Advanced Inorganic Chemistry, 6th Edn, John Wiley and Sons, Inc., New York, 1999.
9. F.A. Carey and R.J. Sundberg, Advanced Organic Chemistry Part A and Part B, 4th Edn., Plenum Press, New York, 2001.
10. M. B. Smith, March's Advanced Organic Chemistry 8th Edition, Wiley.
11. T. H. Lowry and K.C. Richardson, Mechanism and Theory in Organic Chemistry, 3rd Edn., Harper and Row, New York, 1998.
12. H. Neurath, The Proteins: Composition, Structure and Function, Vols. 1-5, Academic Press, New York, 1963.
13. T. W. G. Solomons, C. B. Fryhle and S. A. Snyder, Organic Chemistry, 12th Edition, Wiley.
14. M. Loudon and J. Parise, Organic Chemistry 6th Edition, Mc Millan Learning.
15. J. Clayden, N. Greeves, S. Warren and P. Wothers, Organic Chemistry, Oxford University Press, Oxford, 2001.
16. P. Sykes, A Guide to Mechanism in Organic Chemistry 6th Edition, Orient Longman.
17. D. Nasipuri, Stereochemistry of Organic Compounds, 2nd Edn, Wiley Eastern, New Delhi, 1993.
18. E. L. Eliel, S.H. Wilen and L.N. Mander, Stereochemistry of Organic Compounds, John Wiley & Sons, New York, 1994.
19. N. Tewari, Organic Chemistry, A Modern Approach Volume 1 & 2, Mc Graw Hill Education.
20. R. T. Morrison and R. N. Boyd, Organic Chemistry 6th Edition, Prentice Hall of India.
21. L. Finar, Organic Chemistry, Vol I, 6th Edn., Addison Wesley Longmann, London, 1998.
22. A. K. Nad, B. Mahapatra & A. Ghosal, An Advanced Course in Practical Chemistry, New Central, 2007.
23. S. Ghosh, M. Das Sharma, D. Majumdar and S. Manna, Chemistry in Laboratory, Santra Publication Pvt. Ltd.
24. Vogel's Text Book of Practical Organic Chemistry 5th Edn. Longman.

COURSE TYPE: MINOR

COURSE NAME: GENERAL CHEMISTRY–I

COURSE CODE: BSCCEMMN101

Course Type: **MINOR**	Course Details: MNC-1		L-T-P: **3-0-4**	
Credit: **5** **3 (Theory) + 2(Practical)**	Full Marks: **100**	CA Marks		ESE Marks	
		Practical	Theoretical	Practical	Theoretical
		30	**15**	**20**	**35**

*** Syllabus of Minor Paper (GENERAL CHEMISTRY–I, COURSE CODE: BSCCEMMN101) is same as the Major Paper (GENERAL CHEMISTRY-I, COURSE CODE: BSCCEMMJ101).**

COURSE TYPE: SEC

COURSE NAME: INDUSTRIAL CHEMISTRY (SEC-1)

COURSE CODE: BSCCEMSE101

Course Type: **SEC (Theoretical)**	Course Details: SEC-1		L-T-P: **2-1-0**	
Credit: **3**	Full Marks: **50**	CA Marks		ESE Marks	
		Practical	Theoretical	Practical	Theoretical
			15		**35**

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 KMnO4, CaC2, 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:

Paints (8 Lectures)

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.

Electrochemical and Electro-thermal Industries (3 Lectures)

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

Ceramics (4 Lectures)

Refractories, pottery, porcelain, glass, fibre glass

Rusting of Iron and Steel (3 Lectures)

Cause and prevention of corrosion

Industrial Safety and Fire Protection(4 Lectures)

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

Recommended Books:

1. G. T. Austin, Shreve's Chemical Process Industries, Mc Graw Hills, 5th Edition.
2. Jain, P.C. & Jain, M. Engineering Chemistry Dhanpat Rai & Sons, Delhi.
3. B.K. Sharma & H.Gaur, Industrial Chemistry, Goel Publishing House, Meerut 1996.
4. E.Stocchi, Industrial Chemistry, Vol-I, Ellis Horwood Ltd. UK 1990.

SEMESTER – II

COURSE TYPE: MAJOR

COURSE NAME: GENERALCHEMISTRY–II

COURSE CODE: BSCCEMMJ201

Course Type: **MAJOR**	Course Details: MJC-2			L-T-P: **3-0-4**	
Credit: **5** **3 (Theory) + 2(Practical)**	Full Marks: **100**	CA Marks		ESE Marks	
		Practical	Theoretical	Practical	Theoretical
		30	**15**	**20**	**35**

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

Learning objectives:

1. Physical properties and related laws of gas and liquid states are described.

2. Understanding Kinetic model of gas and its properties.

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

4. Behaviour of real gases, its deviation from ideal behaviour, equation of state, isotherm, and law of corresponding states.

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

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

7. 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.

Syllabus :

1. Acid-Base and Ionic Equilibrium (12 Lectures)

Brönsted Lowry’s concept, co-solvating 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- andF-strain), salvation, H-bonding; Hard and Soft acid base (HSAB) principle: classification and characteristic, hardness and frontier molecular orbital (FMO), Non-aqueous solvent (liq. NH_3, liq.SO_2). 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, pH 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

2. Redox Potential and Redox Equilibria (10 Lectures)

Some basic aspects of redox reactions, equivalent weights of oxidants and reductants,ion-electronmethodofbalancingredoxreactions,complimentaryandnoncomplimentary redox reactions, over potential, electron and atom transfer in redoxreactions, Standardred oxpotentials, sign convention, Nernst equation, electro chemical series, formal potential and its importance in analytical chemistry; Redox potential: effect of complex formation, effect of precipitation, effect of pH change, EMF Diagram (Latimer, Frost), thermodynamic aspects of disproportionation and comproportionation reactions, redox potential and equilibrium constants, redox titration and redox indicators, function of Zimmermann Reinhardt (ZR) solution

3. Chemical Kinetics –I (8 Lectures)

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.

4. Properties of Fluids (15 Lectures)

a) Properties of Gas - 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, Transport properties of gas, Thermal conductivity, Viscosity: mechanism, temperature and pressure dependence, relationship with mean free path. 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.

Nature of imperfect gases with reference to van der Waals, Diterici and virial equations of state; Amagat's and Andrews' curves; continuity of states; critical constants; Boyle temperature; reduced equation of state. Vapour density and limiting density, intermolecular forces.

b) Properties of Liquids - Viscosity of liquids: principles of determination (falling sphere, Poiseuille's equation and Ostwald viscometer); temperature dependence, liquid crystal.

Surface energy and surface tension: temperature dependence; vapour pressure over a curved surface; conditions of convexity and concavity of meniscus; wetting. Principles of determination (capillary-rise and drop-weight methods).

Practical:

1. **CO_3^{2-}/HCO_3^-estimation**

TitrationofNa$_2$CO$_3$+NaHCO$_3$mixturevsHClusingphenolphthaleinand methylorangeindicators

2. **HardnessofWater**

TofindthetotalhardnessofwaterbyEDTAtitration

3. **Estimation of Fe^{2+}**

TitrationofferrousironbyKMnO$_4$/K$_2$Cr$_2$O$_7$

4. **Estimation of alkali content in antacid tablet**
5. **Surface tension of a liquid/solution by drop-weight/drop number.**
6. **Viscosity coefficient of a liquid/solution by Ostwald viscometer.**

Recommended Books :

1. R. L. Dutta and G. S. De, Inorganic Chemistry, Pt – I, 7th Edn, 2013, The New Book Stall, 2013.
2. R. Sarkar, General and Inorganic Chemistry, Pt- I, 2nd Edn, Books & Allied (P) Ltd, 2009.
3. A. K. Das, Fundamental Concepts of Inorganic Chemistry, (Vol. 1-3), 2nd Edn, CBS Publisher, 2012.
4. D. F. Shriver, P. W. Atkins and C. H. Langford, Inorganic Chemistry, Oxford University Press, New York, 1990.

5. J. E. Huheey, E. A. Keiter and R. L. Keiter, Inorganic Chemistry: Principles of Structure and Reactivity, 4th Edn, Pearson Education, India, 2006.
6. N. N. Greenwood and A. Earnshaw, Chemistry of the Elements, 2nd Edn, Elsevier, India, 2005.
7. J. D. Lee, Concise Inorganic Chemistry, 5th Edn, Oxford University Press, 1999.
8. F. A. Cotton, G. Wilkinson, C. M. Murillo and M. Bochmann, Advanced Inorganic Chemistry, 6th Edn, John Wiley and Sons, Inc., New York, 1999.
9. G. W. Castellan, Physical Chemistry, Narosa Publishing House, Calcutta, 1995.
10. K.L. Kapoor, A Text Book of Physical Chemistry (Vol. 1 & 5), Macmillan India Limited, New Delhi.
11. P. C. Rakshit (Revised by S.C. Rakshit), Physical Chemistry, Sarat Book Distributers, Kolkata.
12. Ira N. Levine, Physical Chemistry, PHI Learning Pvt. Ltd.
13. R. A. Alberty and R. J. Silbey, Physical Chemistry, John Wiley and Sons, Inc., New York, 1995.
14. D. A. McQuarrie and J. D. Simon, Physical Chemistry: A Molecular Approach, Viva Books Private Limited.
15. P. W. Atkins & Julio De Paula, Physical Chemistry, Eighth Edition, Oxford University Press, Oxford
16. P. W. Atkins & Julio De Paula, Elements of Physical Chemistry, Fifth Edition, Oxford University Press, Oxford
17. A. Bahl, B.S. Bahl and G.D. Tuli, Essentials of Physical Chemistry, S Chand Publications.
18. Pahari and Pahari, Problems on Physical Chemistry, New Central Book Agency (P) Ltd.
19. A. Ghoshal, Numerical Problems on Physical Chemistry,Books and Allied (P) Ltd.
20. A. K. Nad, B. Mahapatra & A. Ghosal, An Advanced Course in Practical Chemistry, New Central, 2007.
21. S. Ghosh, M. Das Sharma, D. Majumdar and S. Manna, Chemistry in Laboratory, Santra Publication Pvt. Ltd.

COURSE TYPE: MINOR

COURSE NAME: GENERAL CHEMISTRY–II

COURSE CODE: BSCCEMMN201

Course Type: **MINOR**	Course Details: MNC-2		L-T-P: **3-0-4**	
Credit: **5** **3 (Theory) + 2(Practical)**	Full Marks: **100**	CA Marks		ESE Marks	
		Practical	Theoretical	Practical	Theoretical
		30	**15**	**20**	**35**

*** Syllabus of Minor Paper (GENERAL CHEMISTRY–II, COURSE CODE: BSCCEMMN201) is same as the Major Paper (GENERAL CHEMISTRY-II, COURSE CODE: BSCCEMMJ201).**

COURSE TYPE: SEC

COURSE NAME: PHARMACEUTICAL CHEMISTRY (SEC-2)

COURSE CODE: BSCCEMSE201

Course Type: **SEC (Theoretical)**	Course Details: **SEC-2**		L-T-P: 2-**1-0**	
Credit: **3**	Full Marks: **50**	CA Marks		ESE Marks	
		Practical	Theoretical	Practical	Theoretical
			15		**35**

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:

1. Drugs & Pharmaceuticals(15 Lectures)

What are drugs and why do we need new ones? Drug discovery and design, Sources of drugs and lead compounds, Natural sources, Drug synthesis, pharmacokinetics and pharmacodynamics? Introduction to drug action, Absorption, Distribution, Metabolism, Elimination, Solubility and drug design, The importance of water solubility, Salt formation, Structure–activity relationships (SARs), Lipophilicity, Electronic effects and steric effects.

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 (Glyceryltrinitrate), antilaprosy (Dapsone), HIV-AIDS related drugs (AZTZidovudine).

2. Fermentation(5 Lectures)

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.

Recommended Books :

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.

COURSE TYPE: MD

COURSE NAME: CHEMICAL SCIENCE

COURSE CODE: MDC213

<table>
<tr><td>Course Type: MD</td><td colspan="3">Course Details: MDC213</td><td colspan="2">L-T-P: 3-0-0</td></tr>
<tr><td rowspan="3">Credit: 3</td><td rowspan="3">Full Marks: 50</td><td colspan="2">CA Marks</td><td colspan="2">ESE Marks</td></tr>
<tr><td>Practical</td><td>Theoretical</td><td>Practical</td><td>Theoretical</td></tr>
<tr><td></td><td>15</td><td></td><td>35</td></tr>
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On completion of this course, the students will be able to understand:

Learning objectives:

- *Knowledge of Polymer chemistry*
- *Application of polymer in everyday life*
- *Basic concepts and classifications of drugs, medicines, cancer therapy*
- *Knowledge of applications of different essential drug molecules*
- *Elementary idea about bioinorganic chemistry*

Syllabus:

1. Polymers (15 Lectures)

Basic concept, definition of polymers, natural and synthetic polymers, monomers, polymers, degree of polymerization, simple idea of polymer structure: homopolymer (linear, branched, cross-linked) and copolymer (random, block, graft), polymerization reaction step (growth, addition, ring opening), importance of polymers both natural and synthetic, Biodegradable polymers. Number and weight average molecular weights of polymers – significance, structure, properties and use of natural rubber, synthetic rubber (neoprene), synthetic fibres (Nylon 66, polyester), plastics like polyethylene and PVC, macromolecules and environment.

2. Chemistry in everyday life (30 Lectures)

Drugs: Definition of drug, relation between drugs and medicine, designing a drug: drug target & drug metabolism, drug-target interaction, side effects, secondary effects and toxic effects of drugs, classification of drugs, Some important class of drugs and its use: antacids, antihistamines, antifertility, neurologically active drugs (tranquilizers, narcotic analgesic and non-narcotic analgesic), antimicrobials, antibiotics, antiseptics, disinfectants.

Cancer treatment: Anticancer compounds (Pt-complexes and metallocenes), Basic concept in chemotherapy, radiation therapy, immunotherapy.

Bioinorganic Chemistry: metal dependent disease, Essential metals: role of metal ions in biological systems (specially Na+, K^{+}, Mg^{2+}, Ca^{2+}, $Fe^{3+}/^{2+}$, $Cu^{2+/+}$, and Zn^{2+}) detoxification by chelation therapy for Pb and As poisoning, lithium therapy in psychiatric mind disorder.

Recommended Books:

1. S. R. Palit, Elementary Physical Chemistry; Book Syndicate Private Limited.
2. M. S. Bhatnagar, A text book of polymer chemistry, S. Chand Publication
3. Mamta & M. Nithya Devi, Elements of Polymer Chemistry, Anmol Publishers.
4. A. K. Das, Bioinorganic Chemistry, 2^{nd} Edn, Books & Allied (P) Ltd, Kolkata, 2004.
5. G. L. Patrick, Introduction to Medicinal Chemistry, Oxford University Press, UK, 2013.
6. H. Singh & V.K. Kapoor, Medicinal and Pharmaceutical Chemistry, Vallabh Prakashan, Pitampura, New Delhi, 2012.
7. A. Kar, Medicinal Chemistry, New Age International (P) Limited, Publishers.

Post-graduate course (Organic Chemistry Specialization)

Organic chemistry is taught in all 04 Semesters in accordance to the CBCS curriculum of Kazi Nazrul University.

Semester	Name of the Course
I	Organic General I
I	Organic General (Practical)
II	Organic General II
III	Advanced Organic General
III	Organic Major I
III	Organic Major I Practical
IV	Organic Major II
IV	Organic Major II
IV	Organic Major Practical II
IV	Organic Term Paper Project

Semester-I

This semester includes two units:

a) **Unit-I**: This unit includes Stereochemistry (Static and Dynamic) of organic compounds: concept and application &Organic reaction mechanism. This unit provides advanced knowledge of stereochemical aspects of organic reactions to students. Organic reaction mechanism includes substitution, elimination, addition, rearrangement, free radical, metathesis and click chemistry.

b) **Unit-II**: This unit includes Ultraviolet and visible (UV-vis) spectroscopy: Application Infrared (IR) spectroscopy: Application; Nuclear Magnetic Resonance (NMR) spectroscopy: General principles and application; Mass-spectrometry: General principles and application&combined spectral applications. Students are provided advanced knowledge of spectroscopy in this unit.

Organic General Lab: Students learn the processes of separation of binary mixtures of solid-solid/liquid-solid/liquid-liquid organic samples and identification of individual components . Students also learn to synthesize organic compounds through important chemical reactions.

Semester-II

This semester includes two units:

c) **Unit-I**: This unit includes Organic Name reactions, reaction intermediates & synthetic polymers and biopolymers. Students learn about different organic reactions and industrial applications of polymers in this unit.

d) **Unit-II**: Students learn about thechemistry of natural products and medicinal chemistry (drug designing) in this unit.

Semester-III

This semester includes twocore subjects: Advanced Organic General & Organic Major-I Advanced Organic General is taught to all students of post-graduate course: It includes the following units:

a) **Unit-I**: This unit includes the concept, practice and aspects of green chemistry in current synthetic chemistry. This unit also provides the understanding of organic synthesis focusing on carbon-heteroatom bonds.
b) **Unit-II**: This unit includes protection-deprotection and retrosynthetic strategies applied in organic synthesis. This unit also includes the concepts of pericyclic reactions and organic photochemistry.

Organic Major I is taught to students with organic specialization: It includes the following units:

c) **Unit-I**: This unit includes the concept of VBT and MOT in the molecular structure and reactivity of organic reactions. It also includes the understanding of ORD and CD in organic chemistry. Asymmetic synthetic schemes are also taught in this unit.
d) **Unit-II**: This unit includes synthesis, properties and reactions of heterocyclic compounds and different aspects of organometallic chemistry.

Organic Major-I Lab: Students learn the quantitative estimation of organic compounds in this unit and they also prepare organic compounds by single or two step processes in this practical paper.

Semester-IV

This semester includes twocore subjects: Organic Major-II & Organic Major-III. Both these papers are taught to students with organic specialization:

Organic Major-I includes the following units:

e) **Unit-I**: This unit includes the advanced techniques in organic synthesis. And organic photochemistry.
f) **Unit-II**: This unit is intended to teach the Structure-function relationship in carbohydrates, proteins, lipids, nucleic acids and enzymes and coenzyme chemistry.

Organic Major III includes the following units:

g) **Unit-I**: This unit provides advanced knowledge of pericyclic reactions, supramolecular chemistry and chemical concepts of antibiotics, antidiabetic and cardiovascular drugs.
h) **Unit-II**: This unit includes the chemistry of polyphenolics, steroidal hormones and biosynthesis of some selected biologically relevant natural products.

Organic Major-I Lab: Students learn to prepare organic compounds through multiple step reactions and they characterize the organic compounds using spectroscopic methods.

Post-graduate course (Physical Chemistry Specialization)

Post Graduate Studies

Under 'Semester system' of Kazi Nazrul University, Physical Chemistry is taught in 04 Semesters, both Theory and Practical in the post-graduate level. Along with Organic Chemistry, 'Physical Chemistry Specialization' is offered to the students in final year. The course and its outcome is highlighted below:

In **Semester I** Physical General I (Theory) (MCHEM 0103) paper is taught. The following topics are covered:

1. Quantum mechanics I 2. Atomic and molecular spectroscopy: principle and application 3. Solutions thermodynamics and electrochemistry and 4.Statistical thermodynamics

In **Semester II** Physical General II (Theory) (MCHEM 0203) paper is taught. The following topics are covered:

1. Symmetry and group theory2. Quantum mechanics IIand **3. Chemical Kinetics**

In this SemesterPhysical General Practical**(**MCHEM 0205) is also done. The following experiments are performed :

1. Experiments in equilibrium and kinetics
2. Instrumental methods: colorimetrypolarimetry, conductometry and potentiometry
3. Data processing and elementary numerical techniques

In **Semester III** 1. Advanced Physical General (MCHEM 0303) and 2. Physical Major I (MCHEM 0306) are taught as theory papers along with practical paper (I) 'Advanced General' and (II) Physical Major Practical I

The following topics are covered:

Advanced Physical General

1. Applications of group theory in chemistry2. Crystallography and surface chemistry3.Chemistry of Polymers 4. Biophysical chemistry5. Spectroscopy

Physical Major I

1. Classical mechanics 2. Approximate methods in quantum chemistry3. Statistical Mechanics

In this Semester Advanced General andPhysical Major Practical 1 are also done.

In **Semester IV** 1. Physical Major IIand 2. Physical Major III are taught as theory papers and practical paper 'Physical Major Practical II along with Physical Term Project.

The following topics are covered:

Physical Major II

1. Quantum mechanics of many electron systems2. Molecular interaction 3. Irreversible thermodynamics and introductory course on non-equilibrium statistical mechanics 4. Electric and magnetic properties of molecules

Physical Major III

1. Molecular reaction dynamics (MRD) 2. Solid state chemistry 3. Photochemistry and Laser principles 4. Alternative Energy Studies

In this Semester also Physical Major Practical I1 along with Physical Term Project are done.

The topics in Physical Chemistry depicted above are included in the syllabus to meet the demand of advanced studies and research in a very good perspective of present scenario not only in Physical Chemistry but also every sphere of science and technology. Whereas Quantum Mechanics, Statistical Thermodynamics , Group Theory etc. have strong and well established theoretical outcome, Surface Science, Polymer Science, Bio physical Chemistry Solid State Chemistry , Photochemistry and Spectroscopy find light in wide applications in versatile areas. These generate interest of the students not only in the field of Physical Chemistry but also interdisciplinary areas of Science and Technology. Overall it finds a valuable out come and students would move for further studies and research.

SYLLABUS

For

M. Sc. Course in

Chemistry

To be effective from the session 2016-17

KAZI NAZRUL UNIVERSITY

ASANSOL 713 340

WEST BENGAL, INDIA

Duration of PG Course of Studies in Chemistry will be of two years with four Semesters, viz., Semester I, Semester II, Semester III and Semester IV - each of six months' duration coupled with four examinations *viz*. Semester I, Semester II, Semester III and Semester IV in chemistry at the end of each Semester. Syllabus is hereby framed according to certain schemes and structures highlighted below.

Schemes:

(i) 300 marks in Semester I & III, 350 marks for Semester II and 250 marks for Semester IV with a grand total of 1200 marks and 98 credits.

(ii) 24 credits in Semester I & III, 28 credits in Semester II and 22 credits in Semester IV with a total of 98 credits; each theoretical/practical paper of 4 credits; term paper/project of 6 credits;

(iii) 20% marks allotted for internal assessment in each paper

(iv) Four theoretical general papers (common to all students) in each of Semester I and Semester II

(v) Two practical general papers (common to all students) in each of Semester I and Semester II

(vi) Three major electives *viz.* Inorganic, Organic and Physical in Semester III and Semester IV; number of students in each Major paper to be decided by the department; the particular major paper once chosen by any student in Semester III, the corresponding major paper to be continued in Semester IV

(vii) For theoretical papers in Semester III, three advanced general papers (common to all students) and one major paper

(viii) For practical papers in Semester III, one advanced general paper strictly on instrumental methods in chemical analysis with computer simulation (common to all students) and one Major paper (applicable to students as selected by department)

(ix) For theoretical papers in Semester IV, one advanced general paper (common to all students) and two major papers (applicable to students as per provision made in Semester III by the department)

(x) For practical paper in Semester IV, one major practical paper (applicable to students as selected by department)

(xi) In Semester II, one Extra Departmental elective paper to be learnt by the students of the other sister departments and the students of this department be learnt from other sister departments.

(xii) In Semester IV, one paper on term paper/project work (subject matter of each major paper of Semester IV)

(xii) In all semesters each theoretical paper consisting of two units, viz., Unit I and Unit II

(xiii) Total eight questions each with 8 marks to be set in each theoretical paper with each unit containing four questions; examinees to be answered a total of five questions taking at least two from each Unit

(xiv) Duration of examination: each theoretical paper of 50 marks, each practical paper, 6 hours

(xv) For each practical paper: internal assessment, 10; experiments, 30; viva-voce (by external examiner), 10

(xvi) For term paper/project work: internal assessment, 10; presentation of seminar in presence of external expert; 30, and thereafter interaction,10

Course Structure

	Paper Code	Core Subject	Marks*	Credit**
S E M E S T E R I		**Theoretical Papers**		
	MCHEM 0101	Inorganic General I	50	4
	MCHEM 0102	Organic General I	50	4
	MCHEM 0103	Physical General I	50	4
	MCHEM 0104	Analytical General I	50	4
		Practical Papers		
	MCHEM 0105	Inorganic General	50	4
	MCHEM 0106	Organic General	50	4
		Total	**300**	**24**

	Paper Code	Core Subject	Marks*	Credit**
S E M E S T E R II		**Theoretical Papers**		
	MCHEM 0201	Inorganic General II	50	4
	MCHEM 0202	Organic General II	50	4
	MCHEM 0203	Physical General II	50	4
	MCHEM 0204	Analytical General II	50	4
		Practical Papers		
	MCHEM 0205	Physical General	50	4
	MCHEM 0206	Analytical General	50	4
		Extra Departmental Elective#		
	MCHEM 0207	Supramolecular & Medicinal Chemistry	50	4
		Total	**350**	**28**

	Paper Code	Core Subject	Marks*	Credit**
S E M E S T E R III		**Theoretical Papers**		
	MCHEM 0301	Advanced Inorganic General	50	4
	MCHEM 0302	Advanced Organic General	50	4
	MCHEM 0303	Advanced Physical General	50	4
		Major Electives (any one)		
	MCHEM 0304	Inorganic Major I	50	4
	MCHEM 0305	Organic Major I	50	4
	MCHEM 0306	Physical Major I	50	4
		Practical Papers (0307 compulsory, and any one from 0308-0310)		
	MCHEM 0307	Advanced General	50	4
	MCHEM 0308	Inorganic Major Practical I	50	4
	MCHEM 0309	Organic Major Practical I	50	4
	MCHEM 0310	Physical Major Practical I	50	4
		Total	**300**	**24**

	Paper	Core Subject	Marks*	Credit**
SEMESTER IV		**Theoretical Papers**		
	MCHEM 0401	Advanced Analytical General	50	4
		Major Electives (any one from 0402-0404 and any one from 0405-0407)		
	MCHEM 0402	Inorganic Major II	50	4
	MCHEM 0403	Organic Major II	50	4
	MCHEM 0404	Physical Major II	50	4
	MCHEM 0405	Inorganic Major III	50	4
	MCHEM 0406	Organic Major III	50	4
	MCHEM 0407	Physical Major III	50	4
		Major Elective Practical (any one)		
	MCHEM 0408	Inorganic Major Practical II	50	4
	MCHEM 0409	Organic Major Practical II	50	4
	MCHEM 0410	Physical Major Practical II	50	4
		Term Paper/Project## (any one from 0411-0413)		
	MCHEM 0411	Inorganic Term Paper/Project	50	6
	MCHEM 0412	Organic Term Paper/Project	50	6
	MCHEM 0413	Physical Term Paper/Project	50	6
		Total	**250**	**22**
		Grand Total	**1200**	**98**

* Marks: Sem I + Sem II + Sem III + Sem IV = 300 + 350 + 300 + 250 = 1200;

**Credit: Sem I + Sem II + Sem III + Sem IV = 24 + 28 + 24 + 22 = 98;

[#] Number of students-intake for minor electives may depend on the availability of seats;

[##] For term paper/project: preparation + presentation + viva-voce = 25 + 15 + 10 = 50.

Semester I

Theoretical Papers (For Each, Full Marks: 50; Credit: 4)

MCHEM 0101: Inorganic General I

Unit I

1. Bonding, reactivity and molecular properties – a quantum chemical approach (12 lectures)

Fundamentals, LCAO and/or Huckel treatments of σ-and π-MOs (inorganic di-/polyatomic species, organic open-chain/cyclic units such as alkanes, alkenes, vinylic/allylic system, dienes, polyenes, sandwich molecules, boron/carborane compounds, etc) with an inner look into orbital symmetry, molecular term symbols, relative energy, transition probability, selection rules, nature and intensity of transitions (allowed/forbidden), probing reaction center, and aromaticity of inorganic, organic, coordination and organometallic species; Koopmans' theorem, Walsh diagram, isolobal analogy

2. Coordination chemistry – stereochemistry, bonding and structure (13 lectures)

Preamble, Orgel/Tanabe-Sugano diagram, ligand symmetry orbital, molecular orbital, Angular overlap model, spectral features, Nephelauxetic effect, Racah parameter, Franck Condon principle, vibronic coupling, band broadening, spin-orbit coupling, spin-forbidden transition, intensity stealing, magnetic properties, cooperative, anomalous and subnormal magnetic moments, lowering of symmetry, electronic, steric and Jahn-Teller effects on energy levels, conformation of chelator/congregator/macrocycle, structural equilibrium and implication

Unit II

3. Organometallic chemistry I (10 lectures)

Overview, valence electron count, oxidation number and formal ligand charge; carbonyl ligand, linear/cyclic π-ligand system, compounds with M-C, M=C and M≡C bonds, hydride and dihydrogen complexes; phosphine, Jesiphos and related ligands; spectral analysis and structural characterization, Dewar-Chatt-Duncanson bonding model, isolobal analogy, Agostic interaction

4. Bioinorganic and inorganic medicinal chemistry (15 lectures)

Background, myoglobin, heamoglobin, heamocyanin, hemerythrin, cytochromes, rubredoxin, feredoxins; biological nitrogen fixation, chlorophyll and photosynthesis; PS-I, PS-II, bioenergetics and ATP cycle, glucose storage, Na^+/K^+ ion pump, ionophores, metalloenzyme – catalase, peroxidase, ceruloplasmin, cytochrome oxidase, carbonic anhydrase, carboxy peptidase, metallothionine, xanthine oxidase, sulphite oxidase, nitrate reductase, superoxide dismutase, chemistry of respiration; vitamin B_{12} and B_{12}-enzyme

Metals in medicines: diseases due to deficiencies, carcinogenesis, applications of chelators and metal chelates of different generations; antitumour, anticancer and anti-AIDS drugs, mechanistic pathway, limitation, future dimension

Suggested books

C. J. Ballhausen, *Molecular Electronic Structure of Transition Metal Complexes*, McGraw-Hill, London, 1979.

A. B. P Lever, *Inorganic Electronic Spectroscopy*, Elsevier, New York, 1984.

B. E. Douglas and C. A. Hollingsworth, *Symmetry in Bonding and Spectra, An Introduction*, Academic Press, New York, 1985.

T. A. Albright, J. K. Burdett and M. H. Whangbo, *Orbital Interactions in Chemistry*, Wiley, New York, 1985.

K. Fukui and H. Fujimoto, *Frontier Orbital and Reaction Paths*, World Scientific, Singapore, 1995.

J. G. Verkade, *A Pictorial Approach to Molecular Bonding*, 2nd Edn, Springer-Verlag, New York, 1997.

A. Vincent, *Molecular Symmetry and Group Theory*, John Wiley & Sons, New York, 1998.

F. A. Cotton, *Chemical Applications of Group Theory*, 3rd Edn, John Wiley & Sons, New York, 1999.

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D. A. McQuarrie, P. A. Rock and E. B. Gallogly, *General Chemistry*, 4th Edn, University Science Books, Mill Valley, Canada, 2011.

C. N. Banwell and E. M. McCash, *Fundamentals of Molecular Spectroscopy*, Tata McGraw-Hill Publishing Company Ltd, New Delhi, 1994.

D. N. Sathyanarayana, *Electronic Absorption Spectroscopy and Related Techniques*, University Press,2001.

M. Cox, *Optical Properties of Solids*, Oxford University Press, Oxford, 2001.

G. Aruldhas, *Molecular Structure and Spectroscopy*, 2nd Edn, Prentice-Hall of India, New Delhi, 2007.

P. Atkins, T. Overton, J. Rourke, M. Weller and F. Armstrong, *Shriver & Atkins Inorganic Chemistry*, 4th Edn, Oxford, 2006.

I. Pelant and J. Valenta, *Luminescence Spectroscopy of Semiconductors*, Oxford, New York, 2012.

O. Kahn, *Molecular Magnetism*, VCH, New York, 1993.

P. Powell, *Principles of Organometallic Chemistry*, 2nd Edn, Chapman and Hall, London, 1988.

J. D. Atwood, *Inorganic and Organometallic Reaction Mechanisms*, 2nd Edn, VCH, New York, 1997.

A. F. Hill, *Organotransition Metal Chemistry*, Royal Society of Chemistry, London, 2002.

R. H. Crabtree, *The Organomettalic Chemistry of the Transition Metals*, 4th Edn, Wiley, New York , 2005.

C. Elschenbroich, *Organometallics*, 3rd Edn, Wiley-VCH, Weinheim, 2006.

R. A. van Santen and M. Neurock *Molecular Heterogenous Catalysis*, Wiley-VCH, Weinheim, 2006.

G. O. Spessard and G. L. Miessler, *Organometallic Chemistry*, International 2nd Edn, Oxford University Press, Oxford, 2010.

J. F. Hartwig, *Organotransition Metal Chemistry. From Bonding to Catalysis*, University Science Books, Sausalito, CA, 2010.

S. J. Lippard and J. M. Berg, *Principles of Bioinorganic Chemistry*, University Science Books, Mill Valley, CA, 1993.

W. Kaim and B. Schwederski, *Bioinorganic Chemistry: Inorganic Elements in the Chemistry of Life*, Wiley, New York, 1994.

I. Bertini, H. B. Gray, S. J. Lippard and J. S. Valentine, *Bioinorganic Chemistry*, Viva Books Pvt. Ltd., New Delhi, 1998.

E. Ochiai, *Bioinorganic Chemistry: A Survey*, Academic Press, Elsevier, 2009.

R. R. Crichten, *Biological Inorganic Chemistry:A New Introduction to Molecular Structure,* 2nd Edn, Elsevier, New York, 2012.

R. M. Roat-Malone, *Bioinorganic Chemistry: A short Course*, 2nd Edn, Wiley, New York, 2013.

G. L. Patrik, *An Introduction to Medicinal Chemistry*, 3rd Edn, Oxford University Press, 2006.

C. G. Wermuth (Ed), *The Practice of Medicinal Chemistry*, Academic Press, Noida, India, 2008.

MCHEM 0102: Organic General I

Unit I

1. Stereochemistry (Static and Dynamic) of organic compounds: concept and application (10 lectures)

Static stereochemistry: Molecular symmetry and chirality; axial chirality, planar chirality and helicity; topicity and prostereoisomerism; conformation of acyclic and cyclic systems (3 to 5 and 7 to 8 members ring) along with fused and bridged ring compounds; conformations of rings with multiple double bonds; stereoelectronic effects; Baldwin's rule, stereochemistry of fused ring and bridged ring compounds (with special reference to decalin and phenanthrene systems)

Dynamic stereochemistry: Curtin-Hammett principle and Wenstein-Eliel equations;conformation, reactivity & mechanism (*viz.*acyclic and cyclic system focusing on nucleophilic substitution reaction, formation and cleavage of epoxide ring, addition reactions to double bonds, elimination reactions, pyrolytic *syn*-elimination, oxidation of cyclohexanols,*etc*.);elementary idea about asymmetric synthesis

2. Organic reaction mechanism (15 lectures)

Substitution reactions: Aliphatic nucleophilic substitution — S_N1, S_N2, mixed S_N1 and S_N2, SET mechanisms; neighbouring group participation by *pi*- and *sigma*-bonds, anchimeric assistance; S_Ni mechanism; nucleophilic substitution at an allylic, aliphatic trigonal and a vinylic carbon; effect of substrate structures on reactivity, nucleophiles, leaving group and reaction medium; phase transfer catalysis, regioselectivity; Aromatic nucleophilic substitution — S_NAr, benzyne and $S_{RN}1$ mechanisms; effect of substrate structures on reactivity, leaving group and attacking nucleophile; Aliphatic electrophilic substitution — S_E1, S_E2, and S_E^i mechanisms; electrophilic substitution accompanied by double bond shifts; effects of substrates, leaving group and solvent polarity on the reactivity, Aromatic electrophilic substitution — the arenium ion mechanism; orientation and reactivity; energy profile diagrams; the *ortho*/*para*ratio; orientation in other ring systems; *ipso* attack; *Free radical reactions*: Types of free radical reactions; free radical substitution mechanism; mechanism at an aromatic substrate; neighbouring group assistance; reactivity for aliphatic and aromatic substrates at a bridgehead; reactivity in the attacking radicals; effects of solvents on reactivity; allylic halogenation (NBS), oxidation of aldehydes to carboxylic acids; auto-oxidation; free radical rearrangements

Elimination reactions: E1, E2 and E1cB mechanisms; product stereochemistry; effects of substrate structures, attacking base, leaving group and the medium on reactivity; mechanism and orientation in pyrolytic elimination

Addition reactions: Addition to carbon–carbon multiple bonds — mechanistic and stereochemical aspects of addition reactions involving electrophiles, nucleophiles and free radicals; region- and chemoselectivity; orientation and reactivity; Addition to carbon–hetero multiple bonds — mechanism of metal hydride reduction of saturated and unsaturated carbonyl compounds, acids, esters and nitriles; addition of Grignard reagents, organozinc and organolithium reagents to carbonyl and unsaturated carbonyl compounds; Mechanism of condensation reactions involving enolates — Aldol, Knoevenagel, Claisen, Perkin and Stobbe reactions

Rearrangement reactions: Formation and stability of carbonium ions, carbanion, carbenes, nitrenes, radicals and arynes. Rearrangement involving carbocation (Wagner-Meerwein, Pinacol-Pinacolone rearrangement), reaction involving acyl cation, PPA cyclization and Fries rearrangement, rearrangement of carbenes (Wolff & Arndst-Eistert synthesis), rearrangement of nitrenes (Hoffmann, Curtius, Schmidt, Lossen, Beckmann rearrangement); sigmatropic rearrangements

Metathesis and click chemistry: Definition, classes of reactions, catalysts used, mechanistic aspects and synthetic applications of methathesis reactions and click reactions in organic chemistry with suitable examples

Unit II

3. Ultraviolet and visible (UV-vis) spectroscopy: Application (3 lectures)

Recapitulation of the principle, preparation of samples for UV-vis spectroscopy, effects of solvents, chromophores and auxochromes, characteristic absorptions of varying chromophoric systems, applications

4. Infrared (IR) spectroscopy: Application (3 lectures)

Recapitulation of the principle, Fourier transform infrared spectroscopy (FTIR), preparation of samples for infrared spectroscopy, characteristic group frequencies and applications

5. Nuclear Magnetic Resonance (NMR) spectroscopy: General principles and application (10 lectures)

^{1}H-NMR spectroscopy: General introduction and definition; chemical shifts; spin-spin interaction; shielding mechanism; mechanism of measurement; chemical shifts and correlation for protons bonded to carbon (aliphatic, olefinic, aldehydic and aromatic) and other nuclei (alcohol, phenols, enols, carboxylic acids, amines, amides & mercapto); chemical exchange; effect of deuteration; complex spin-spin interaction between two, three, four and five nuclei (first order spectra), virtual coupling, stereochemistry; hindered rotation; Karplus curve-variation of coupling constant with dihedral angles; simplification of complex spectra - nuclear magnetic double resonance, shift reagents, solvent effect; Fourier transform technique; nuclear Overhauser effect (NOE); resonance of other nuclei, ^{19}F, ^{31}P, etc

Carbon-13 NMR spectroscopy - general considerations; chemical shift values (aliphatic, olefinic, alkyne, aromatic, heteroaromatic and carbonyl carbon); coupling constant; Two Dimensional NMR Spectroscopy - COSY, NOESY, DEPT, INEPT, APT and INADEQUATE techniques.

6. Mass spectrometry: General principles and application (04 lectures)

Introduction; ion production - EI, CI, FD and FAB; factors affecting fragmentation; ion analysis; ion abundance; Mass spectral fragmentation of organic compounds; common functional groups; molecular ion peak; metastable peak; McLafferty rearrangement; nitrogen rule; high resolution mass spectrometry; examples of mass spectral fragmentation of organic compounds with respect to their structure determination.

7. Combined spectral applications (05 lectures)

Applications of all the spectroscopic techniques (UV, FT-IR, NMR and Mass) in a combined manner to solve structural problems of unknown organic compounds

Suggested books

E. L. Eliel, S. H. Wilson and L. N. Mander,*Stereochemistry of Organic Compounds*, John Wiley & Sons, Inc., 2003.

E. L. Eliel, *Stereochemistry of Carbon Compounds*, Tata McGraw-Hill Edition, New Delhi, 1988.

D. Nasipuri, *Stereochemistry of Organic Compounds (Principles and Applications),* 2nd Edn, Wiley Eastern Limited, New Delhi, 1994.

E.L. Eliel, N.L. Allinger, S. J. Angyal and G.A Morrison, *Conformational Analysis*,John Wiley & Sons, Inc., 1967.

J. Eames and J. Peach, *Stereochemistry at a Glance*, Blackwell Science, 2003.

K. Mislow and W. A. Benjamin, *Introduction to Stereochemistry*New York, 1965.

B. Testa, *Principles of Organic Stereochemistry,*Marcel Dekker, New York, 1979.

E. Juaristi, *Stereochemistry & Conformational Analysis,*John Wiley & Sons, Inc., 1991.

M. Nogradi, *Stereochemistry: Concepts and Applications*, Pergamon Press, New York, 1981

Hua-Jie Zhu,*Organic Stereochemistry: Experimental and Computational Methods*, Wiley-VCH, 2015.

Michael B. Smith and Jerry March, *March's Advanced Organic Chemistry (Reactions, Mechanisms, and Structure)*, 5th Edn., John Wiley & Sons, Inc., 2001.

Reinhard Bruckner, *Advanced Organic Chemistry (Reaction Mechanisms)*, Harcourt/Academic Press, 2002.

Thomas H. Lowry and K. S. Richardson, *Mechanism and Theory in Organic Chemistry.*3rd Edn., Addison-Wesley, 1998.

Peter Sykes, *A Guidebook to Mechanism in Organic Chemistry*, 6thEdn., Orient Longman Ltd., 1970.

Lloyd N. Ferguson, *The Modern Structural Theory of Organic Chemistry*, Prentice-Hall of India Pvt. Ltd., New Delhi, 1963.

R. H. Grubbs and D. J. O'leary (Eds), *Handbook of Metathesis* – vol. 1 and 2, Wiley-VCH, 2015.

D. L. Pavia, G. M. Lampman and G.S. Kriz, *Introduction to Spectroscopy*, 3rdEdn.,Harcourt, Inc., 2001.

R. M. Silverstein, G. C. Bassler and T. C. Morrill, *Spectroscopic Identification of Organic Compounds*, 5th Edn., John Wiley & Sons, Inc., 1991.

D. H. Williams and I. Fleming, *Spectroscopic Methods in Organic Chemistry*, 5th Edn., Tata McGraw-Hill Edition, New Delhi, 2004.

William Kemp, *Organic Spectroscopy*, 3rdEdn.,Macmillan Press Ltd., 1991.

G. Siuzdak, *Mass Spectrometry for Biotechnology*, Academic Press, 2005.

H. Budzikiewicz, C. Djerassi and D. H. Williams, *Interpretation of Mass Spectra of Organic Compounds*, Holden-Day Inc., 1965.

J. S. Splitter and F. Tureček,*Applications of Mass Spectrometry to Organic Stereochemistry*, Wiley-VCH, 1994.

Atta-ur-Rahman and Md. Iqbal Choudhary, *Solving Problems with NMR Spectroscopy*, Academic Press, Inc., 1996.

Jag Mohan, *Organic Spectroscopy (Principles and Chemical* Applications), 2ndEdn.,Narosa Publishing House Pvt. Ltd., New Delhi, 2004.

Norman S. Bhacca and D. H. Williams, *Applications of NMR Spectroscopy in Organic Chemistry*, Holden-Day, Inc., 1964.

L. M. Jackman and S. Sternhell, *Applications of Nuclear Magnetic Resonance Spectroscopy In Organic* Chemistry, 2nd Edn., Pergamon Press, Oxford. Second Edition. 1969.

R. G. Linington, P. G. Williams and J. B. MacMillan, *Problems in Organic Structure Determination: A practical Approach to NMR Spectroscopy*, CRC Press, Taylor & Francis Group, 2016.

MCHEM 0103: Physical General I

Unit I

1. Quantum mechanics I (13 lectures)

Drawback of classical physics: A brief discussion on Black Body radiation, photo-electric effect and Double slit experiment .Wave-particle duality. Uncertainty principle, Operators in QM, Operator algebra, Commutation relation, Eigen functions and Eigen values, Postulates of QM, Ehrenfest's theorem, Schrodinger Equations, Theorems of QM. Few Model Systems, their solutions: Particle in 1-d Box, Selection Rules. Discussion on Bohr's correspondence principle. Checking the validity of Schrodinger wave equation based on correspondence principle and Heisenberg's Uncertainty principle Particle in 3-d Box, Particle in a ring and in a sphere, Tunneling.

2. Atomic and molecular spectroscopy: principle and application (12 lectures)

Review of basic spectroscopy, Hydrogen energy levels, spectroscopic transitions and selection rules, Multi-electron Atoms, Vector model, orbital and spin angular momentum of electrons, normal and anomalous Zeeman and Paschenback effects, Stern-Gerlach experiment, LS and jj coupling, spin-orbit coupling, atomic energy terms and term symbols,hyperfine structure

Rotational spectra: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, classical and quantum treatment of rotational and vibrational Raman spectra of diatomics, resonance Raman spectroscopy; NMR spectra: theory, relaxation process, spin interactions - its origin, equivalent protons, qualitative idea of energy levels of AX, AX_2 and AX_3 systems, a few representative examples

Unit II

3. Solutions thermodynamics and electrochemistry (15 lectures)

Partial molar quantities, significance and the determination of partial molar quantities, Thermodynamics of ideal and non-ideal binary solutions, excess functions and their determination, Activity co-efficients, Experimental determination of activity coefficients of electrolytes and non-electrolytes, Ion-Ion interactions, Debye-Huckel theory, Limiting and extended Debye Huckel equations for activity coefficients, ion-solvent interaction: Born model and Born equation, enthalpy of ion-solvent interaction and its calculation, Eley-Evan model, solvation number and methods for determination of solvation number, ion association: Bjerrum equation, fraction of ions associated, ion association constant; electrode kinetics: relation between current and rate of electrode reaction, current-overpotential relationship, Tafel equation and its importance

4. **Statistical thermodynamics** (10 lectures)

Motivation for study, Entropy and Probability, Stirling approximations, Maxwell-Boltzmann Distribution, Gibbs paradox, Sackur-Tetrode equation, concept of partition functions, translational, rotational, vibrational and electronic partition functions, Thermodynamic properties in terms of partition functions, Equilibrium constant , Equipartition principle, Einstein theory of specific heat capacity of solids.

Suggested books

L. Pauling and E. B. Wilson, *Introduction to Quantum Mechanics*, McGraw-Hill, New York, 1939.

H. Eyring, J. Walter and G. F. Kimball, *Quantum Chemistry*, Wiley, New York, 1944.

P. W. Atkins, *Molecular Quantum Mechanics*, Clarendon Press, Oxford, 1980.

L. I. Schiff, *Quantum Mechanics*, McGraw-Hill, New York, 1985.

A. K. Chandra, *Introductory Quantum Chemistry*, Tata McGraw-Hill Publishing Co, New Delhi, 1989.

F. L. Pilar, *Elementary Quantum Chemistry*, Tata McGraw-Hill, New Delhi, 1990.

D. A. McQuarrie, *Quantum Chemistry*, Viva Books Pvt. Ltd, New Delhi, 2003.

I. N. Levine, Quantum Chemistry, PHI Learning Pvt. Ltd, New Delhi, 2010.

M. Jammer, Conceptual Development of Quantum Mechanics, McGraw-Hill, 1966.

E. Merzbacher, Quantum Mechanics, Wiley, 1998.

S. M. Blinder, Introduction to Quantum Mechanics, Elsevier Academic, 2004.

H. E. White, *Introduction to Atomic Spectra*, McGraw-Hill Kogakusha Ltd., Tokyo, 1934.

G. M. Barrow, *Introduction to Molecular Spectroscopy*, McGraw-Hill International Book Company, Tokyo, 1982.

C. N. Banwell and E. M. McCash, *Fundamentals of Molecular Spectroscopy*, 4th Edn, Tata McGraw-Hill Publishing Company Ltd, New Delhi, 1994.

J. D. Graybeal, *Molecular Spectroscopy*, McGraw-Hill International Editions, Spectroscopy series, 1998.

D. A. McQuarrie and J. D. Simon, *Molecular Thermodynamics*, University Science Books, California, 1999.

I. N. Levine, *Physical Chemistry*, Tata McGraw-Hill, New Delhi, 1978. K. Denbigh, *Principles of Chemical Equilibrium*, Cambridge University Press, Cambridge, 1981. I. M. Klotz and R. M. Rosenberg, *Chemical Thermodynamics*, John Wiley, New York, 1994.

G. W. Castellan, *Physical Chemistry*, 3rd Edn, Narosa Publishing House, 1995.

N. A. Gokcen and R. G. Reddy, *Thermodynamics*, Plenum Press, New York, 1996.

G. K. Vemulapalli, *Physical Chemistry*, Prentice-Hall, India, 1997.

P. W. Atkins, *Physical Chemistry*, Oxford University Press, Oxford, 1998.

R. S. Berry, S. A. Rice and J. Ross, *Physical Chemistry*, Oxford University Press, Oxford, 2000.

J. O'M. Bockris and A. K. N. Reddy, *Modern Electrochemistry*, Vol I, Plenum Press, New York, 1970.

MCHEM 0104: Analytical General I

Unit I

1. Statistical methods in analytical methods (08 lectures)

Application of counting statistics in analytical and nuclear measurements: probability and binomial distribution, radioactivity as a statistical phenomenon, standard deviation of counting data, Poisson distribution, optimization of counting experiments

2. Separation techniques (17 lectures)

Preamble, successive extraction and separation; techniques of solvent extraction: Craig extraction and counter current distribution; ionic liquid assisted and supercritical solvent extraction, problems; chromatography: mathematical relations of capacity, selectivity factor, distribution constant and retention time; chromatogram, elution in column chromatography: band broadening and column efficiency; van Deemter equation; column resolution, numerical problems, gas chromatography, high performance chromatography and supercritical fluid chromatography: principles, methods, comparison and applications; size-exclusion chromatography, ion chromatography and capillary electrophoresis: principles, methods and applications

Unit II

3. Thermal methods (10 lectures)

Different methods of analysis: TGA, DTA, DSC; thermogram, applications, thermal stability of covalent and non-covalent bonds, thermal degradation, single crystal phase transformation, thermochemiluminescence, different types of titrations and their applications, solid state reaction kinetics

4. Elecroanlytical methods I (15 lectures)

Fundamentals, electrochemical cell, reference and indicator electrodes, supporting electrolyte, solvent, electrolytic process, three electrode system, DME, Ilkovic equation, Ilkovic-Heyrolsky equation, test of reversibility, current-voltage diagram, DC and AC polarography, Cottrell equation, stripping voltammetry, amperometric titration, membrane electrodes, electrode-solution interface layer, gas-sensing probe

Suggested books

D. A. Skoog, D. M. West and F. J. Holley, *Fundamentals in Analytical Chemistry*, 5th Edn, Saunders, Philadelphia, 1988.

G. D. Christian, *Analytical Chemistry*, 6th Edn, Wiley-India, New Delhi, 2004.

M. Koel and M. Kaljurand, *Green Analytical Chemistry*, RSC Publishing, Cambridge, 2010.

Y. Marcus and A. S. Kertes, *Ion Exchange and Solvent Extraction of Metal Complexes*, Wiley Interscience, New Jersey, 1969.

E. Heftman, *Chromatography*, Reinhold, New York, 1969.

H. F. Walton and W. Reiman, *Ion Exchange in Analytical Chemistry*, Pergamon Press, Oxford, 1970.

J. A. Dean, *Chemical Separation Methods*, Van Nostrand Reinhold, London, 1970.

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.

A. Tarter,*Advanced Ion Chromatography*, Wiley Interscience, New York, 1989.

S. Lindsay and J. Barnes, *High Performance Liquid Chromatography*, John Wiley, New York, 1992.

G. D. Christian, *Analytical Chemistry*, 5th Edn, Wiley, New York, 1994.

S. M. Khopkar, *Basic Concepts of Analytical Chemistry*, Wiley Eastern Ltd., New Delhi, 1998.

C. Duval, *Inorganic Thermogravimetric Analysis*, Elsevier Publishing Co, New York, 1963.

W. W. Wendlandt, *Thermal Methods of Analysis*, Interscience Publishers, New York, 1964.

R. C. McKenzie (Ed), *Differential Thermal Analysis*, Academic Press, New York, 1970.

D. R. Crow, *Polarography of Metal Complexes*, Academic Press, London, 1979.

A. J. Bard and L. F. Faulkner, *Electrochemical Methods – Fundamentals and Applications*, 2nd Edn, Wiley, New York, 1998.

C. G. Zoski (Ed) *Handbook of Electrochemistry*, Elsevier, New York, 2007.

J. Goodisman, *Electrochemistry: Theoretical Foundations*, Wiley, New York, 1987.

R. J. Gale (Ed), *Spectroelectrochemistry: Theory and Practice*, Plenum Press, New York, 1988.

J. O'M. Bockris and S. U. M. Khan, *Surface Electrochemistry*, Plenum Press, New York, 1993.

C. M. A. Brett and A. M. O. Brett, *Electrochemistry: Principles, Methods and Applications*, Oxford University Press, Oxford, 1993.

K. V. Kordesch, *Fuel Cells and Their Applications*, VCH, Weinheim, 1994.

D. T. Sawyer, A. Sobkowiak and J. L. Roberts, Jr, *Experimental Electrochemistry for Chemists*, 2nd Edn, Wiley, New York, 1995.

P. G. Bruce, *Solid-state Electrochemistry*, Cambridge University Press, Cambridge, 1995.

W. Schmickler, *Interfacial Electrochemistry*, Oxford University Press, Oxford, 1996.

C. A. Vincent and B. Scrosati, *Modern Batteries*, 2nd Edn, Arnold, London, 1997.

C. H. Hamann, A. Hamnett and W. Vielstich, *Electrochemistry*, Wiley-VCH, Weinheim, Germany, 2007.

Practical Papers (For Each, Full Marks: 50; Credit: 4)

MCHEM 0105: Inorganic General

1. Preparation/synthesis of inorganic and coordination compounds: selected simple salts, double salts and coordination compounds with some common inorganic and organic ligands
2. Characterization using microanalysis, conductivity measurement and spectroscopic analysis

MCHEM 0106: Organic General

1. Separation (chemical/column chromatographic) of binary mixtures of solid-solid/liquid-solid/liquid-liquid organic samples and identification of individual components
2. Synthesis of organic compounds involving important chemical reactions (halogenations, nitration, diazotisation, Beckmann transformation, photochemical reaction, Sandmayer reaction, pinacol-pinacolone rearrangement, etc.)

Semester-II

Theoretical Papers (For Each, Full Marks: 50; Credit: 4)

MCHEM 0201: Inorganic General II

Unit I

1. Chemistry of elements and their compounds (25 lectures)

Elements – structural versatility coupled with properties; compounds – design and benign synthesis, isolation, characterization, solution structure, molecular aggregate, crystalline architecture, spectral, magnetic and catalytic properties and application in chemistry, biology and materials science

Non-transition and transition metal ion homoleptic/heteroleptic and homonuclear/heteronuclear complexes of different dimensions with varied mono- and polydentate blockers containing carbon, nitrogen, phosphorus, chalcogen, halogen donors with/without mono-/polydentate pure/mixed bridges and counter ions

Mono- and polynuclear compounds of lanthanoid and actinoid ions stressing on choice of different multidentate chelators and congregators with special emphasis on electric, magnetic, conducting, superconducting and fluorophoric behaviours

Unit II

2. Inorganic reaction mechanism I (13 lectures)

Preamble, factors affecting the rate of a chemical reaction, analysis of rate data, complex rate laws, kinetically indistinguishable schemes, nucleophilicity and rate scales: Edward scale, n_{Pt} scale, Gutmann donor number, Drago E & C scale, trans- and cis- effects, water exchange rates, proton ambiguity, mechanistic simulation; associative, dissociative, interchange, nucleophilic, electrophilic, insertion pathways; Hammett relation, application of LFER in chemical kinetics

3. Cluster compounds (12 lectures)

Classification, elemental clusters, cluster skeletal electron (Elm) counting, higher boron hydrides-structures and reactions, equation of balance, Lipscomb topological diagrams, polyhedral skeletal electron pair theory (PSEPT), carboranes, metalloboranes and heteroboranes, metallocarboranes, zintl ions, chevrel compounds, infinite metal chains, multidecker molecules, cluster-surface analogy

Suggested books

J. D. Lee, *Concise Inorganic Chemistry*, Chapman and Hall, London, 1991.

N. N. Greenwood and A. Earnshaw, *Chemistry of the Elements*, 2nd Edn, Pergamon, New York, 1997.

F. A. Cotton, G. Wilkinson, C. M. Murillo and M. Bochmann, *Advanced Inorganic Chemistry*, 6^{th} Edn, John Wiley & Sons, Inc, New York, 1999.

G. Wulfsberg, *Inorganic Chemistry*, Viva Books Pvt. Ltd, New Delhi, 2001.

B. Douglas, D. McDaniel and J. Alexander, *Concepts and Models of Inorganic Chemistry*, 3rd Edn, John Wiley & Sons, Inc, New York, 2001.

P. Atkins, T. Overton, J. Rourke, M. Weller and F. Armstrong, *Shriver & Atkins Inorganic Chemistry,* 4th Edn, Oxford, 2006.

J. E. Huheey, E. A. Keiter, R. L. Keiter and O. K. Medhi, *Inorgnic Chemistry: Principles of Structures and Reactivity*, 4th Edn, Pearson, New Delhi, 2006.

R. Xu, W. Pang and Q. Huo (Eds), *Modern Inorganic Synthetic Chemistry*, Elsevier, New York, 2011.

J. Crowe, T. Bradshaw and P. Monk, *Chemistry of Biosciences,* Oxford University Press, Oxford, 2006.

G. L. Miessler and D. A. Tarr, *Inorganic Chemistry*, 3rd Edn, Pearson, New Delhi, 2009.

J. R. Anderson and M. Boudart (Eds), *Catalysis: Science and Technology*, Springer, London, 2012.

G. Cao, *Nanostructures & Nanomaterials, Synthesis, Properties & Applications*, Imperial College Press, London, 2004.

L. Cademartiri and G. A. Ozin, *Concepts of Nanochemistry*, Wiley-VCH, Weinheim, 2009.

A. von Zelewsky, *Stereochemistry of Coordination Compounds*, Wiley, New York, 1996.

S. P. Sinha, *Systematics and Properties of Lanthanides*, Riedel, Dordrecht, 1983.

J. J. Katz, G. T. Seaborg and L. R. Morss (Eds), *The Chemistry of the Actinide Elements*, Vols I and II, 2nd Edn, Chapman and Hall, London, 1986.

J. W. Steed and J. L. Atwood, *Supramolecular Chemistry*, 2nd Edn, John Wiley and Sons, New York, 2009.

I. Pelant and J. Valenta, *Luminescence Spectroscopy of Semiconductors, Oxford*, New York, 2012.

J. O. Edwards and W. A. Benjamin, *Inorganic Reactions Mechanism*, INC, New York, 1965.

C. H. Langford and H. B. Gray, *Ligand Substitution Processes*, W. A. Benjamin, New York, 1966.

F. Basolo and R. G. Pearson, *Mechanism of Inorganic Reactions*, 2nd Edn, Wiley, New York, 1967.

D. Katakis and G. Gordon, *Mechanisms of Inorganic Reactions*, John Wiley & Sons, New York, 1987.

R. G. Wilkinns, *Kinetics and Mechanism of Reactions of Transition Metal Complexes*, 2nd Edn, VCH, Weinheim, 1991.

R. B. Jordan, *Reaction Mechanisms of Inorganic and Organometallic Systems*, Oxford University Press, Oxford, 1998.

J. D. Atwood, *Inorganic and Organometallic Reaction Mechanisms*, 2nd Edn, Wiley-VCH, Weinheim, 1997.

M. B. Wright, *Fundamental Chemical Kinetics – An Explanatory Introduction to the Concepts*, Harwood Publishing, Chichester, 1999.

S. Asperger, *Chemical Kinetics and Inorganic Reaction Mechanisms*, 2nd Edn, Springer, London, 2012.

C. E. Housecroft, *Cluster Molecules of the p-Block Elements*, Oxford University Press, Cambridge, 1994.

M. H. Chisholm (Ed), *Early Transition Metal Clusters with π-Donor Ligands*, VCH, New York, 1995.

D. M. P. Mingos (Ed.), *Structural and Electronic Paradigms in Cluster Chemistry*, Springer, Berlin, 1997.

P. Braunstein, L. A. Oro and P. R. Raithby (Eds), *Metal Clusters in Chemistry*, Wiley-VCH, Weinheim, 1999.

M. Driess and H. Noth (Eds), *Molecular Clusters of the Main Group Elements*, Wiley-VCH, Weinheim, 2004.

T. P. Fehlner, J. -F. Halet and J. -Y. Saillard, *Molecular Clusters - A Bridge to Solid State Chemistry*, Cambridge University Press, Cambridge, 2007.

C. E. Housecraft and A. G. Sharpe, *Inorganic Chemistry*, 3rd Edn, Pearson Education Ltd, Essex, England, 2008.

MCHEM 0202: Organic General II

Unit I

1. Organic name reactions (10 lectures)

Baeyer-Villiger oxidation; Barton reaction; Beckmann rearrangement; Birch reduction; Claisen rearrangement; Favorskii reaction; Fries rearrangement; Heck reaction; Mannich reaction; McMurry reaction; Michael addition; Perkin reaction; Sharpless asymmetric epoxidation; Stile coupling; Strecker reaction; Suzuki coupling; Wittig reaction; Yamaguchi esterification

2. Reaction intermediates (09 lectures)

Generation, stability & structure, and reactivity of the reaction intermediates, *viz.* carbocations, carbanions, carbon free-radicals, carbenes, benzynes and nitrenes

3. Synthetic polymers and biopolymers (06 lectures)

Introduction to polymers - synthetic polymers;principles of macromolecular synthesis: step-growth vs. chain-growth polymerizations; Dendrimers: Dendritic polymers and their potential applications; chemistry of biopolymers (carbohydrates, proteins, and nucleic acids)

Unit II

4. Chemistry of natural products: Chemistry and function (15 lectures)

Chemistry and function of some major groups of natural products such as terpenoids (*monoterpenoids*: geraniol, alpha-pinene, camphor, menthol, carvone; *sesquiterpenoids*: farnesol, zingiberine, caryophyllene, santonin; *diterpenoids*: abietic acid, taxol; *triterpenoids*: beta-amyrene, oleanolic acid, ursolic acid), alkaloids (papaverine, emitene, morphine, quinine, nicotine, ephedrine) andcarbohydrates (monosaccharides and disaccharides); concepts on biosynthetic pathways (*mevalonic acid*, *geranyl pyrophosphate*, *shikimic acid*) for natural products

5. Medicinal chemistry (10 lectures)

Concept of drug design (physiochemical principles and basis of drug design, quantitative description, physicochemical approach of drug molecules, different methods of drug design, Free Wilson method and its application to extrathermodynamic approach);pharmacodynamic and pharmacokinetic (drug absorption, distribution, metabolism and excretion) aspects;drug targets (enzymes, receptors, nucleic acids); membranes and receptors (drug transport mechanism and absorption processes, prodrugs and bioactivation, receptor theories and receptor models, drug receptor interactions); concept on lead compounds and lead modifications; pharmacophore; structure-activity relationship (SAR); clinical trials; bioavailability; computer-aided drug design(*de novo* design), docking procedures and molecular modeling; discussion with suitable examples of choice.

Suggested books

A. Hassner, I. Namboothiri, *Organic Syntheses Based on Name Reactions*, 3rd Edn., Elsevier, 2012.

B. P. Mundy and M. G. Ellerd,*Name Reactions and Reagents in Organic Synthesis*, John Wiley & Sons, 1988.

L. Kürti and B. Czakó, *Strategic Applications of Named Reactions in Organic Synthesis: Background and Detailed Mechanisms*, Elsevier Academic Press, 2005.

Z. Wang, *Comprehensive Organic Name Reactions and Reagents*, Wiley-VCH, 2009.

J. J. Li, *Name Reactions: A Collection of Detailed Reaction Mechanisms*, Springer, 2014.

G. Brahmachari, *Organic Name Reactions: A Unified Approach*, Narosa Publishing House Pvt. Ltd., New Delhi, 2012.

Michael B. Smith and Jerry March, *March's Advanced Organic Chemistry (Reactions, Mechanisms, and Structure)*, 5th Edn, John Wiley & Sons, Inc., 2001.

Reinhard Bruckner, *Advanced Organic Chemistry (Reaction Mechanisms)*, Harcourt/Academic Press, 2002.

Reinhard Bruckner, *Advanced Organic Chemistry (Reaction Mechanisms)*, Harcourt/Academic Press, 2002.

J. Clayden, N. Greeves, S. Warren and P. Wothers, *Organic Chemistry*, Oxford University Press, 2001.

F. A. Carry and R. J. Sundberg, *Advanced Organic Chemistry – Part-A and B*, 5th Edn, Springer, 2007.

L. G. Wade, Jr. and M. S. Singh, *Organic Chemistry*, 6th Edn, Pearson Education, 2008.

T. G. Graham and C. B. Fryhle, *Organic Chemistry*, 8th Edn, John Wiley & Sons, 2004.

C. J. Moody, *Reactive Intermediates*, Oxford University Press, 1992.

R. T. Morrison, R. N. Boyd and S. K. Bhattacharjee, *Organic Chemistry*, 7th Edn, Pearson Education, 2013.

S. Ebnesajjad, *Handbook of Biopolymers and Biodegradable Plastics: Properties, Processing and Applications*, PDL handbook series, William Andrew, 2013.

A. Walton, *Biopolymers*, Elsevier, 2012.

D. Plackett, *Biopolymers - New Materials for Sustainable Films and Coatings*, John Wiley & Sons, 2011.

P.J. Flory, *Principles of Polymer Chemistry,* Cornell University Press, 1953

M.M. Coleman and P.C. Painter, *Fundamentals of Polymer Science – An Introductory Text*, CRC Press, Taylor & Francis, 1998.

M.P. Stevens, *Polymer Chemistry: An Introduction*, Oxford University Press, 1998.

J.N. Nicholson, *The Chemistry of Polymers*, Royal Society of Chemistry, 2012.

D. A. Tomalia, J. B. Christensen and U. Boas, *Dendrimers, Dendrons and Dendritic Polymers: Discovery, Applications and the Future,* Cambridge University Press, 2012.

S. R. Sharma, *Biomolecules*, Discovery Publishing House, 2003.

R. J. Simmonds,*Chemistry of Biomolecules: An Introduction 1st Edition*, Royal Society of Chemistry, 2002.

D. Feldman and A. Barbalata, *Synthetic Polymers: Technology, Properties and Applications*, Springer, 1996.

G. Brahmachari, *Bioactive Natural Products*: *Chemistry & Biology*, Wiley-VCH, 2015.

S. K. Talapatra and B. Talapatra, *Chemistry of Plant Natural Products*, Springer, 2012.

T. Ogura, *Dynamic Aspects of Natural Products Chemistry*, CRC Press, 1997.

A. E. Osbourn and Lanzotti, V., *Plant-derived Natural Products: Synthesis, Function, and Application,* Springer, 2009.

J. R. Hanson, *Natural Products: The Secondary Metabolites*, Royal Society of Chemistry, 2003.

S. Hanessian,*Natural Products in Medicinal Chemistry: Methods and Principles in Medicinal Chemistry*, Wiley-VCH, 2014.

G. Brahmachari, *Handbook of Pharmaceutical Natural products – Vols. 1 and 2*, Wiley-VCH, 2010.

G. Brahmachari, *Chemistry and Pharmacology of Naturally Occurring Bioactive Compounds*, CRC Press, Taylor & Francis, 2013.

G. Brahmachari, *Bioactive Natural Products: Opportunities and Challenges in Medicinal Chemistry*, World Scientific Publishing Co., 2011.

S. V. Bhat, B. A. Nagasampagi and M. Sivakumar, *Chemistry of Natural Products*, Narosa Publishing House, New Delhi, 2005.

X. -T. Liang and W. -S. Fang, *Medicinal Chemistry of Bioactive Natural Products*, John Wiley & Sons, 2006.

P. Manitto, *Biosynthesis of Natural Products*, Ellis Horwood Ltd., 1981.

G. L. Patrik, An Introduction to Medicinal Chemistry, 3rd Edn, Oxford University Press, 2006.

C. G. Wermuth (Ed), The Practice of Medicinal Chemistry, Academic Press, Noida, India, 2008.

G. Thomas, *Fundamentals of Medicinal Chemistry*, 5th Edn, Oxford University Press, 2013.

R. B. Silverman, *The Organic Chemistry of Drug Design and Drug Action*,3rd Edn, Academic Press, 2014.

M. P. S. Ishar and A Faruk, *Syntheses of Organic Medicinal Compounds*, Alpha Science, 2006.

D. R. Budman,A. H. Calvert and E. K. Rowinsky, *Handbook of Anticancer Drug Development*, Lippincott Williams & Wilkins, Philadelphia, PA, USA, 2003.

E. Garrett-Meyer, *Principles of Anticancer Drug Development*, Springer, 2010.

MCHEM 0203: Physical General II

Unit I

1. Symmetry and group theory (25 lectures)

Concept of symmetry, symmetry elements and symmetry operations, optical activity, concept of groups, point symmetry groups, class, group multiplication tables, matrix representation, equivalent and reducible representations, irreducible representations, great orthogonality theorems statement and interpretation, proof of its corollaries, character table and its construction, number of times an irreducible representation occurs in a reducible one; the reduction of reducible representations, notation of irreducible representations, link between group theory and quantum mechanics, direct product representations, vanishing integrals and projection operators

Unit II

2. Quantum mechanics II (15 lectures)

Harmonic Oscillator: solution of Schrodinger equation of a harmonic oscillator using the operator method as well as the technique for solution of differential equation, selection rules for harmonic oscillator, checking the validity of Schrodinger wave equation based on correspondence principle, Heisenberg's Uncertainty principle, QM of rotational motion; angular momentum operators and their commutation relations, operator algebra and Ladder operators for rotational motion, solution of Schrodinger equation using the operator method as well as the technique for solution of differential equation, quantum mechanics of rigid rotor and its application

Hydrogen atom: Separation of translational and internal motion of a two-body problem, determination of radial part of the wave function, relation among principal, azimuthal and magnetic quantum number, nodal properties of angular part as well as the radial part of the hydrogen atom wave function, shape of the orbitals, space quantization, selection rules for hydrogen atom.

3. Chemical Kinetics (10 lectures)

Transition state theory, potential energy surfaces, concept of imaginary frequency, thermodynamic treatment of reaction rates, energy of activation, volume of activation, reactions in solutions, diffusion and activation controlled reactions, influence of solvent dielectric constant and ionic strength on reaction rates, linear free energy relationship, effect of substituents, Hammett's and Taft's constants, Hammet's acidity functions, Oscillatory reactions

Suggested books

S. C. Rakshit, *Molecular Symmetry Group and Chemistry*, The New Book Stall, Kolkata, 1988.

V. Heine, *Group Theory in Quantum Mechanics: An Introduction to Its Present Usage*, Dover Publication, New York, 1991.

D. M. Bishop, *Group Theory and Chemistry*, Oxford University Press, Oxford, 1993.

A. Vincent, *Molecular Symmetry and Group Theory*, John Wiley & Sons, New York, 1998.

F. A. Cotton, *Chemical Applications of Group Theory*, 3rd Edn, John Wiley & Sons, New York, 1999.

L. Pauling and E. B. Wilson, *Introduction to Quantum Mechanics*, McGraw-Hill, New York, 1939.

H. Eyring, J. Walter and G. F. Kimball, *Quantum Chemistry*, Wiley, New York, 1944.

P. W. Atkins, *Molecular Quantum Mechanics*, Clarendon Press, Oxford, 1980.

L. I. Schiff, *Quantum Mechanics*, McGraw-Hill, New York, 1985.

A. K. Chandra, *Introductory Quantum Chemistry*, Tata McGraw-Hill Publishing Co, New Delhi, 1989.

F. L. Pilar, *Elementary Quantum Chemistry*, Tata McGraw-Hill, New Delhi, 1990.

D. A. McQuarrie, *Quantum Chemistry*, Viva Books Pvt Ltd, New Delhi, 2003.

I. N. Levine, Quantum Chemistry, PHI Learning Pvt. Ltd, New Delhi, 2010.

M. Jammer, Conceptual Development of Quantum Mechanics, McGraw-Hill, 1966.

E. Merzbacher, Quantum Mechanics, Wiley, 1998.

S. M. Blinder, Introduction to Quantum Mechanics, Elsevier Academic, 2004.

K. J. Laidler, *Reaction Kinetics*, Vols I and II, Pergamon Press, London, 1970.

L. P. Hammett, *Physical Organic Chemistry*, McGraw-Hill Book Company, New Delhi, 1970.

J. Albery, *Electrode Kinetics*, Oxford Chemistry Series, Clarendron Press, Oxford, 1975.

K. J. Laidler, *Chemical Kinetics*, Tata McGraw-Hill Publishing Company Ltd, New Delhi, 1988.

M. R. Wright, *Fundamental Chemical Kinetics*, Horwood Publishing, 1999.

MCHEM 0204: Analytical General II

Unit I

1. Nuclear force, structures and properties (18 lectures)

Fundamentals, nuclear composition, different nuclear forces; concept of nuclear angular momentum, magnetic dipole moment and electronic quadruple moment (elementary idea), nuclear magnetic dipole moment and electric quadruple moment in terms of shell model, parity of nuclear energy states; liquid drop model, formulation of semi-empirical binding energy equation, mass parabola and application of binding energy equation; nuclear reactions, Q-value and cross section of nuclear reaction, compound nucleus theory, shell model, nuclear magic number and its derivation from nuclear potential well, calculation of nuclear spin, nuclear isomerism and non-optical transitions; two body problem - properties of deuteron and derivation of depth-range relationship, its applications in explaining nature of nuclear force, nuclear models - strong and weak interaction, collective model, Fermi gas model, nuclear excitation, idea of nuclear temperature and entropy

2. Nuclear quadruple resonance and Mossbauer spectroscopy (07 lectures)

NQR, Mossbauer effect - conditions, nuclear recoil, Doppler effect, instrumentation, chemical shift examples, quadrupole effect, effect of magnetic field, effect of simultaneous electric and magnetic fields, typical spectra of iron and tin compounds

Unit II

3. Theory of radioactive decay and radioactive equilibrium (10 lectures)

Introduction, quantum mechanical aspects of radioactive disintegration, alpha decay paradox and its explanation in terms of tunnel effect, Geiger-Muller relationship, time-dependant perturbation theory, Golden rule and its application in explaining beta and gamma transition, selection rules

Successive disintegration, Bateman equation, secular and transient equilibrium, no equilibrium; analysis of special types of successive disintegration, formation of radioelement in a nuclear reaction, activation analysis

4. Surfactants and utility (07 lectures)

Preamble, surface excess; classification of surfactants BET isotherm, LB film, membrane equilibrium, micellaisation,Kraft temperature, synthetic application of micellar catalysis, mixed micelles, foaming of surfactant solution, different types of interface, emulsion and emulsifier, photochemistry and redox reaction in micellar systems, nanoemulsion and stabilisation

5. Environmental chemistry (08 lectures)

Sustainable development, twelve principles of green chemistry and implementations, atom economy, environmental E-factor, role of catalysts, microwave and ultrasound irradiation in green synthesis, traditional and alternative commercial syntheses of ibuprofen, adipic acid and maleic acid etc, green chemistry in action developing foam, whitening agent, detergent builders, green insecticides, biosynthesis of synthetic chemical, photochemical reactions in atmosphere, photochemical smog and stratospheric ozone depletion; chemicals from renewable feedstock

Suggested books

B. Harvey, *Introduction to Nuclear Physics and Chemistry*, Prentice Hall, New York, 1965.

S. Glasstone, *Source Book of Atomic Energy*, East-West Press Private Ltd, New Delhi, 1967.

R. D. Evans, *The Atomic Nucleus*, McGraw-Hill, New York, 1979.

G. R. Choppin and J. Rydberg, *Nuclear Chemistry: Theory and Applications*, Pergamon Press, Oxford, 1980.

G. Friedlander, J. W. Kennedy, E. S. Macias and J. M. Miller, *Nuclear and Radiochemistry*, 3rd Edn, Jhon Wiley & Sons Inc, New York, 1981.

H. J. Arnikar, *Essentials of Nuclear Chemistry*, 4th Edn, New Age International (P) Ltd Publications, New Delhi, 2001.

D. D. Sood, A.V. R Reddy and N. Ramamoorty, *Fundumentals of Radiochemistry*, Yancas, Mumbai, 2004.

W. D. Loveland, D. J. Morrissey and G. T. Seaborg, *Modern Nuclear Chemistry*, Wiley Interscience, New Jersey, 2006.

V. I. Goldanskii and R. H. Herber, *Chemical Applications of Mossbauer Spectroscopoy*, Academic Press, New York, 1968.

N. N. Greenwood and T. C. Gibb, *Mossbauer Spectroscopy*, Chapman and Hall, London, 1971.

R. S. Drago, *Physical Methods for Chemists*, Saunders, Philadelphia, 1992.

J. M. Hollas, *Modern Spectroscopy*, Wiley, New York, 1996.

D. D. Clayton, *Principles of Steller Evolution and Nucleosynthesis,* Chicago University Press, Chicago, 1983.

K. Heyde, *Basic Ideas and Concepts in Nuclear Physics*, IOP, Briston, 1999.

G. R. Choppin, J. O. Liljenjin and J. Rydberg, *Radiochemistry and Nuclear Chemistry,* Butterworth-Heinmann, Woburu, 2002.

Y.Moroi, *Micelles, Theoretical and Applied Aspects*, Plenum Press, New York, 1992.

M. M. Rieger and L. D. Rheis (Eds), *Surfactants in Cosmetics*, Marcel Dekker Inc, New York, 1997.

K. Holmberg, B. Jonsson, B. Kronberg and B. Lindman, *Surfactants and Polymers in Aqueous Solution,* John Wiley & Sons, New York, 2002.

M. N. Khan, *Miceller Catalysis*, Taylor and Francis Group, New York, 2007.

T. F. Tadros (Ed), *Emulstion Science and Technology*, Willey-VCH, Verlag GmbH and Co, 2009.

O. Hutzinger (Ed), *The Handbook of Environmental Chemistry*, Springer-Verlag, Weinheim, 1980.

D. F. S. Natusch and P. K. Hopke, *Analytical Aspects of Environmental Chemistry*, John Wiley & Sons, New York, 1983.

R. M. Harrison (Ed), *Pollution: Causes, Effects and Control*, Royal Society of Chemistry, Great Britain, 1990.

J. E. Fergusson, *The Heavy Elements: Chemistry, Environmental Impact and Health Effects*, Pergamon Press, Oxford, 1990.

S. E. Manahan, *Environmental Chemistry*, Lewis Publishers, Boston, 1991.

R.Sanghi and V. Singh, *Green Chemistry for environmental remediation*, Wiley, New York, 2012.

Practical Papers (For Each, Full Marks: 50; Credit: 4)

MCHEM 0205: Physical General

1. Experiments in equilibrium and kinetics
3. Instrumental methods: colorimetry polarimetry, conductometry and potentiometry
4. Data processing and elementary numerical techniques

MCHEM 0206: Analytical General

1. Experiments on quantitative estimation: analysis of selected ores and alloys
2. Separation techniques involving ion-exchange and solvent extraction
3. Titrimetric estimation of different organic compounds
4. Beer’s law: application in different chemical matrices

Extra Departmental Electives (Full Marks: 50; Credit: 4)

MCHEM 0207: Supramolecular & Medicinal Chemistry

Concept and language, choice of building blocks – a sheer necessity, atomic and molecular valences, supramolecular orbitals, principle of three C’s, pallet of non-covalent forces such as hydrogen bond, π…π, C-H…π, halogen…π, S…π, cation…π, hydrophobic, hydrophilic etc interactions and their harnessing towards crystal engineering, structure directed supramolecular arrays, allosterism, proton and hydride sponges, lock and key principle, host-guest interaction, self organization and self complementarity, superstructures in organic, inorganic, metallo-organic and organometallic compounds, 0D, 1D, 2D, 3D architectures and hierarchies, crystal synthesis, supramolecular devices, deliberate isolation of different functional materials,molecular receptor and specific molecular recognition

Drug discovery and history of medicinal chemistry, drug and medicine, physiochemical principles and basis of drug design, pharmacodynamic and pharmacokinetic (drug administration, dosing, absorption, distribution, metabolism and excretion) aspects; drug targets (enzymes, receptors, nucleic acids); prodrugs and bioactivation, concept on lead compounds and lead modifications; pharmacophore; structure-activity relationship, clinical trials; bioavailability; computer-aided drug design; uses of different drugs and medicines: carcinogenesis, applications of chelators and metal chelates of different generations; antitumour, anticancer and anti-AIDS drugs, mechanistic pathway, limitation, future dimension

Suggested books

F. Vogtle, *Supramolecular Chemistry: An Introduction*, Wiley, Chichester, 1991.

B. Dietrich, P. Viout and J. -M. Lehn, *Macrocyclic Chemistry – Aspects of Organic and Inorganic Supramolecular Chemistry*, VCH, Weinheim, 1993.

J. -M. Lehn, *Supramolecular Chemistry: Concepts and Perspectives*, VCH, Weinheim, 1995.

G. A. Jeffrey, *An Introduction to Hydrogen Bonding,* Oxford University Press, Oxford, 1997.

S. T. Hyde, B. Ninham, S. Anderson, Z. Blum, T. Landh, K. Larsson and S. Liddin, *The Language of Shape*, Elsevier, Amsterdam, 1997.

G. R. Desiraju (Ed), *Crystal Design: Structure and Function, Perspectives in Supramolecular Chemistry*, Vol 7, Wiley, Chichester, 2003.

J. W. Steed and J. L. Atwood,*Supramolecular Chemistry*, 2nd Edn, John Wiley & Sons, New York, 2009.

K. Rurack and R. Martinez-Manez (Eds), *The Supramolecular Chemistry of Organic-Inorganic Hybrid Materials,* John Wiley & Sons, Hoboken, New Jersey, 2010.

E. R. T. Tiekink and J. Zukerman-Schpector (Eds), *The Importance of Pi-Interactions in Crystal Engineering: Frontiers in Crystal Engineering*, 1st Edn, John Wiley & Sons, Chichester, UK, 2012.

G. L. Patrik, *An Introduction to Medicinal Chemistry*, 3rd Edn, Oxford University Press, 2006.

C. G. Wermuth (Ed), *The Practice of Medicinal Chemistry*, Academic Press, Noida, India, 2008.

X. -T. Liang and W. -S. Fang, *Medicinal Chemistry of Bioactive Natural Products*, John Wiley & Sons, 2006.

S. Sánchez and A. L. Demain, *Antibiotics: Current Innovations and Future Trends*,Caister Academic Press, 2015.

K. Chatterjee and E. J. Topol, *Cardiac Drugs*, 1st Edn, Jaypee Brothers Medical Pub., 2013.

W. H. Frishman and D. A. Sica, *Cardiovascular Pharmacotherapeutics,* 3rd Edn, CardioText, 2011.

Atta-ur-Rahman and M. I. Choudhary, *Frontiers in Cardiovascular Drug Discovery*, Bentham Publications, 2010.

S. Quideau, *Chemistry and Biology of Ellagitannins*, World Scientific Publishing Co., 2009.

X. -T. Liang and W. -S. Fang, *Medicinal Chemistry of Bioactive Natural Products*, John Wiley & Sons, 2006.

G. Brahmachari, *Bioactive Natural Products*: *Chemistry & Biology*, Wiley-VCH, 2015.

S. Hanessian, *Natural Products in Medicinal Chemistry: Methods and Principles in Medicinal Chemistry*, Wiley-VCH, 2014.

G. Brahmachari, *Handbook of Pharmaceutical Natural products , Vols. 1 and 2*, Wiley-VCH, 2010.

G. Brahmachari, *Chemistry and Pharmacology of Naturally Occurring Bioactive Compounds*, CRC Press, Taylor & Francis, 2013.

G. Brahmachari, *Bioactive Natural Products: Opportunities and Challenges in Medicinal Chemistry*, World Scientific Publishing Co., 2011.

X. -T. Liang and W. -S. Fang, *Medicinal Chemistry of Bioactive Natural Products*, John Wiley & Sons, 2006.

G. Thomas, *Fundamentals of Medicinal Chemistry*, 5th Edn, Oxford University Press, 2013.

R. B. Silverman, *The Organic Chemistry of Drug Design and Drug Action*, 3rd Edn, Academic Press, 2014.

M. P. S. Ishar and A Faruk, *Syntheses of Organic Medicinal Compounds*, Alpha Science, 2006.

D. R. Budman, A. H. Calvert and E. K. Rowinsky, *Handbook of Anticancer Drug Development*, Lippincott Williams & Wilkins, Philadelphia, PA, USA, 2003.

E. Garrett-Meyer, *Principles of Anticancer Drug Development*, Springer, 2010.

Semester-III

Theoretical Papers (For Each, Full Marks: 50; Credit: 4)

MCHEM 0301: Advanced Inorganic General

Unit I

1. Structure and properties of solids (13 lectures)

Fundamentals, ionic, covalent, metallic hydrogen bonded and molecular solids; perovskite, ilmenite and rutile; spinel and inverse spinel, diamond cubic, silicates: single/double chain, 3D network, pyroxene, amphibole, talc, mica, clay, zeolite; crystal defects, non-stoichiometric compounds; electronic properties of solids, F-centre, conductors, insulators, semiconductors, superconductors; ferroelectricity, antiferroelectricity, pyroelectricity, piezoelectricity, liquid crystals, cooperative magnetism.

2. Metal ion promoted reactions (12 lectures)

Fundamentals, simple cycle, catalytic cycle, pliancy of substrates, Tolman catalytic loop, homogeneous/heterogeneous catalysis: Wacker-Smidt synthesis, Monsanto acetic acid process, hydrogenation by Wilkinson's catalyst, water gas shift reaction (WGSR), Fischer-Tropsch synthesis, hydrosilation, hydrophosphilynation, hydroamination, hydrocyanation and hydroboration reactions, reactions on inorganic functional groups

Unit II

3. Molecular magnetism I (13 lectures)

Classification of magnetic materials, van Vleck equation and its application, Curie-Weiss law and its implication, Lande interval rule, microstates, multiplet, multiplet width, hole formalism, zero-field splitting, spin-orbit coupling, quenching of orbital contribution, Fermi contact and pseudo-contact shifts, chemical shift reagent

4. Supramolecular Chemistry I (12 lectures)

Concept and language, scientific/technological landscape, building block, atomic and molecular valences, supramolecular orbitals, pallet of non-covalent forces and their harnessing towards crystal engineering, structure directed supramolecular arrays, crystal synthesis, deliberate isolation of different functional materials

Suggested books

A. F. Wells, *Structural Inorganic Chemistry*, 5th Edn, Oxford University Press, Oxford, 1984.

W. A. Harrison, *Electronic Structure and the Properties of Solids: The Physics of the Chemical Bonds*, Dover Publications, New York, 1989.

D. M. Adams, *Inorganic Solids*, Wiley, New York, 1992.

T. C. W. Mak and G. -D. Zhou, *Crystallography in Modern Chemistry*, Wiley, New York, 1992.

S. R. Elliot, *The Physics and Chemistry of Solids*, John Wiley & Sons, Chichester, 1998.

M. Cox, *Optical Properties of Solids*, Oxford University Press, Oxford, 2001.

L. E. Smart and E. A. Moore, *Solid State Chemistry: An Introduction*, 4th Edn, CRC Press, Boca Raton, FL, 2012.

A. R. West, *Solid State Chemistry and Its Application*, 2nd Edn, Wiley-VCH, Weinheim, 2014.

G. W. Parshall, *Homogeneous Catalysis*, Wiley, New York, 1980.

C. N. Satterfield, *Heterogeneous Catalysis in Practice*, McGraw-Hill, New York, 1980.

O. N. Temkin, *Homogeneous Catalysis with Metal Complexes: Kinetic Aspects and Mechanisms*, John Wiley & Sons, New York, 2012.

M. Beller, A. Renken and R. A. van Santen, *Catalysis*, Wiley, New York, 2012.

M. M. Rieger and L. D. Rheis (Eds), *Surfactants in Cosmetics*, Marcel Dekker Inc, New York, 1997.

M. N. Khan, *Miceller Catalysis*, Taylor and Francis Group, New York, 2007.

O. Kahn, *Molecular Magnetism*, VCH, New York, 1993.

P. Day and A. E. Underhill (Eds), *Metal-organic and Organic Molecular Magnets*, RSC, London, 2000.

J. S. Miller and M. Drillon (Eds), *Magnetism: Molecules to Materials, V; Molecule-based Magnets*, Wiley-VCH, Weinheim, 2005.

F. E. Mabbs and D. J. Machin, *Magnetism and Transition Metal Complexes*, Dover Publications, New York, 2008.

R. Winpenny (Ed), *Single-Molecule Magnets and Related Phenomena*, Structure and Bonding Series, Vol 122, Springer, Berlin, 2010.

B. D. Cullity and C. D. Graham, *Introduction to Magnetic Materials*, 2nd Edn, John Wiley & Sons, New York, 2011.

D. Gatteschi, R Sessoli and J. Villain, *Molecular Nanomagnets*, Oxford University Press, Oxford, 2006.

R. Hilzinger and W. Rodewald, *Magnetic Materials*, Wiley, New York, 2013

F. Vogtle, *Supramolecular Chemistry: An Introduction*, Wiley, Chichester, 1991.

V. Balzani and F. Scandola, *Supramolecular Photochemistry*, Ellis Horwood, Chichester, 1991.

J. -M. Lehn, *Supramolecular Chemistry: Concepts and Perspectives*, VCH, Weinheim, 1995.

G. A. Jeffrey, *An Introduction to Hydrogen Bonding*, Oxford University Press, Oxford, 1997.

S. T. Hyde, B. Ninham, S. Anderson, Z. Blum, T. Landh, K. Larsson and S. Liddin, *The Language of Shape*, Elsevier, Amsterdam, 1997.

C. N. R. Rao, A. Muller and A. K. Cheetham, *Nanomaterials Chemistry: Recent Developments and New Directions*, Wiley-VCH, Weinheim, Germany, 2007.

C. C. Koch, *Nanostructured Materials Processing, Properties, and Applications*, William Andrew Inc, 2007.

J. W. Steed and J. L. Atwood,*Supramolecular Chemistry*, 2nd Edn, John Wiley & Sons, New York, 2009.

K. Rurack and R. Martinez-Manez (Eds), *The Supramolecular Chemistry of Organic-Inorganic Hybrid Materials*, John Wiley & Sons, Hoboken, New Jersey, 2010.

E. R. T. Tiekink and J. Zukerman-Schpector (Eds), *The Importance of Pi-Interactions in Crystal Engineering: Frontiers in Crystal Engineering*, 1st Edn, John Wiley & Sons, Chichester, 2012.

MCHEM 0302: Advanced Organic General

Unit I

1. Green chemistry: Concept, practice and aspects in current synthetic chemistry (08 lectures)

The concept and 'Twelve Principles' of green chemistry; current-day need in chemical and industrial sectors; atom-economy; choice of catalysts, solvents, energy consideration and reaction media, and eco-friendliness and sustainability of a chemical process; tools of green chemistry; real-world cases of practicing green chemistry

2. Organic synthesis focusing on carbon-heteroatom bonds (17 lectures)

Organoboron chemistry: Chemistry of organoboron compounds, carboranes, hydroboration, reactions of organoboranes, unsaturated hydrocarbon synthesis, allyl boranes, boron enolates; *Organosilicon chemistry*: Chemistry of organosilicon compounds, synthetic uses of silyl ethers, silylenol ethers, TMSCN, alkene synthesis, alkynyl, vinyl, aryl, allyl and acyl silanes; Brook rearrangement, silicon Baeyer-Villiger rearrangement; *Organophosphorous chemistry*: Chemistry of organophosphorus compounds, phosphorus ylides – Wittig reaction and itsmodifications, phosphine oxides and its applications; *Organosulphur chemistry*: Chemistry of organosulphur compounds, sulphur- stabilized anions and cations, sulphonium salts, sulphonium and sulphoxonium ylides

Unit II

3. Protection-deprotection and retrosynthetic strategy applied in organic reactions (10 lectures)

Protection-deprotection: Principle of protection-deprotection and its role in organic synthesis, differentmethods for protection-deprotection of common functional groups (alcoholic and phenolic hydroxyl(s), amino, carbonyl and carboxylic groups)

Retrosynthetic strategy: The disconnection approach – basic principles, one-group and two-group disconnections; strategies of retrosynthesis; retrosynthetic analysis for ibogamine, valeranone, squalene, estrone, progesterone and ginkgolide B

4. Pericyclic reaction I (09 lectures)

Definition and classification of pericyclic reactions; methods of analyzing pericyclic reactions (Molecular Orbital Symmetry Correlation Method, Frontier Orbital Method (FMO), and Transition State Aromaticity Method); *Electrocyclic reactions*: Definition, classification, Woodward-Hoffmann Rules for electrocyclic reactions, examples of different types of electrocyclic reactions (three-, four-, five- six-, seven- and eight-membered ring systems); *Cycloaddition reactions*: Definition, classification, Woodward-Hoffmann Rules for cycloaddition reactions, examples of different types of cycloaddition reactions – [$2\pi + 2\pi$]-cycloadditions, [$4\pi + 2\pi$]-cycloadditions, dienes and dienophiles, Diels-Alder reaction, '*cis*' rule, Alder's '*endo*' rule, regioselectivity, 1,3-dipolar cycloadditions, higher order cycloadditions ([$4\pi + 4\pi$]-, [$6\pi + 4\pi$]-, [$8\pi + 2\pi$]- and [$14\pi + 2\pi$]-cycloadditions).

5. Organic photochemistry I (06 lectures)

Basic principles, Jablonski diagram, photochemistry of olefinic compounds, *Cis-trans* isomeriation, Paterno-Buchi reaction, Norrish type I and II reactions, di-pi-methane rearrangement, photochemical reactions of carbonyl compounds

Suggested books

P. T. Anastas and J. C. Warner, *Green Chemistry: Theory and Practice*, Oxford University Press, 2000.

P. T. Anastas (Series editor), *Handbook of Green Chemistry*, Wiley-VCH Book Series

James H Clark (Series Editor-in-Chief), *RSC Green Chemistry*, Royal Society of Chemistry Book Series

V. K. Ahluwalia and K. Kidwai, *New Trends in Green Chemistry*, Springer, 2004.

R. A.Sheldon, Arends, I.and U. Hanefeld, *Green Chemistry and Catalysis*, Wiley-VCH, 2007.

M. Doble and A. K. Kruthiventi,*Green Chemistry and Engineering*, Academic Press, 2007.

G. Brahmachari, *Green Synthetic Approaches for Biologically Relevant Heterocycles*, Elsevier, 2014.

V. K. Ahluwalia, *Green Chemistry: Environmentally Benign Reaction*, Ane Books, 2006.

V. M. Kolb, *Green Organic Chemistry and its Interdisciplinary Applications*, CRC Press, 2016.

S. K. Sharma and A. Mudhoo, *Green Chemistry for Environmental Sustainability*, CRC Press, 2010.

A. P. Dicks, *Green Organic Chemistry in Lecture and Laboratory*, CRC Press, 2011.

S. A. Henrie, *Green Chemistry Laboratory Manual for General Chemistry*, CRC Press, 2015.

J. Clayden, N. Greeves, S. Warren and P. Wothers, *Organic Chemistry*, Oxford University Press, 2001.

F. A. Carry and R. J. Sundberg, *Advanced Organic Chemistry – Part-A and B*, 5th Edn, Springer, 2007.

L. G. Wade, Jr. and M. S. Singh, *Organic Chemistry*, 6th Edn, Pearson Education, 2008.

T. G. Graham and C. B. Fryhle, *Organic Chemistry*, 8th Edn, John Wiley & Sons, 2004.

R. T. Morrison, R. N. Boyd and S. K. Bhattacharjee, *Organic Chemistry*, 7th Edn, Pearson Education, 2013.

M. Schlosser and K. Smith, *Organoboron Chemistry,* Wiley-VCH, 2013.

M. G Davidson, K. Wade, T B Marder and A.K Hughes (Editors), *Contemporary Boron Chemistry*, Royal Society of Chemistry, 2000.

B. Marciniec, *Progress in Organosilicon Chemistry*, Taylor & Francis, 1995.

N. Auner and J. Weis (editors), *Organosilicon Chemsitry III: From Molecules to Materials,* Wiley-VCH, 1998.

G. H. Whitham, *Organosulfur Chemistry*, Oxford University Press, 1995.

R. J. Cremlyn, An Introduction to Organosulfur Chemistry, Wiley-VCH, 1996.

R. Engel, Handbook of Organophosphorous Chemistry, CRC Press, 1992.

L. D. Quin, *A Guide to Organophosphorus Chemistry*, Wiley-VCH, 2000.

D. W Allen, D. Loakes and J. C Tebby (Series Editors), *Organophosphorous Chemistry*, RSC Book Series.

P. G. M. Wuts and T. W. Greene, *Greene's Protective Groups in Organic Synthesis*, 4th Edn, Wiley-VCH, 2006.

S. Warren and P. Wyatt, *Organic Synthesis: The Disconnection Approach*,2nd Edn, Wiley-VCH, 2008.

E. J. Corey and X.-M. Chelg, *The Logic of Organic Synthesis*, John Wiley & Sons, 1995.

T.L. Gilchrist and R.C. Storr,*Organic Reactions and Orbital Symmetry*, 2ndEdn., Cambridge University Press, 1979.

N. J. Turro,*Modern Molecular Photochemistry*, The Benjamin/ Cummings Publishing Co., Inc., 1978.

R. B. Woodward and R. Hoffman, *The Conservation of Orbital Symmetry*, Academic Press, 1970.

J.M. Coxon and B.H. Halton, *Organic Photochemistry*, Cambridge University Press, 1974.

S. Sankararaman,*Pericyclic Reactions – A Textbook*, Wiley-VCH Verlag, 2005.

MCHEM 0303: Advanced Physical General

Unit I

1. Applications of group theory in chemistry (13 lectures)

Molecular vibrations, Normal mode analysis, symmetry of normal modes, Selection rules for infrared and Raman spectra, Hybridization, Construction of Symmetry adapted linear combination of atomic orbitals (SALC), Molecular orbital description of different organic, inorganic and organometallic molecules.. Application of group theory to ligand and crystal field theory, construction of energy level diagrams, correlation diagrams. Symmetry and chemical reactions; Woodward-Hoffmann rules.

2. Crystallography and surface chemistry (12 lectures)

Crystal symmetry, translation, glide plane and screw axis, Bravis lattice, space groups and its determination, stereographic projection, Fourier series, electron density and structure factor, methods for solving the phase problems, Bzones and Fermi level in lattice, concept of particle-hole in conduction process, band theory, theory of conductors, semiconductors and insulators.

Solid surfaces: External and internal surfaces; Bulk and surface structure of FCC, BCC and HCP metals; Notation of surface structures; Relaxation and reconstruction of surfaces; homogeneous and heterogeneous surfaces. Solid-gas interfaces: Types of adsorption; Adsorption isotherms – Langmuir, Tempkin and BET. Determination of surface area of adsorbents; temperature dependence of adsorption isotherms.

Unit II

3. Chemistry of Polymers (08 lectures)

Basic Concepts, classification, nomenclature, molecular weights, molecular weight distribution Methods for determination of Molecular weights, viscosity molecular weight, intrinsic viscosity, mark-Houwink relationships, Glass transition temperature, Polymerization reaction, kinetics of free radical and condensation polymer. Graft polymerization. Morphology and crystallinity of polymer by TGA and SEM analysis.Criteria for polymer solubility.Thermodynamics of polymer solutions.Theta temperature.Flory-Huggins model, dilute polymer solution.Excluded volume.

4. Biophysical chemistry (08 lectures)

Structure and functions of proteins and nucleic acids, Hydrophobic effect and micelle formation, hydrophobic interaction, stabilization and denaturation of protein. Water structure alternation theory of denaturation of protein, protein–lipid interaction, Transport of ions and small molecules through membranes. Ion channels.

5. Spectroscopy (09 lectures)

Maxwell's field equations, transition between states, selection rules and forbidden transitions; NMR: Relaxation and exchange phenomena, theories of chemical shift and nuclear spin-spin coupling in 2-spin systems with applications, pulsed NMR (spin echo); Electronic: n-π*, π- π* and CT transitions; vibrational: simple polyatomic molecules, normal modes, influence of nuclear spin on vibration-rotation spectra of polyatomics, time-resolved IR, 2-d IR, principles of 1D and 2D NMR. Principles of ESR and Mossbauer spectroscopy.

Suggested books

S. C. Rakshit, *Molecular Symmetry Group and Chemistry*, The New Book Stall, Kolkata, 1988.

V. Heine, *Group Theory in Quantum Mechanics: An Introduction to Its Present Usage*, Dover Publication, New York, 1991.

D. M. Bishop, *Group Theory and Chemistry*, Oxford University Press, Oxford, 1993.

A. Vincent, *Molecular Symmetry and Group Theory*, John Wiley & Sons, New York, 1998.

F. A. Cotton, *Chemical Applications of Group Theory*, 3rd Edn, John Wiley & Sons, New York, 1999.

R. L. Cramer, *Molecular Symmetry and Group Theory*, Wiley, 2013.

C. Kittel, *Introduction to Solid State Physics*, 4th Edn, John Wiley & Sons, New York.

P. A. Cox, *The Electronic Structure & Chemistry of Solids*, Oxford University Press, Oxford, 1987.

M. F. C. Ladd and R. A. Palmer, *Structure Determination by X-ray Crystallography*, 3rd Edn, Plenum Press, New York, 1994.

X. Clegg, *Crystal Structure Determination*, Oxford University Press, Oxford,

A. R. West, Basic Solid State Chemistry, Wiley

G. A. Somorjai, Y Li., Introduction to Surface Chemistry and Catalysis, Wiley.

W. Adamson, *Physical Chemistry of Surfaces*, John Wiley & Sons, New York, 1990.

H. -J. Butt, K. Graf and M. Kappl, *Physics and Chemistry of Interfaces*, Wiley-VCH, 2003.

J. H. Clint, *Surface Chemistry*, Blackie and Son Ltd, 1992.

P. W. Atkins, *Physical Chemistry*, Oxford University Press, Oxford, 1998.

R. S. Berry, S. A. Rice and J. Ross, *Physical Chemistry*, Oxford University Press, Oxford, 2000.

P. J. Flory, Principles of Polymer Chemistry, Cornell University Press.

C. Tanford, *Physical Chemistry of Macromolecules*, John Wiley & Sons, Inc, New York, 1961.

F. W. Billmeyer, *Text Book of Polymer Science*, 2nd Edn, Wiley-Interscience, New York, 1971.

G. S. Mishra, *Introductory Polymer Chemistry*, Wiley Eastern, New Delhi, 1993.

S. F. Sun, *Physical Chemistry of Macromolecules: Basic Principles and Issues*, John Wiley & Sons, New York, 1994.

J. P. Allen, Biophysical Chemistry, Wiley

I. N. Levine, Quantum Chemistry: Molecular Spectroscopy,

G. M. Barrow, *Introduction to Molecular Spectroscopy*, McGraw-Hill International Book Company, Tokyo, 1982.

W. Kemp, *NMR in Chemistry: A Multinuclear Approach*, Macmillan Press, Hong Kong, 1986.

R. S. Drago, *Physical Methods for Chemists*, Saunders, Philadelphia, 1992.

J. K. M. Sanders, E. C. Constable and B. K. Hunter, *Modern NMR Spectroscopy: A Workbook of Chemical Problems*, Oxford University Press, Oxford, 1993.

C. N. Banwell and E. M. McCash, *Fundamentals of Molecular Spectroscopy*, Tata McGraw-Hill Publishing Company Ltd, New Delhi, 1994.

H. Gunther, *NMR Spectroscopy: Basic Principles, Concepts and Applications in Chemistry*, Wiley, New York, 1995.

A. Abragam and B. Bleaney, *Electron Paramagnetic Resonance of Transition Metal Ions*, Clarendon Press, Oxford, 1970.

N. M. Atherton, *Principles of Electron Spin Resonance*, Ellis Horwood/Prentice-Hall, Hemel Hempsted, 1993.

Major Electives (any one)

MCHEM 0304: Inorganic Major I

Unit I

1. Synthetic methodology in inorganic, coordination and organometallic chemistry (15 lectures)

Ligand design/synthesis, ligand topology, molecular mechanics/engineering, tailoring/appending of pendant arm; coordination compound design/synthesis using classical/benign method, self-assembly, atom economy, thermolysis, photolysis, sonolysis, electrolysis, sol-gel method, hydrothermal method, cryochemistry, top-down and bottom-up methods for nano-structured solids

2. Organometallic chemistry II (10 lectures)

Reactions occurring in metal-bound state: ligand substitution, oxidative addition, reductive elimination; reactions triggered by modification on ligand framework: insertion and deinsertion, ligand-based nucleophilic addition, nucleophilic abstraction, electrophilic reactions; applications to organic synthesis: enantioselective functional group interconversion, chiral synthesis, protection and deprotection; transmetallation and cyclisation reactions, bioorganometallics, organo-dendrimer, surface organometallic chemistry

Unit II

3. Spectral (IR, NMR, EPR, UV-Vis Mossbauer, etc.) studies of inorganic, coordination and organometallic species (25 lectures)

Fundamentals, elucidation of geometric structure, electronic structure, stereochemistry, bonding, molecular aggregate, superstructure and reaction pathway in halide, pseudohalide, carbonyl, nitrosyl, DMSO, polypyridine, azoheterocycle, oxime, quinone, macrocycle containing compounds and organometallic complexes; enumeration and characterization: geometrical (*cis*/*trans*, *fac*/*mer*) and stereo (optical) isomers in different polyhedra; ligational motif and chelate loop, structural distortion, effective pi-acceptance centre, oxidation state, spin state, redox site of non-innocent ligands, mu-bonding and hapticity, electrophilicity/nucleophilicity, quasi- and superaromaticity, fluxionality, matalloligand, probing chemical reactivity and reaction pathways (intramolecular/intermolecular, stereoretentivity/stereodynamicity), covalency of ML bonding and comment on bonding theories

Suggested books

L. S. Hegedus, *Transition Metal in the Synthesis of Complex Organic Molecules*, University Science Press, Mill Valley, CA, 1994.

G. Wulfsberg, *Inorganic Chemistry*, Viva Books Private Ltd, New Delhi, 2001.

W. Carruthers and I. Coldham, *Modern Methods of Organic Synthesis*, 4th Edn, Cambridge University Press, Cambridge, 2004.

G. Rothenberg, *Catalysis: Concepts and Green Applications*, Wiley-VCH, Weinheim, 2008.

H. -D. Höltje, W. Sippl, D. Rognan and G. Folkers, *Molecular Modeling: Basic Principles and Applications*, 3rd Edn, Wiley-VCH, Weinheim, 2008.

J. W. Steed and J. L. Atwood, *Supramolecular Chemistry*, 2nd Edn, John Wiley & Sons, New York, 2009.

R. Xu, W. Pang and Q. Huo (Eds), *Modern Inorganic Synthetic Chemistry*, Elsevier, New York, 2011.

A. Yamamoto, *Organotransition Metal Chemistry*, Wiley, New York, 1986.

J. P. Collmann, L. S. Hegedus, J. R. Norton and R. G. Finke, *Principles and Applications of Organotransition metal Chemistry*, University Science Books, Mill Valley, CA, 1987.

R. G. Wilkinns, *Kinetics and Mechanism of Reactions of Transition Metal Complexes*, 2nd Edn, VCH, Weinheim, 1991.

R. H. Crabtree, *The Organomettalic Chemistry of the Transition Metals*, 2nd Edn, Wiley, New York , 1994.

L. S. Hegedus, *Transition Metal in the Synthesis of Complex Organic Molecules*, University Science Press, Mill Valley, CA, 1994.

G. O. Spessard and G. L. Miessler, *Organometallic Chemistry,* Prentice-Hall, New Jersey, 1997.

R. B. Jordan, *Reaction Mechanisms of Inorganic and Organometallic Systems*, Oxford University Press, Oxford, 1998.

R. V. Eldik and C. D. Hubbard (Eds) *Advances in Inorganic Chemistry*, Vol 54, Academic Press, New York, 2003.

R. H. Crabtree, *The Organomettalic Chemistry of the Transition Metals*, 4th Edn, Wiley, New York, 2005.

D. Steinborn, *Fundamentals of Organometallic Catalysis*, John Wiley & Sons, New York, 2011.

G. Aruldhas, *Molecular Structure and Spectroscopy*, 2nd Edn, Prentice-Hall of India, New Delhi, 2007.

D. N. Sathyanarayana, *Electronic Absorption Spectroscopy and Related Techniques*, University Press, 2001.

D. Shillady, *Essentials of Physical Chemistry*, CRC Press, Boca Raton, FL, 2012.

A. B. P Lever, *Inorganic Electronic Spectroscopy*, Elsevier, New York, 1984.

Raton, FL, 2008.

H. H. Jaffe and M. Orchin, *Symmetry, Orbitals and Spectra*, Wiley, New York, 1982.

K. Nakamoto, *Infrared and Raman Spectra of Inorganic and Coordination Compounds*, Part B, 6th Edn, John Wiley & Sons, New Jersey, 2009.

B. Schrader (Ed) Infrared and Raman Spectroscopy: Methods and Applications, VCH Weinheim, 1995.

W. Henderson and J. S. McIndoe, *Mass Spectrometry of Inorganic, Coordination and Organometallic Compounds: Tools-Techniques-Tips*, John Wiely & Sons, Ltd, Chichester, 2005.

H. Gunther, *NMR Spectroscopy: Basic Principles, Concepts and Applications in Chemistry*, Wiley, New York, 1995.

N. M. Atherton, *Principles of Electron Spin Resonance*, Ellis Horwood/Prentice-Hall, Hemel Hempsted, 1993.

E. A. V. Ebsworth, D. W. H. Rankin and S. Cradock, *Structural Methods in Inorganic Chemistry*, 2nd Edn, Blackwell Scientific Publications, Oxford, 1991.

J. E. Wertz and J. R. Boulton, *Electron Spin Resonance: Elementary Theory and Practical Applications*, Chapman and Hall, London, 1986.

J. Garcia Sole, L. E. Bausa and D. Jaque, *An Introduction to the Optical Spectroscopy in Inorganic Solids*, John Wiley & Sons, New York, 2005.

MCHEM 0305: Organic Major I

Unit I

1. VBT and MOT: Concept, molecular structure and reactivity (05 lectures)

Orbitals, atomic orbitals, hybridization of atomic orbitals, HOMO, LUMO, molecular structure and reactivity – Basic concepts and understanding with the help of Valence Bond Theory (VBT) and Molecular Orbital Theory (MOT)

2. Optical Rotatory Dispersion (ORD) and Circular Dichroism (CD) (05 lectures)

Chiroptical properties of organic molecules; ORD and CD principles and applications; ORD and CD curves: Cotton effect; empirical and semiemperical rules

3. Asymmetric synthesis (15 lectures)

Principles and newer methods of asymmetric synthesis (including enzymatic and catalytic nexus); enantio- and diastereoselective synthesis;reactions of enolates (α−substitution);addition to C=C double bonds (electrophile- induced cyclisation, iodolactonisation, hydroboration, conjugate additions); asymmetric hydrogenation with special reference to Ru-BINAP catalysts; asymmetric reduction of prochiral ketones with Baker’s Yeast and CBS-catalyst; asymmetric epoxidation with special reference to Sharpless and Jacobsen epoxidation; asymmetric aldol reactions, asymmetric Michael reaction; Few important industrial applications of asymmetric synthesis

Unit II

4. Chemistry of heterocyclic compounds: Synthesis, properties and reactions (15 lectures)

Nomenclature of bicyclic and tricyclic fused systems;heterocyclic synthesis – principles of heterocyclic synthesis involving cyclization reactions and cycloaddition reactions; synthesis and reactivity of 3-, 4-, 5- 6- & 7-membered heterocycles with one, two or more heteroatoms (aziridines, oxiranes, thiiranes, azetidines, oxetanes, thietanes, diazines, triazines, thiazines, azepines, oxepines); benzo-fused five and six-membered heterocycles - synthesis and reactions including medicinal applications of benzopyrroles, benzofurans, benzothiophenes, quinolizinium and benzopyrylium salts, coumarins and chromones; phosphorus and selenium containing heterocycles;role of heterocyclic compounds in biological systems; heterocycles in pharmaceutical industry.

5. Organometallic chemistry (10 lectures)

Application of transition metals in organic synthesis – preparative, structural and mechanistic aspects; Davies rule, catalytic nucleophilic addition and substitution reactions;coupling reaction – Heck, Stille, Suzuki coupling Ziegler Naata reaction;olefin metathesis; Tebbe's reagent, Pauson-Khand reactions; Volhsrdt co-trimerisation, functional organometallic compounds; use of non-transition metals- Indium, tin, zinc in organic synthesis

Suggested books

E. V. Anslyn and D. A. Dougherty,*Modern Physical Organic Chemistry*, University Science Books, 2006.

S. Shaik, and P. C. Hiberty, (2004) *Valence Bond Theory, Its History, Fundamentals, and Applications: A Primer, In: Reviews in Computational Chemistry*, Volume 20 (eds. K. B. Lipkowitz, R. Larter and T. R. Cundari), John Wiley & Sons, Inc., Hoboken, NJ, USA, 2004.

F. A. Carroll, *Perspectives on Structure and Mechanism in Organic Chemistry*, 2nd Edn, Wiley-VCH, 2011.

P. Crabbe, *ORD and CD in Chemistry and Biochemistry*, Academic Press, 1972.

E. L. Eliel, S. H. Wilson and L. N. Mander,*Stereochemistry of Organic Compounds*, John Wiley & Sons, Inc., 2003.

D. Nasipuri, *Stereochemistry of Organic Compounds (Principles and Applications)*, 2nd Edn, Wiley Eastern Limited, New Delhi, 1994.

R. E. Gawley and J. Aube, *Principles of Asymmetric Synthesis*, Elsevier, 1996.

M. Gruttadauria and F. Giacalone, Catalytic Methods in Asymmetric Synthesis: Advanced Materials, Techniques, and Applications, John Wiley & Sons, 2011.

I. Ojima, *Catalytic Asymmetric Synthesis*, John Wiley & Sons, 2013.

G.-Q. Lin, Y.-M.Li and A. C. Chan, Principles and Applications of Asymmetric Synthesis, John Wiley & Sons, 2003.

A. M. P. Koskinen, *Asymmetric Synthesis of Natural Products*, John Wiley & Sons, 2012.

J. A. Joule and K. Mills, Heterocyclic Chemistry, Blackwell Science Publication, 2000.

R. K. Bansal,*Heterocyclic Chemistry: Syntheses, Reactions and Mechanisms*, Wiley Eastern Limited, New Delhi, 1999.

T. L. Gilchrist, *Heterocyclic Chemistry*, Pearson Education, 2008.

T. Eicher, S. Hauptmann and A. Speicher, *TheChemistry of Heterocycles*, Wiley-VCH, 2012.

G. Brahmachari, *Green Synthetic Approaches for Biologically Relevant Heterocycles*, Elsevier, 2014.

A. I. Meyers, Heterocycles in Synthesis, John Wiley & Sons, 1974.

A.R. Katritzky, *Comprehensive Heterocyclic Chemistry*, Elsevier Book series.

R. C. Mehrotra, *Organometallic Chemistry*, New Age International., 2007.

G. O. Spessard and G. L. Miessler, *Organometallic Chemistry*, oxford University Press, 2010.

B. D. Gupta, *Basic Organometallic Chemistry: Concepts, Syntheses and Applications*, Universities Press, 2011.

D. Astruc, *Organometallic Chemistry and Catalysis*, Springer, 2007.

MCHEM 0306: Physical Major I

Unit I

1. Classical mechanics (10 lectures)

Newtons' prescription for classical mechanics, Laws of motion: law of inertia, law of causality, Superposition principle of force, introduction to the idea of law of force for motion, Conservative and non-conservative force, definition of potential energy, conservation of total mechanical energy for conservative system and its implication, principle of least action, generalized coordinate systems, Legendre transformation, Poission bracket Lagrangian equation of motion and definition of generalized momentum, Hamiltonian equation of motion.

2. Approximate methods in quantum chemistry (15 lectures)

Variation theorem, application to ground states of various systems. Linear variation method, Secular determinant, Introduction to matrix mechanics-eigen values and eigen vectors, Variation method for excited states. Time-independent perturbation theory for nondegenerate states, Perturbation of a two-level system, Many level systems, Degenerate perturbation theory and Stark effect, Hellman-Feynman and Virial Theorems. Time-dependent perturbation theory, Rabi Oscillation, Many level system; the variation of constants, the effect of slowly switched constant perturbation, The effect of oscillating perturbation, Transition rates to continuum, A semi-classical treatment to radiation-matter interaction. Fermi Golden rule, Einstein transition probabilities, lifetime and energy uncertainty.

Unit II

3. Statistical Mechanics (25 Lectures)

Concept of Ensemble. A priori probability. Gibbs postulate in Statistical mechanics. Ergodic hypothesis. Prescription for studying of thermodynamic systems based on ensemble method. Preparation of equilibrium ensemble corresponding to given thermodynamic system (isolated, closed and open).Determination of distribution function.Partition function.Calculation of thermodynamic properties in terms of partition function.Theory of Fluctuations. Calculation of fluctuation in energy, number of particles, density, entropy, volume, temperature etc The classical partition function. Phase space and the Liouville equation

Boltzmann, Fermi-Dirac and Bose-Einstein Statistics Canonical partition function for non-interacting distinguishable and non-identical particles. Boltzmann Statistics. Grand canonical partition function for non-interacting identical particles. Fermi-Dirac and Bose-Einstein statistics and their limiting behavior.Ideal monoatomic gas.The translational partition function.The electric and nuclear partition function.Thermodynamic function.Ideal diatomic gases.The rigid rotor-Harmonic oscillator approximation.The vibrational partition function. The rotational partition function of a heteronuclear molecule. The symmetry requirement of the total wave function of a homonuclear diatomic molecule. The rotational partition function of a homonuclear diatomic molecule. Thermodynamic functions. A weakly degenerate ideal Fermi-Dirac Gas. A strongly degenerate ideal Fermi-Dirac gas. A weakly degenerate ideal Bose-Einstein gas.A strongly degenerate ideal Bose-Einstein gas. An ideal gas of photons.Einstein and Debye theory of Specific heat capacity of solids.Equilibrium Constants in terms of partition functions.Imperfect gases, The Virial equation of state from the grand partition functions.The expression for second Virial co-efficient.

Suggested books

R. P. Feynman, R. P. Leighton and M. Sands, The Feynman Lectures on Physics, Narosa, New Delhi.

N. C. Rana, P. S. Joag, Classical Mechanics, Mcgraw-Hill Education India Pvt. Ltd., New Delhi.

H. Eyring, J. Walter and G. F. Kimball, *Quantum Chemistry*, Wiley, New York, 1944.

P. W. Atkins, *Molecular Quantum Mechanics*, Clarendon Press, Oxford, 1980.

L. I. Schiff, *Quantum Mechanics*, McGraw-Hill, New York, 1985.

A. K. Chandra, *Introductory Quantum Chemistry*, Tata McGraw-Hill Publishing Co, New Delhi, 1989.

F. L. Pilar, *Elementary Quantum Chemistry*, Tata McGraw-Hill, New Delhi, 1990.

D. A. McQuarrie, *Quantum Chemistry*, Viva Books Pvt Ltd, New Delhi, 2003.

I. N. Levine, Quantum Chemistry, PHI Learning Pvt. Ltd, New Delhi, 2010.

E. Merzbacher, Quantum Mechanics, Wiley, 1998.

F. Reif, *Fundamentals of Statistical and Thermal Physics*, McGraw-Hill, New York, 1965.

E. S. R. Gopal, *Statistical Mechanics and Properties of Matter*, Ellis Horwood, England, 1974.

S. K. Ma, *Statistical Mechanics*, World Sci, Singapore, 1985.

R. K. Pathria, *Statistical Mechanics*, Butterworth-Heinemann, 1996.

D. A. McQuarrie, Statistical Mechanics, Viva Books Pvt. Ltd.

Practical Papers (For Each, Full Marks: 50; Credit: 4)

MCHEM 0307: Advanced General (compulsory for all)

1. Instrumental methods in chemical analysis:use of different instruments like UV-Vis, FTIR, Fluorimeter, Thermal Analyser, CHN(S) Analyser, Electrochemical Analyser, etc in various chemical analyses and computer simulation

MCHEM 0308: Inorganic Major Practical I

1. Synthesis of di-, tri- and polydentate Schiff bases and related chelators/congregators
2. Isolation of the complexes with synthesized ligands in (1) and ones commercially available
3. Spectroscopic (IR, UV-Vis, Fluorescence, etc) characterization of the ligands and complexes
4.Determination of composition and formation constants of selected systems by pH-metric and spectrophotometric methods

MCHEM 0309: Organic Major Practical I

1. Quantitative estimation of organic compounds
   a) Sugars (glucose, cane sugar), (b) phenol, (c) aniline, (d) acetone, (e) nitrogen by Kjldahl method, (e) saponification and iodine value of oil
2. Organic preparation (single and/or two-step process)
   Preparation of organic compoundsby conventional and green chemical methods (involving single and/or two-step process) followed by purification and characterization by spectroscopic technique

MCHEM0310: Physical Major Practical I

1. Determination of dissociation constants by measuring conductivity of weak acids
2. Determination of weak acids' dissociation constant via potentiometric titration

Semester-IV

Theoretical Papers (For Each, Full Marks: 50; Credit: 4)

MCHEM 0401: Advanced Analytical General

Unit I

1. Complexes in aqueous solution (09 lectures)

pH-potentiometric, spectrophotometric methods (slope-ratio, mole-ratio and Job's method of continuous variation of measuring stability constants of complexes, Bjerrum half n method, stability of mixed ligand complexes and calculations; determination of composition, evaluation of thermodynamic parameters, factors influencing the stability of complexes

2. Advanced spectroscopic methods including hyphenated ones (16 lectures)

Instrumentation, presentation of spectra, Applications of heteronuclear NMR spectroscopy; ^{11}B, ^{13}C, ^{14}N, ^{17}O, ^{19}F and ^{31}P-NMR, ^{195}Pt. CD/ORD: methods, molecular dissymmetry and chiroptical properties, Cotton effect, Faraday effect in magnetic circular dichroism (MCD) and application. EPR: anisotropy, intensity, hyperfine spliting, Kramer's theorem, photoelectron spectroscopy, ESCA, UPS, Auger, AES, XRF and EXFAS; Synergistic benefit: spectroscopic and other tools in structure elucidation

Unit II

3. Electroanalytical methods II (09 lecturers)

Instrumentation: cyclic voltammetry, differential pulse voltammetry, coulometry, electrogravimetry, LSV; methods, low-temperature accessory, interfacing, conjunctive study, switching potential, electrode potential, pathways of electron transfer: EEE, EC, EC', ECE; electro-induced reactions; conventional secondary batteries: Ni-Cd, Ni-Fe, Ag-Zn, ZEBRA system; surface-modified study, materials preparation

4. Application of radiotracers and radiopharmaceuticals (09 lectures)

Radiotracers: isotope dilution; DIDA, IIDA and substoichiometric methods of analysis, application, nuclear activation analysis: principles, classifications and methods of nuclear activation analysis; special types of derivative activation analysis, depth profile activation analysis, cyclic activation analysis, charged-particle activation analysis (CPAA): PGNAA, PIXE, PIGE, IPAA, RBS; general considerations and factors; biosynthesis, factors in labeling: efficiency, isotope effect, specific methods of labeling

Radiopharmaceuticals: design of a new radiopharmaceutical: nuclear pharmacy: concept, pharmaceuticals and radiopharmaceuticals; radionuclide generators; ideal radiopharmaceuticals, methods of radiolabelling, specific radiopharmaceuticals for diagnostic and therapeutic purposes

5. Chemical and biological effects of radiation (07 lectures)

Ionizing radiation and its physical and chemical effect in target, water, radiolysis; definition of different units in radiation chemistry, calculation of radiation dose, biological effects, source of human data, lethal dose, permissible level of radiation dose; primary radiological products of water and their characterization, dosimetric concepts and quantities, thermoluminescence and lyoluminescence

Suggested books

R. M. Smith and A. F. Martell, *Critical Stability Constants*, 6 Vols, Plenum Press, New York, 1974-89.

M. Meloun, J. Havel and E. Hogfeldt, *Computation of Solution Equilibria: A Guide to Methods in Potentiometry, Extraction and Spectrophotometry*, Halsted, New York, 1988.

A. E. Martell and R. J. Motekaitis, *Determination and use of Stability Constants*, 2nd Edn, VCH, New York, 1992.

J. G. Grasselli, M. K. Snavely and B. J. Bulkin, *Chemical Application of Raman Spectroscopy*, Wiley, New York, 1981.

W. Kemp, *NMR in Chemistry: A Multinuclear Approach*, Macmillan Press, Hong Kong, 1986.

R. S. Drago, *Physical Methods for Chemists*, Saunders, Philadelphia, 1992.

C. N. Banwell and E. M. McCash, *Fundamentals of Molecular Spectroscopy*, Tata McGraw-Hill Publishing Company Ltd, New Delhi, 1994.

J. M. Hollas, *Modern Spectroscopy*, Wiley, New York, 1996.

K. Nakanishi and N. Berova, *Circular Dichroism,Principles and Applications*, VCH, New York, 1994.

H. Gunther, *NMR Spectroscopy: Basic Principles, Concepts and Applications in Chemistry*, Wiley, New York, 1995.

J. A. Iggo, *NMR Spectroscopy in Inorganic Chemistry* (Oxford Chemistry Primers), 2003.

A. K Brisdon, *Inorganic Spectroscopic Methods* (Oxford Chemistry Primers), Oxford University Press, (Indian Edn), 2005.

L. Kevan and R. N. Schwartz (Eds), *Time Domain Electron Spin Resonance*, John Wiley, New York, 1979.

J. E. Wertz and J. R. Boulton, *Electron Spin Resonance: Elementary Theory and Practical Applications*, Chapman and Hall, London, 1986.

N. M. Atherton, *Principles of Electron Spin Resonance*, Ellis Horwood/Prentice-Hall, Hemel Hempsted, 1993.

D. W. Turner, C. Baker and C. R. Bundle, *Molecular Photoelectron Spectroscopy*, Wiley Interscience, New York, 1970.

J. H. D Eland, *Photoelectron Spectra*, Butterworth, London, 1984.

T. L. Barr, *Modern ESCA: the Principles and Practice of X-ray Photoelectron Spectroscopy*, CRC Press, Boca Raton, FL, 1994.

D. P. Woodruff and T. A. Delchar, *Modern Techniques of Surface Science*, Cambridge University Press, Cambridge, 1988.

T. Thomson, M. D. Baker, A. Christie and J. F. Tyson, *Auger Electron Spectroscopy*, John Wiley, New York, 1985.

G.A. Ozin, A. C. Arsenault and L. Cadematiri, *Nanochemistry: A Chemical approach to Nanomaterrials*, Royal Society of Chemistry, London, 2009.

V. I. Goldanskii and R. H. Herber, *Chemical Applications of Mossbauer Spectroscopoy*, Academic Press, New York, 1968.

N. N. Greenwood and T. C. Gibb, *Mossbauer Spectroscopy*, Chapman and Hall, London, 1971.

R. S. Drago, *Physical Methods for Chemists*, Saunders, Philadelphia, 1992.

J. M. Hollas, *Modern Spectroscopy*, Wiley, New York, 1996.

D. R. Crow, *Polarography of Metal Complexes*, Academic Press, London, 1979.

A. J. Bard and L. F. Faulkner, *Electrochemical Methods – Fundamentals and Applications*, 2^{nd} Edn, Wiley, New York, 1998.

S. Torii, *Electro-Organic Syntheses*, Part I: *Oxidations*, Part II: *Reductions*, VCH, Weinheim, 1985.

D. E. Kyriacou and D. A. Jannakoudis, *Electrocatalysis for Organic Synthesis*, Wiley, New York, 1986.

J. Goodisman, *Electrochemistry: Theoretical Foundations*, Wiley, New York, 1987.

R. J. Gale (Ed), *Spectroelectrochemistry: Theory and Practice*, Plenum Press, New York, 1988.

J. Janata, *Principles of Chemical Sensors*, Plenum Press, New York, 1989.

J. O'M. Bockris and S. U. M. Khan, *Surface Electrochemistry*, Plenum Press, New York, 1993.

C. M. A. Brett and A. M. O. Brett, *Electrochemistry: Principles, Methods and Applications*, Oxford University Press, Oxford, 1993.

K. V. Kordesch, *Fuel Cells and Their Applications*, VCH, Weinheim, 1994.

D. T. Sawyer, A. Sobkowiak and J. L. Roberts, Jr, *Experimental Electrochemistry for Chemists*, 2^{nd} Edn, Wiley, New York, 1995.

P. G. Bruce, *Solid-state Electrochemistry*, Cambridge University Press, Cambridge, 1995.

W. Schmickler, *Interfacial Electrochemistry*, Oxford University Press, Oxford, 1996.

C. A. Vincent and B. Scrosati, *Modern Batteries*, 2^{nd} Edn, Arnold, London, 1997.

C. H. Hamann, A. Hamnett and W. Vielstich, *Electrochemistry*, Wiley-VCH, Weinheim, Germany, 2007.

J. W. T. Spinks and R. J. Woods, *An Introduction to Radiation Chemistry*, Wiley, New York, 1964.

J. F. Duncan and G. B. Cook. *Isotopes in Chemistry*, Clarendon Press, Oxford, 1968.

S. Ahrland, J. O. Liljerzin and J. Rydberg, *Chemistry of the Actinides*, Pergamon Press, Oxford, 1986.

W. D. Ehmann and D. E. Vance, *Radiochemistry and Nuclear Methods of Analysis*, John Wiley, New York, 1991.

J. Turner, *Atoms, Radiation and Radiation Protection*, Willey Interscience, New York, 1995.

Major Electives (any one from 0402-0407 and any one from 0405-0407)

MCHEM0402: Inorganic Major II

Unit I

1. Electrochemical studies of redox non-innocent ligands and metal complexes (18 lectures)

Fundamentals, experimental findings of CV, DPV and coulometry, delving reversible, quasireversible and irreversible electrochemical and chemical processes in model compounds; electro-induced reactions: protic/electroprotic equilibrium, electrocatalysis, electropolymerisation, electrocrystallisation, electrochemiluminiscence; electrosynthesis, evaluating comproportionation constant, photoelectrochemistry, spectroelectrochemistry, excimer and its structure, excited state potential and chemical simulation, redox orbital, redox series, redox isomer, electron hopping, spatially isolated orbital; synergistic experiments and exposing electron transfer site, model case correlating biological processes

2. Mechanism of electron transfer reactions (07 lectures)

Fundamentals, complementary and non-complementary redox reactions, outer-sphere reaction, inner-sphere reaction, effect of bridging ligand in inner-sphere reaction, kinetics and mechanism, electron tunneling hypothesis, heteronuclear redox reaction and simplified Marcus theory; Marcus cross relationship and its application, remote attack, doubly-bridged process, ligand exchange, intervalence electron transfer, induced reaction, electron transport in biological systems and their simulations

Unit II

3. Inorganic photochemistry (13 lectures)

Preamble, photoexcitation, fluorescence, phosphorescence, photosensitization, quenching, charge and energy transfer, prompt and delayed reactions, excimer structure, substitution, fragmentation, isomerisation, exchange and redox reactions; chemiluminescence, photochromism; chemical actinometry and determination of quantum yield, inorganic photochemistry in biological processes and their model studies; applications of photochemical reactions of coordination compounds - synthesis and catalysis, solar energy conversion and storage

4. Inorganic and organometallic reaction mechanism (12 lectures)

Substitution reactions in square planar, tetrahedral and octahedral geometries with special reference to d^n ion complexes: operational tests, aquation and anation, reactions without metal-ligand bond breaking, kinetics of chelate formation, reaction mechanisms of organometallic systems, studies on fast reactions, kinetic and activation parameters - tools to propose a plausible mechanism; stereochemical changes: types of ligand rearrangements, isomerism in 4-, 5- and 6-coordinated complexes; reactions of coordinated ligands: model choice of metal and ligand, acid-base reaction, hydrolysis of esters, amides and peptides, aldol condensation, trans-amination, template reactions, organic synthesis with special reference to macrocyclic ligand; variable-temperature reactions in fluxional organometallic compounds

Suggested books

A. J. Bard, R. Parsons and J. Jordan, *Standard Potentials in Aqueous Solution*, Dekker, New York, 1985.

S. Torii, *Electro-Organic Syntheses*, Part I: *Oxidations*, Part II: *Reductions*, VCH, Weinheim, 1985.

D. E. Kyriacou and D. A. Jannakoudis, *Electrocatalysis for Organic Synthesis*, Wiley, New York, 1986.

J. Goodisman, *Electrochemistry: Theoretical Foundations*, Wiley, New York, 1987.

R. J. Gale (Ed), *Spectroelectrochemistry: Theory and Practice*, Plenum Press, New York, 1988.

J. Janata, *Principles of Chemical Sensors*, Plenum Press, New York, 1989.

J. O'M. Bockris and S. U. M. Khan, *Surface Electrochemistry*, Plenum Press, New York, 1993.

C. M. A. Brett and A. M. O. Brett, *Electrochemistry: Principles, Methods and Applications*, Oxford University Press, Oxford, 1993.

K. V. Kordesch, *Fuel Cells and Their Applications*, VCH, Weinheim, 1994.

D. T. Sawyer, A. Sobkowiak and J. L. Roberts, Jr, *Experimental Electrochemistry for Chemists*, 2nd Edn, Wiley, New York, 1995.

P. G. Bruce, *Solid-state Electrochemistry*, Cambridge University Press, Cambridge, 1995.

W. Schmickler, *Interfacial Electrochemistry*, Oxford University Press, Oxford, 1996.

C. A. Vincent and B. Scrosati, *Modern Batteries*, 2nd Edn, Arnold, London, 1997.

A. J. Bard and L. F. Faulkner, *Electrochemical Methods – Fundamentals and Applications*, 2nd Edn, Wiley, New York, 1998.

C. H. Hamann, A. Hamnett and W. Vielstich, *Electrochemistry*, Wiley-VCH, Weinheim, Germany, 2007.

W. L. Reynolds and R. W. Lumry, *Mechanism of Electron Transfer*, Ronald Press, New York, 1966.

H. Taube, *Electron Transfer Reaction of Complex Ions in Solution*, Academic Press, New York, 1970.

P. Atkins, T. Overton, J. Rourke, M. Weller and F. Armstrong, *Shriver & Atkins Inorganic Chemistry*, 4th Edn, Oxford, 2006.

G. L. Miessler and D. A. Tarr, *Inorganic Chemistry*, 3rd Edn, Pearson, New Delhi, 2009.

B. N. Figgis, *Introduction to Ligand Field Theory*, Interscience, New York, 1966.

C. J. Ballhausen, *Molecular Electronic Structure of Transition Metal Complexes*, McGraw-Hill, London, 1979.

V. Balzani and V. Carassiti, *Photochemistry of Coordination Compounds*, Academic Press, New York, 1970.

A. W. Adamson and P. D. Fleischauer (Ed), *Concept of Inorganic Photochemistry*, Wiley, New York, 1975.

G. L. Geoffroy and M. S. Wrighton, *Organometallic Photochemistry*, Academic Press, New York, 1970.

D. Rendell and D. Mowthrope, *Fluorescence and Phosphorescence Spectroscopy*, John Wiley, New York, 1987.

C. E. Wayne and R. P. Wayne, *Photochemistry*, Oxford University Press, 1st Indian Edn, New Delhi, 2005.

J. R. Lakowicz, *Principles of fluorescence spectroscopy*, 3rd Edn, Springer, USA, 2006.

M. sauer, J. Hofkens and J. Enderlein, *Handbook of Fluorescence Spectroscopy and Imaging: from Singles to Ensembles*, Wiley-VCH, Weinheim, Germany, 2011.

F. Basolo and R. G. Pearson, *Mechanism of Inorganic Reactions*, 2nd Edn, Wiley, New York, 1967.

D. Katakis and G. Gordon, *Mechanisms of Inorganic Reactions*, John Wiley & Sons, New York, 1987.

R. G. Wilkinns, *Kinetics and Mechanism of Reactions of Transition Metal Complexes*, 2nd Edn, VCH, Weinheim, 1991.

R. B. Jordan, *Reaction Mechanisms of Inorganic and Organometallic Systems*, Oxford University Press, Oxford, 1998.

J. D. Atwood, *Inorganic and Organometallic Reaction Mechanisms*, 2nd Edn, Wiley-VCH, Weinheim, 1997.

S. Asperger, *Chemical Kinetics and Inorganic Reaction Mechanisms*, 2nd Edn, Springer, London, 2012.

MCHEM0403: Organic Major II

Unit I

1. Advanced techniques in organic synthesis (17 lectures)

Recent advances in organic synthesis focusing on the successful application of microwave (MW) irradiation, ultrasound (US)irradiation, visible light, ball-milling,and syntheses under solid-phase, room-temperature synthesis (ambient conditions)

2. Organic photochemistry II (8 lectures)

Photochemistry of arenes; photoreaction in solid state; method of generation and detection (ESR), radical initiators, reactivity pattern of radicals, substitution and addition reactions involving radicals, synthetic applications; cyclization of radicals; photo-induced oxidations and reductions

Unit II

3. Structure-function relationship in carbohydrates, proteins, lipids, nucleic acids and enzymes (18 lectures)

Carbohydrates: Basic structure and type of sugars, reactions, protection and deprotection, deoxy-sugars, amino sugars, glycal sugars and their synthetic aspects, mutarotaions, carbohydrates as chiral pools in organic synthesis; *Proteins*: Chemical and enzymatic hydrolysis of proteins to peptides, amino acid sequencing, secondary structure of proteins, Ramachandran Diagram, forces responsible for holding of secondary structures, α-helix, β-sheets,tertiary structure of protein-folding, quaternary structure, biosynthesis of peptide chain;*Lipids*: Fatty acids, structure and function of triacylglycerols, glycerophospholipids,properties of lipid bi-layers, biological membranes, fluid mosaic model of membrane structure; *Nucleic acids*: Purine and pyrimidine bases of nucleic acids, base pairing via H-bonding,structure of ribonucleic acids (RNA) and deoxyribonucleic acids (DNA), double helix model of DNA and forces responsible for holding it; *Enzymes*: Chemical and biological catalysis, properties of enzymes like catalytic power, specificity and regulation, concept and identification of active site by the use of inhibitors, affinity labeling and enzyme modification by site-directed mutagenesis; mechanism of enzyme action: transition state theory,examples of some typical enzyme mechanisms for chymotrypsin, ribonuclease

4. Co-enzyme chemistry (07 lectures)

Cofactors as derived from vitamins, coenzymes, prosthetic groups, apoenzymes, Structure and biological functions for pyridoxal phosphate, NAD+, NADP+, FMN, FAD;mechanisms of reactions catalyzed by the above cofactors

Suggested books

D. Bogdal, *Microwave-assisted Organic Synthesis*, Elsevier, 2005.

G. Brahmachari, Room Temperature Organic Synthesis, Elsevier, 2015.

G. Brahmachari, *Green Synthetic Approaches for Biologically Relevant Heterocycles*, Elsevier, 2014.

A. Stolle and B. C. Ranu, *Ball Milling Towards Green Synthesis: Applications, Projects, Challenges*, Royal Society of Chemistry, 2014.

R. Cella,and H. A. Stefani, *Ultrasonic Reactions, In: Green Techniques for Organic Synthesis and Medicinal Chemistry* (eds W. Zhang and B. W. Cue), John Wiley & Sons, Ltd, Chichester, UK, 2012.

K. Tanka, Solvent-free Organic Synthesis, 2ndEdn., Wiley-VCH, 2009.

V. K. Ahluwalia and M. Kidwai,*New Trends in Green Chemistry*, Springer, 2004.

N. J. Turro,*Modern Molecular Photochemistry*, The Benjamin/ Cummings Publishing Co., Inc., 1978.

R. B. Woodward and R. Hoffman, *The Conservation of Orbital Symmetry*, Academic Press, 1970.

J.M. Coxon and B.H. Halton, *Organic Photochemistry*, Cambridge University Press, 1974.

S. Sankararaman,*Pericyclic Reactions – A Textbook*, Wiley-VCH Verlag, 2005.

M. Klessinger and J. Michl, *Excited States and Photo-Chemistry of Organic Molecules*, Wiley, 1995.

S. V. Bhat, B. A. Nagasampagi and M. Sivakumar, *Chemistry of Natural Products*, Narosa Publishing House, New Delhi, 2005.

X.-T. Liang and W.-S. Fang, *Medicinal Chemistry of Bioactive Natural Products*, John Wiley & Sons, 2006.

T. Hudlicky and J. W. Reed, *The Way of Synthesis*, Wiley-VCH, 2007.

H. Osbon, *Carvbohydrates*, Academic Press, 2003.

I. L. Finar, *Organic Chemistry, Volume 2: Stereochemistry And The Chemistry Natural Products*, 5thedn., Pearson Education India, 1956.

G. C. Howard and W. E. Brown, *Modern Protein Chemistry: Practical Aspects*, CRC Press, 2001.

S. P. Bhutani, *Chemistry of Biomolecules*, CRC Press, 2010.

O. Stone, *Chemical Biology: An Overview on Chemistry and Biology of the Biomolecules*, Foster Academics, 2015.

T. Palmer, *Enzymes: Biochemistry, Biotechnology and Clinical Chemistry*, Horwood, 2001.

T. D. H. Bugg, *Introduction to Enzyme and Coenzyme Chemistry, 3rd Edition*, Wiley, 2012.

MCHEM 0404: Physical Major II

Unit I

1. Quantum mechanics of many electron systems (18 lectures)

Introduction to spin. Operator algebra for spin. Construction of matrix representation of spin operators, eigen values and eigen functions of spin operators. Many-electron wave functions- examples with 2 and 3 electron systems, Slater determinants. The Pauli exclusion principle.The Born-Oppenheimer approximation, Hartree self consistent field method, Koopman's theorem, Hartree-Fock method for many-electron systems. Coulomb operators, Exchange operators, Coulomb and Fermi hole, Restricted and unrestricted Hartree-Fock calculations, The Roothan equation. Correlation energy, Basis sets for electronic structure calculations. Spin-orbit interaction, The Condon-Slater rules. The Huckel and Extended Huckel MO method, Introduction to density functional theory, Definition of density, Hohenberg-Kohn variation theorem, Kohn-Sham equations, Exchange-correlation energy, Local density approximation, Generalized gradient approximation

2. Molecular interactions (07 lectures)

Hamiltonian in absence and presence of external fields, forces in molecules, Hellmann-Feynmann theorem, perturbative treatment of electric polarisability, intermolecular interaction - calculation of dispersion energy, the London formula

Unit II

3. Irreversible thermodynamics and introductory course on non-equilibrium statistical mechanics (18 lectures)

Thermodynamic criteria for Non-equilibrium states. Entropy production in irreversible process. Entropy balance equations. Generalized flux and forces.Stationary states.Coupling of irreversible process, Phenomenological equations.Microscopic reversibility and Onsager equation.Applications in physico-chemical and biological phenomena.

Einstein's theory of Brownian motion, Langevin description of Brownian motion: general expression for mean square displacement (i) short time limit and (ii) long time limit. Fluctuation-dissipation relation, Fokker-Planck equation, Brownian motion in phase space (motion in a force field): Kramers' equation. Application to Kramer's theory and transport problems, Master equations and its applications.

4. Electric and magnetic properties of molecules (07 lectures)

Dielectric polarization; Debye equation and its limitation; Onsager's reaction field model; electric polarizability of molecules; magnetic susceptibility - diamagnetic and paramagnetic, Currie law

Suggested books

A. Szabo, N. S. Ostlund, Modern Quantum Chemistry, Dover Publications, Inc, NY

P. W. Atkins, *Molecular Quantum Mechanics*, Clarendon Press, Oxford, 1980.

L. I. Schiff, *Quantum Mechanics*, McGraw-Hill, New York, 1985.

A. K. Chandra, *Introductory Quantum Chemistry*, Tata McGraw-Hill Publishing Co, New Delhi, 1989.

F. L. Pilar, *Elementary Quantum Chemistry*, Tata McGraw-Hill, New Delhi, 1990.

D. A. McQuarrie, *Quantum Chemistry,* Viva Books Pvt Ltd, New Delhi, 2003.

I. N. Levine, Quantum Chemistry, PHI Learning Pvt. Ltd, New Delhi, 2010.

E. Merzbacher, Quantum Mechanics, Wiley, 1998.

A. J. Stone, *The Theory of Intermolecular Forces*, Clarendon Press, Oxford, 1996.

C. J. F. Böttcher, *Theory of Electric Polarisation*, Vols 1 and 2, Elsevier Scientific Publishing Co, New York, 1973.

D. W. Davies, *The Electric and Magnetic Properties of Molecules,*

I. Prigogine, *Introduction to Thermodynamics of Irreversible Processes*, Inter science Publishers, 1967.

R. Zwanzig, Nonequilibrium Statistical Mechanics, Oxford University Press.

MCHEM0405: Inorganic Major III

Unit I

1. Supramolecular chemistry II (12 lectures)

Judicious choice of geometry setter/blocker/spacer/counter ion – an essential prerequisite, hydrogen bonding, π…π, C-H…π, halogen…π, S…π, etc interactions, allosterism, proton and hydride sponges, principle of three C's, lock and key principle, host-guest interaction, self organization and self complementarity, receptors, superstructures in inorganic, metallo-organic and organometallic compounds, 0D, 1D, 2D, 3D architectures and hierarchies, supramolecular devices

2. Inorganic materials (13 lectures)

Molecules and crystals to materials, art of synthesis, predictable crystalline architecture, intermolecular and interion interactions, secondary building unit (SBU), surface functionalisation, hysteresis, robust and directional interactions, click chemistry, functional materials: conducting, superconducting, magnetic, non-linear, porous, luminous, liquid crystals, quantum dots, catalysts, molecular and electronic devices, biosensors, biomineralization, proteomics, dendrimers, molecular recognition

Unit II

3. Molecular magnetism II (13 lectures)

Isolation of different molecular magnets, magnetic interactions in di- and polynuclear systems and clusters, cryogenic experiment, mechanism of exchange interaction, Bleaney-Bowers equation, antiferromagnetism (AF), ferromagnetism (F), single molecule magnet, deliberate synthetic approach of ferromagnetically coupled system, accidental orthogonality, spin canting, canted-AF, canted-F, spin frustration, admixed-spin, spinflop, metamagnetism, superparamagnetism, long-range ordering, calculation of ground state and spin manifold, magnetization versus field studies, inorganic, organic, metal-organic and organometallic magnetic materials

4. Structure-function relationship (12 lectures)

A sheer necessity and an ultimatum, thermodynamic and kinetic parameters; diagnostic probes: spectroscopic, thermal, electrochemical, magnetic, crystallographic; parameters: stretching frequency, chemical shift, spin-spin coupling constant, isomer shift, potential value, bond distance, bond angle, torsion angle, crystal packing and Madelung constant, magnetic moment value, rate constant, half life, correlation diagram, room temperature and variable-temperature results, breakthrough and legacy

Suggested books

F. Vogtle, *Supramolecular Chemistry: An Introduction*, Wiley, Chichester, 1991.

B. Dietrich, P. Viout and J. -M. Lehn, *Macrocyclic Chemistry – Aspects of Organic and Inorganic Supramolecular Chemistry*, VCH, Weinheim, 1993.

J. -M. Lehn, *Supramolecular Chemistry: Concepts and Perspectives*, VCH, Weinheim, 1995.

G. R. Newkome, C. N. Moorefield and F. Vogtle, *Dendritic Molecules*, VCH, Weinheim, 1996.

G. A. Jeffrey, *An Introduction to Hydrogen Bonding*, Oxford University Press, Oxford, 1997.

S. T. Hyde, B. Ninham, S. Anderson, Z. Blum, T. Landh, K. Larsson and S. Liddin, *The Language of Shape*, Elsevier, Amsterdam, 1997.

G. R. Desiraju (Ed), *Crystal Design: Structure and Function, Perspectives in Supramolecular Chemistry*, Vol 7, Wiley, Chichester, 2003.

J. W. Steed and J. L. Atwood,*Supramolecular Chemistry*, 2^{nd} Edn, John Wiley & Sons, New York, 2009.

K. Rurack and R. Martinez-Manez (Eds), *The Supramolecular Chemistry of Organic-Inorganic Hybrid Materials*, John Wiley & Sons, Hoboken, New Jersey, 2010.

R. Xu, W. Pang and Q. Huo (Eds), *Modern Inorganic Synthetic Chemistry*, Elsevier, New York, 2011.

E. R. T. Tiekink and J. Zukerman-Schpector (Eds), *The Importance of Pi-Interactions in Crystal Engineering: Frontiers in Crystal Engineering*, 1^{st} Edn, John Wiley & Sons, Chichester, UK, 2012.

V. Balzani and F. Scandola, *Supramolecular Photochemistry*, Ellis Horwood, Chichester, 1991.

U. Schubert and N. Hüsing, *Synthesis of Inorganic Material*, Wiley-VCH, Weinheim, 2004.

C. N. R. Rao, A. Muller and A. K. Cheetham, *The Chemistry of Nanomaterials: Synthesis Properties and Applications*, Wiley-VCH, Weinheim, Germany, 2004.

G. A. Ozin and A. C. Arsenault, *Nanochemistry: A Chemical Approach to Nanomaterials*, RSC Publishing, Cambridge, 2005.

C. N. R. Rao, A. Muller and A. K. Cheetham, *Nanomaterials Chemistry: Recent Developments and New Directions*, Wiley-VCH, Weinheim, Germany, 2007.

E. Ruiz-Hitzky, K. Ariga and Y. Lvov, *Bio-inorganic Hybrid Nanomaterials. Strategies, Syntheses, Characterization and Applications*, Wiley-VCH, Weinheim, 2008.

A. Sayari and M. Jaroniec, *Nanoporous Materials*, World Scientific Publishing, Singapore, 2008.

L. Cademartiri and G. A. Ozin, *Concepts of Nanochemistry*, Wiley-VCH, Weinheim, 2009.

J. N. Lalena, D. A. Cleary, E. E. Carpenter and N. F. Dean, *Inorganic Materials Synthesis and Fabrication*, John Wiley & Sons, Inc. Hoboken, New Jersey, 2008.

P. Comba, T. W. Hambley and B. Martin, *Molecular Modeling of Inorganic Compounds*, 3rd Edn, Wiley-VCH, Weinheim, 2009.

S. R. Batten, S. M. Neville and D. R. Turner, *Coordination Polymers Design, Analysis and Application*, The Royal Society of Chemistry, Cambridge, 2009.

M. -C. Hong and L. Chen (Eds), *Design and Construction of Coordination Polymers*, John Wiley & Sons, Inc, Hoboken, New Jersey, 2009.

J. N. Lalena and D. A. Cleary, *Principles of Inorganic Materials Design*, 2nd Edn, John Wiley & Sons, Inc, Hoboken, New Jersey, 2010.

V. Balzani, A. Credi and M. Venturi,*Molecular Devices and Machines*, Wiley-VCH, Weinheim, 2003.

M. Petty,*Molecular Electronics: From Principles to Practice*, Wiley, Chichester, 2008.

L. R. Macgillivray (Ed), *Metal-Organic Frameworks: Design and Application*, John Wiley & Sons, Inc, Hoboken, New Jersey, 2010.

S. R. Marder, J. E. Sohn and G. D. Stucky (Eds), *Materials for Non-linear Optics: Chemical Perspectives,* ACS Symposium Ser, 1991.

R. W. Boyd, *Nonlinear Optics*, Academic Press, San Diego, 1992.

R. L. Carlin, *Magnetochemistry*, Springer-Verlag, New York, 1986.

O. Kahn, *Molecular Magnetism*, VCH, New York, 1993.

P. Day and A. E. Underhill (Eds), *Metal-organic and Organic Molecular Magnets*, RSC, London, 2000.

P. M. Lathi (Ed), *Magnetic Properties of Organic Materials*, Marcel Dekker, New York, 1999.

J. S. Miller and M. Drillon (Eds), *Magnetism: Molecules to Materials, V; Molecule-based Magnets*, Wiley-VCH, Weinheim, 2005.

P. Gutlich and H. A. Goodwin, *Spin Crossover in Transition Metal Compounds I*, Springer, Berlin, 2004. F. E. Mabbs and D. J. Machin, *Magnetism and Transition Metal Complexes*, Dover Publications, 2008.

R. Winpenny (Ed), *Single-Molecule Magnets and Related Phenomena*, Structure and Bonding Series, Vol. 122, Springer, Berlin, 2010.

B. D. Cullity and C. D. Graham, *Introduction to Magnetic Materials,* 2nd Edn, John Wiley & Sons, New York, 2011.

K. H. J. Buschow, *Handbook of Magnetic materials,* Vol 20, Elsevier, New York, 2012.

D. Gatteschi, R Sessoli and J. Villain, *Molecular Nanomagnets*, Oxford University Press, Oxford, 2006.

R. Hilzinger and W. Rodewald, *Magnetic Materials*, Wiley, New York, 2013.

B. Pignataro (Ed), *Tomorrow's Chemistry Today – Concepts in Nanoscience, Organic Materials and Environmental Chemistry*, Wiley-VCH, Weinheim, 2008.

L. Cademartiri and G. A. Ozin, *Concepts of Nanochemistry*, Wiley-VCH, Weinheim, 2008.

B. R. Eggins, Chemical Sensors and Biosensors, Wiley India Pvt Ltd, New Delhi, 2002.

S. Chandrasekhar, *Liquid Crystals*, 2nd Edn, Cambridge University Press, Cambridge, 1992.

G. R. Desiraju, *Crystal Engineering: Designing of Organic Solids*, Elsevier, New York, 1989.

D. Braga, F. Grepioni and A. G. Orpen, *Crystal Engineering: from Molecules and Crystals to Materials*, Kluwer Academic Publishers, Dordrecht, 1999.

U. Schubert and N. Husing, *Synthesis of Inorganic Material*, 2nd Edn, Wiley-VCH Verlag GmbH& Co, Weinheim, 2005

X. -D. Xiang and I. Takenchi (Eds), *Combinatorial Synthesis*, Marcel Dekker, New York, 2003.

E. I. Stiefel (Ed), *Dithiolene Chemistry: Synthesis, properties, and Applications*, John Wiley & Sons, New Jersey, 2004.

P. Gomez-Romero and C. Sanchez (Eds), *Functional Hybrid Materials*, Wiley-VCH, Weinheim, 2004.

M. F. C. Ladd and R. A. Palmer, *Structural Determination by X-ray Crystallography*, 3rd Edn, Plenum, New York, 1994.

D. Farrusseng (Ed), *Metal-Organic Framework: Applications from Catalysis to Gas Storage*, Wiley-VCH, Verlag, GmbH& Co, 2011.

MCHEM0406: Organic Major III

Unit I

1. Pericyclic reactions II (08 lectures)

Sigmatropic reactions: Definition, classification, stereochemistry, Woodward-Hoffmann rules, illustrations for [1,2]-, [1,3]-, [1,4]-, [1,5]-, [2,3]- and [3,3]-sigmatropic rearrangements, Claisen rearrangement, Cope rearrangement; Chelotropic reactions: Definition, Woodward-Hoffmann rules, examples of chelotropic reactions (chelotropic reactions involving SO_2, chelotropic extraction of nitrogen, chelotropic decarbonylation of ketones, chelotropic trapping of nitric oxide), synthetic applications; Ene reactions: Definition, classification, catalyzed and uncatalyzed ene reactions, stereochemistry of ene reactions – diastereoselection, oxy-ene and anionic oxy-ene-reactions, imino-ene reactions, carbonyl ene-reactions, singlet oxygen ene-reactions, retro-ene reactions.

2. Supramolecular chemistry (07 lectures)

Basic concepts of supramolecular chemistry, different non-covalent forces (hydrogenbonding, cation-π, CH-π, π-stacking, hydrophobic, hydrophilic interactions etc.)leading to strong bonding of guest molecules to the host, design principleof host or receptor molecules, different experimental techniques to characterize the host–guest complexation, example of molecular receptors: crown ethers, ionophores,cyclophanes, cyclodextrins and their application in specific recognition processes.

3. Antibiotics, antidiabetic and cardiovascular drugs: Chemical aspects (10 lectures)

Antibiotics: Cell wall biosynthesis, inhibitors, β-lactam rings, synthesis of penicillin;synthesis and mode of action of sulphonamides, nalidixic acid, norfloxacin, aminosalicyclic acid, ethinamide, fluconazole, chloroquin and premaquin; Antidiabetic drugs: insulinsensitizers (biguanides, thiazolidinediones), secretagogues (sulfonylureas, nonsulfonylurea secretagogues, alpha-glucosidase inhibitors, peptide analogues (injectable incretin mimetics, injectable amylin analogues);

Cardiovascular drugs: Introduction to cardiovascular diseases, synthesis and mode of action of statins, amyl nitrate, sorbitrate, diltiazem, quinidine, verapamil and methyl dopa

Unit II

4. Chemistry of polyphenolics (12 lectures)

Natural occurrence, chemical aspects, biological activities and therapeutic potential of some notable natural polyphenolics from the respective group: ellagitannins, flavonoindsand xanthonoides

5. Chemistry of steroidal hormones (07 lectures)

Chemistry and function of some steroidal hormones – estrogens, estrone, estradiol, estriol, progesterone, testosterone, oral contraceptives, anabolic steroids

6. Biosynthesis of some selected biologically relevant natural products (06 lectures)

Atropine, quinine, nicotine, abietic acid, β-carotene, cholesterol

Suggested books

T.L. Gilchrist and R.C. Storr, *Organic Reactions and Orbital Symmetry*, 2nd Edn., Cambridge University Press, 1979.

R. B. Woodward and R. Hoffman, *The Conservation of Orbital Symmetry*, Academic Press, 1970.

S. Sankararaman, *Pericyclic Reactions – A Textbook*, Wiley-VCH Verlag, 2005.

I. Fleming, *Pericyclic Reactions*, Oxford University Press, 1996.

F. Vögtle, *Supramolecular Chemistry: An Introduction*, John Wiley & Sons, 1991

J. M. Lehn, *Supramolecular Chemistry: Concept and Perspectives*, Wiley-VCH, 1995

P. J. Cragg, *Supramolecular Chemistry,* Springer, 2010.

H.-J. Schneider and A. Yatsimirsky, *Principles and Methods in Supramolecular Chemistry*, Wiley-VCH, 1999.

K. Ariga and T. Kunitake,*Supramolecular Chemistry - Fundamentals and Applications*, Springer, 2006.

J. C. Gallagher and C. MacDougall,*Antibiotics Simplified*, 3rd Revised edition, Jones and Bartlett Publishers, Inc. 2013.

C. Walsh, *Antibiotics: Actions, Origins, Resistance*, Wiley-VCH, 2016.

S. Sánchez and A. L. Demain, *Antibiotics: Current Innovations and Future Trends*,Caister Academic Press, 2015.

B. Testa and U. A. Meyer, *Antidiabetic Agents: Recent Advances in their Molecular and Clinical Pharmacology*,Acdemic Press, 1996.

K. Chatterjee and E. J. Topol, *Cardiac Drugs*, 1 edition,Jaypee Brothers Medical Pub., 2013.

W. H. Frishman and D. A. Sica, *Cardiovascular Pharmacotherapeutics - 3rd Edition*, CardioText, 2011.

Atta-ur-Rahman and M.I. Choudhary, *Frontiers in Cardiovascular Drug Discovery*, Bentham Publications, 2010.

S. Quideau, *Chemistry and Biology of Ellagitannins*, World Scientific Publishing Co., 2009.

O. M. Anderson and K. R. Markham, *Flavonoids: Chemistry, Biochemistry and Applications*, CRC Press, Taylor & Francis, 2006.

S. K. Talapatra and B. Talapatra, *Chemistry of Plant Natural Products*, Springer, 2012.

S. V. Bhat, B. A. Nagasampagi and M. Sivakumar, *Chemistry of Natural Products*, Narosa Publishing House, New Delhi, 2005.

M. M. M. Pinto, *Chemistry of Love and Sex*, Wiley-VCH, 2012.

D. B. Gower, *Steroid Hormones*, Year Book Medical Pub., 1979.

X.-T. Liang and W.-S. Fang, *Medicinal Chemistry of Bioactive Natural Products*, John Wiley & Sons, 2006.
P. Manitto, *Biosynthesis of Natural Products*, Ellis Horwood Ltd., 1981.
T. Hudlicky and J. W. Reed, *The Way of Synthesis*, Wiley-VCH, 2007.

MCHEM 0407: Physical Major III

Unit I

1. Molecular reaction dynamics (MRD) (12 lectures)

Motivation for studying MRD, Spectator model, Molecular collisions, Vocabularies in MRD, Dynamics of elastic molecular collisions, Collision cross section, The impact parameter, Centrifugal energy and barrier, The reaction cross section, Reaction probability, opacity function, translation energy requirements of chemical reactions, Scattering as probe of the collision dynamics, The angular function, The deflection function, Scattering as a probe for the potential, Product angular distribution in reactive collisions, Potential energy surfaces (PES) for a reaction, attractive and repulsive PES. Polyani's rules

2. Solid state chemistry (13 lectures)

Crystal structure: lattice, basis, concept of Bravais lattice, primitive and non primitive cell for SC, BCC, FCC, HCP; construction of Wigner Seitz cell; different lattice structures: diamond, zincblande, etc.; crystallographic point group and space group Reciprocal lattice, relation with Miller indices; Fourier transformation and Fourier space, conversion of primitive axes, Brillouin zone for 1D, 2D and 3D lattices, Determination of crystal structure: Bragg's condition, von Laue condition, their interrelation, geometrical structure factor, Electronic structure: Classical Drude model and its limitation, DC electrical conductivity, equation of motion; Hall effect, concept of charge carrier, thermal conductivity; Sommerfeld theory, ground state properties of electron gas, Fermi energy, Fermi surface; thermal properties of metal, Electron level in periodic potential: Bloch's theorem and its consequences; weak periodic potential, density of states, band structure; interaction of bands, tight-binding formulations; semiconductor solids and their properties.

Unit II

3. Photochemistry and Laser principles (15 lectures)

Excitation of molecules – Singlet and Triplet states. Jablonsky diagrams, Radiative and Non-radiative relaxations. Franck-Condon principle.Absorption, emission and excitation spectra - mirror symmetry. Florescence, Phosphorescence, quantum yield, mechanism and decay kinetics of photophysical process, quenching (dynamic and static), Stern-Volmer equation, Excited state processes – proton transfer, electron transfer and energy transfer (Forster's dipole coupling). Marcus Theory. Solvent effect in spectroscopy.Solvation dynamics.Non-linear optical processes. Stimulated emission of radiation.Principles of Laser action.Population inversion, Basic elements in laser, characteristics of laser radiation, Applications of Lasers.

4. Alternative Energy Studies (10 lectures)

Solar energy conversion, artificial photosynthesis; Si-p-n junction solar cell, basic principles and application, Dye-sensitized solar cells; structure, components and their functions. operating principles, Efficiencies of solar cells. Quantum dot sensitized solar cell, Nano hybrid materials for solar cell application.

Suggested books

R. D. Levine, Molecular Reaction Dynamics, 2006, Oxford University Press.

R. D. Levine, R. B. Bernstein, Molecular Reaction Dynamics and Chemical Reactivity, Oxford University Press, 1987.

C. Kittel, *Introduction to Solid State Physics*, 4th Edn, John Wiley & Sons, New York.

P. A. Cox, *The Electronic Structure & Chemistry of Solids*, Oxford University Press, Oxford, 1987.

A. R. West, Basic Solid State Chemistry, Wiley

L. Azzarof, Introduction to Solids, 1966

K, K. Rohatgi-Mukherjee, Fundamentals of Photochemistry, New Age International Publishers.

N. J. Turro, Modern Molecular Photochemistry, University Science Books

B. O'Regan, M. Gratzel, Nature, Vol- 353, Page-737, 1991.

M. Gratzel, J. Photochemistry and Photobiology C, Photochemistry Reviews, Vol-4, Page-145, 2003.

U. Mehmood et al. Review article on Recent advances in dye sensitized solar cells, Advances in Materials Science and Engineering Volume 2014, Article ID 974782.

Major Elective Practical (any one) (For Each, Full Marks: 50; Credit: 4)

MCHEM0408: Inorganic Major Practical II

1. Preparation of inorganic and coordination compounds using self-assembly
2. Growing of single crystals
3. Spectral, thermal, electrochemical and magnetic studies
4. Reactivities
5. Kinetic and mechanistic studies of some selected reactions (substitution and redox)

MCHEM 0409: Organic Major Practical II

1. Preparation of organic compounds involving multiple step reactions
2. Characterization of organic compounds using spectroscopic methods

MCHEM 0410: Physical Special II

1. Instrumental methods of studying hydrolysis, solubility and kinetics; elementary computer-based numerical methods
2. Study on charge transfer/EDA complexes

3. Determination of the binding constant of a ‘Host-Guest’ complex by spectrophotometric method
4. Determination of the thermodynamic parameters of the formation of a ‘Host-Guest’ complex
5. Fluorescence lifetime measurement
6. Study of a chemical oscillating system

Term Paper/Project work* (any one from 0411-0413)
(For Each, Full Marks: 50; Credit: 6)

MCHEM 0411: Inorganic Term Paper/Project
MCHEM 0412: Organic Term Paper/Project
MCHEM 0413: Physical Term Paper/Project

*In each discipline concerned MCHEM 0411-0413, topic-selection in consultation with the teacher; literature search from different reference books and using internet search; typed write-up with proper tables, structures, figures and literature to be submitted (approximately 25-30 pages with 12 font size); seminar lecture on this topic to be delivered in presence of all the teachers and an external subject expert.