# Learning Outcome Based Curriculum (LOCF)

# for

# B.Sc. (Program in Chemistry)

**Undergraduate Programme (CBCS)**
**w.e.f. Academic Session 2020-21**

**Kazi Nazrul University**
**Asansol, West Bengal**

# Preamble

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

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

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

# PART I

# INTRODUCTION

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

## 1. Introduction:

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

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

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

## 2. Learning Outcome Based Curriculum:

Curriculum is the heart of any educational system. The Learning Outcomes-based Curriculum Framework (LOCF) for the B.Sc. (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 Chemistry Programme:

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

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

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

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

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

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

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

## 2.iii. Program Learning Outcomes:

The student graduating with the Degree B.Sc (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 and analysis.

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

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

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

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

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

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

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

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

**2.iv Course Learning Outcomes:**

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

| **Programme Outcomes** | **CC 1** | **CC 2** | **CC 3** | **CC 4** |
|---|---|---|---|---|
| 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 and Industry.

### 2.v Teaching Learning Outcomes:

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

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

## 3. Attributes of a Chemistry Graduate:

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

a. **Core competency:** The chemistry graduates are expected to know the fundamental concepts of chemistry and applied chemistry. These fundamental concepts would reflect the latest understanding of the field, and therefore, are dynamic in nature and require frequent and time-bound revisions.
b. **Communication skills:** Chemistry graduates are expected to possess minimum standards of communication skills expected of a science graduate in the country. They are expected to read and understand documents with in-depth analyses and

logical arguments. Graduates are expected to be well-versed in speaking and communicating their idea/finding/concepts to wider audience

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

d. **Psychological skills:** Graduates are expected to possess basic psychological skills required to face the world at large, as well as the skills to deal with individuals and students of various sociocultural, economic and educational levels. Psychological skills may include feedback loops, self-compassion, self-reflection, goal-setting, interpersonal relationships, and emotional management.

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

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

g. **Research-skills:** Graduates are expected to be keenly observant about what is going on in the natural surroundings to awake their curiosity. Graduates are expected to design a scientific experiment through statistical hypothesis testing and other *a priori* reasoning including logical deduction.

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

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

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

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

## 4. Qualification Descriptors:

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

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

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

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

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

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

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

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

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

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

## 5. Assessment Methods:

Academic performance in various courses i.e. core, discipline electives, 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 surprise tests),
- Closed-book and open-book tests,
- Problem-solving exercises,
- Practical assignments and laboratory reports,
- Observation of practical skills,
- Individual and group project reports,
- Efficient delivery using seminar presentations,
- *Viva voce* interviews are majorly adopted assessment methods for this curricullum.

# 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**

<table>
<tr><td colspan="2">Course Type: Core (Theoretical)</td><td colspan="2">Course Details: CC-1(1)</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>
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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**

| Course Type: **CORE** | Course Details: **CC-1(2)** | | | L-T-P: **4-0-4** | |
|---|---|---|---|---|---|
| Credit: **6** | Full Marks: **100** | CA Marks | | ESE Marks | |
| | | Practical | Theoretical | Practical | Theoretical |
| | | **30** | **10** | **20** | **40** |

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

**Learning objectives:**

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

**Syllabus:**

**Unit – I: Kinetic Theory of Gases**

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

**Unit – II: Thermodynamics**

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

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

**Unit – III: Stereochemistry**

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

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

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**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)

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**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**

<table>
<tr><td colspan="2">Course Type: SEC (Theoretical)</td><td colspan="2">Course Details: SEC-1</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 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**

**P**aints, 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 ($\Delta G$, $\Delta H$ and $\Delta S$).

**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.

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**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**

| Course Type: SEC | 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. 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**

| Course Type: SEC | Course Details: SEC-3 | | | 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 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**

| Course Type: DSE | Course Details: DSEC-1(2) or 2(2) or 3(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. 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**

| Course Type: DSE | Course Details: DSEC-1(2) or 2(2) or 3(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. *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*

**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.

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