

**MANIPURUNIVERSITY**  
**Bachelor of Science (Hons) Chemistry**  
**(Effective from Academic Year 2025-26)**

**SEMESTER-I**

**CHEMISTRY Major-1**

**CHEMISTRY MAJOR -1**

**Course Code: MJC45CHM101(T)25**

**(45 classes of 1 hour each)**

L	T	P	Credit
3	0	1	4

**1.1 Major Courses**

**1.1 CHEMISTRY - A. INORGANIC CHEMISTRY - I**

**1.2 CHEMISTRY - B. ORGANIC CHEMISTRY – I**

**1.3 CHEMISTRY- C. PHYSICAL CHEMISTRY-I**

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

**Learning objective:**

- ❖ Atomic theory and its evolution.
- ❖ Learning scientific theory of atoms, concept of wavefunction.
- ❖ Elements in periodic table; physical and chemical characteristics, periodicity.
- ❖ Atomic structure, chemical bonding, and molecular geometry based on accepted models.
- ❖ Understand atomic theory of matter, composition of atom.
- ❖ Identity of given element, relative size, charges of proton, neutron and electrons, and their assembly to form different atoms.
- ❖ Physical and chemical characteristics of elements in various groups and periods according to ionic size, charge, etc. and position in periodic table.
- ❖ Characterize bonding between atoms, molecules, interaction and energetic, hybridization and shapes of atomic, molecular orbitals, bond parameters, bond distances and energies.
- ❖ Valence bond theory incorporating concepts of hybridization predicting geometry of molecules.
- ❖ Importance of hydrogen bonding, metallic bonding.
- ❖ Basic of organic molecules, structure, bonding, reactivity and reaction mechanisms. molecules and nomenclature.
- ❖ Reactivity, stability of organic molecules, structure, reaction stereochemistry
- ❖ Electrophile, nucleophiles, free radicals, electronegativity, resonance, and intermediates along the reaction pathways.
- ❖ Mechanism of organic reactions (effect of nucleophile / leaving group, solvent), substitution vs. elimination
- ❖ Physical properties of each state of matter and laws related to describe the states.
- ❖ Calculation of lattice parameters.

## SECTION A: INORGANIC CHEMISTRY

### UNIT-1 Atomic Structure:

(5 Classes of 60 minutes each)

Brief revision of Bohr model and its limitations, atomic spectra of Hydrogen and Hydrogen-like atoms, Quantization of angular momentum, dual nature of electrons, de Broglie equation, wave functions, Quantum numbers and their significance, concept of orbit and orbitals. Radial probability diagrams and shapes of s, p and d-orbitals. Pauli's Exclusion Principle, Hund's rule of maximum multiplicity, Aufbau's principle and its limitations, Electronic configuration of atoms, Variation of orbital energy with atomic number.

### UNIT-2: Periodicity of Elements:

(5 Classes of 60 minutes each)

Details on modern Periodic Table with reference to the periodic changes of atomic, ionic and covalent radii. Ionisation energies, successive ionization energies, factors affecting ionization energy and application of ionization energy. Electron affinity and electron negativity, Pauling, Mullikan, Alfred Rachow scales of electronegativity. Bond order, partial charge, hybridization, group electronegativity, Effective nuclear charge, shielding or screening effect, Slater's rule, variation of effective nuclear charge in periodic table.

### UNIT-3: Chemical Bonding:

(8 Classes of 60 minutes each)

Type of chemical bonding and its characteristics:

*Ionic bond:* General characteristics, type of ions, size effect, radius ratio rule and its limitation, packing of ions in crystals, Madelung constant, Born-Haber cycle and its application, Solvation energy.

*Covalent bond:* Lewis structure, Shapes of simple molecules containing lone/bond-pairs of electrons, multiple bonding, sigma and pi-bond approach, Valence Shell Electron Pair Repulsion Theory (VSEPR), Valence Bond theory (Heitler-London approach). Molecular orbital theory. Molecular orbital diagrams of simple homonuclear/heteronuclear diatomic molecules, N<sub>2</sub>, O<sub>2</sub>, B<sub>2</sub>, F<sub>2</sub>, CO, NO and their ions. (ideas of s-p mixing and orbital interaction to be given.) Hybridization of atomic orbitals (s, p and d only), shapes of s, p and d hybrid orbitals, BeF<sub>2</sub>, BF<sub>3</sub>, NH<sub>3</sub>, H<sub>3</sub>O<sup>+</sup>, SF<sub>4</sub>, ClF<sub>3</sub>, ICl<sub>2</sub><sup>-</sup>.

Covalent character in ionic compounds and Ionic character in covalent compounds. Bond moment and Dipole moment. Ionic character from dipole moment and electronegativity difference.

## Section B. ORGANIC CHEMISTRY – I

### UNIT-4: Basic Concepts of Organic Chemistry:(8 classes of 60 minutes each)

Organic Compounds: Classifications and nomenclature, hybridization, shapes of molecules, influence of hybridization on bond properties. Electronic displacements: Inductive, electromeric, resonance and mesomeric effects, hyperconjugation and their applications.

Organic acids and bases and their relative strengths. Homolytic and heterolytic fission with suitable examples. Curly arrow rules, formal charges, Electrophiles and Nucleophiles, Nucleophilicity and basicity, Types, shape and relative stabilities of reaction intermediates (Carbocations, Carbanions, Free radicals, Carbenes and Nitrenes). Organic reactions and their mechanism: Addition, Elimination and Substitution reactions.

#### **UNIT-5: Chemistry of Aliphatic Hydrocarbons:** (12 classes of 60 minutes each)

Preparation, properties and reactions of alkanes: Wurtz reaction, Wurtz-Fittig reaction, Free radical substitutions: Halogenation -relative reactivity and selectivity.

Preparation, properties and reactions of alkenes and alkynes: Elimination reactions, Mechanism of E1, E2, E1cB reactions. Saytzeff's and Hofmann's eliminations. 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, ethylbenzene, acidity of alkynes

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

### **Section C. PHYSICAL CHEMISTRY-I**

#### **UNIT-6: Introduction to Classical Thermodynamics** (7 class of 60 minutes each)

Intensive and extensive variables; state and path functions; isolated, closed and open systems; Laws of thermodynamics, zeroth law of thermodynamics. First law: Concept of heat (q), work (w), internal energy (U), enthalpy (H), relation between heat capacities, 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: Heat of reactions, standard states; enthalpy of formation of molecules and ions and enthalpy of combustion and its applications; calculation of bond energy, bond dissociation energy and resonance energy from thermochemical data, effect of temperature (Kirchhoff's equations), pressure on enthalpy of reactions.

Total Number of Hours = 45

#### **Recommended Books/References:**

1. Lee, J.D. *Concise Inorganic Chemistry*, Wiley, 5<sup>th</sup> Edn.
2. Douglas, B.E., McDaniel, D.H., Alexander J.J., *Concepts & Models of Inorganic Chemistry, (Third Edition)* John Wiley & Sons, 1999.
3. Atkins, P.W. and DePaula, J. *Physical Chemistry*, Tenth Edition, Oxford University Press, 2014.

4. Rodger, G.E. *Inorganic and Solidstate Chemistry*, Cengage Learning, 2002
5. Morrison, R.N. and Boyd, R.N. *Organic Chemistry*, 6th Edn., Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
6. Pine S.H. *Organic Chemistry*, Fifth Edition, McGraw Hill, (2007)
7. F.A. Carey, *Organic Chemistry*, Seventh Edition, Tata McGraw Hill (2008).
8. J. Clayden, N. Greeves, S. Warren, *Organic Chemistry*, 2nd Ed., (2012), Oxford University Press.
9. F.A. Carey, R.J. Sundberg, *Advanced Organic Chemistry, Part A: Structure and mechanism*, Kluwer Academic Publisher, (2000).

**SEMESTER- I PRACTICAL  
(1 CREDIT)**

**MJC 45CHM101(P)25**

**INORGANIC CHEMISTRY LABORATORY (MAJOR)**

**Titrimetric Analysis**

- (i) Calibration and use of apparatus.
- (ii) Preparation of solutions of different Molarity/Normality of titrants.
- (iii) Use of primary and secondary standard solutions.

**Acid-Base Titrations (any one of the following)**

- (i) Estimation of carbonate and hydroxide present together in mixture.
- (ii) Estimation of carbonate and bicarbonate present together in a mixture.
- (iii) Estimation of free alkali present in different soaps/detergents

**CHN501: Organic Chemistry Laboratory I (Major)**

1. Purification of organic compounds by crystallization using the following solvents:  
a. Water b. Alcohol c. Alcohol-Water
2. Determination of the melting points of given organic compounds and unknown organic compounds (using Kjeldahl method and electrically heated melting point apparatus).
3. Effect of impurities on the melting point—mixed melting point of two unknown organic compounds.
4. Determination of boiling point of liquid compounds. (boiling point lower than and more than 100°C by distillation and capillary method)
5. Chromatography : Separation of a mixture of two amino acids by ascending and horizontal paper chromatography

**Mark distribution in practical:(1 credit)**

Inorganic Chemistry	Organic Chemistry	Lab. Note Book	Viva voce	Total
6 Marks	12 Marks	3 Marks	4 Marks	25 Marks

## Recommended Books/References:

1. Mendham, J., *A.I. Vogel's Quantitative Chemical Analysis*, Sixth Edition, Pearson, 2009.
2. Svehala G. and Sivasankar I.B, *Vogel's Qualitative Inorganic Analysis*, Pearson, India, 2012.
3. Mann, F.G. & Saunders, B.C. *Practical Organic Chemistry*, Pearson Education (2009)
4. Furniss, B.S.; Hannaford, A.J.; Smith, P.W.G.; Tatchell, A.R. *Practical Organic Chemistry*, 5thEd., Pearson (2012)

(List of experiments and references are suggestive. However, more experiments can be added/list of experiments can be revised as per available facilities).

## CHEMISTRY Minor-1

### CHEMISTRY MINOR -1

Course Code: MNC45CHM101(T)25

(45 classes of 1 hour each)

L	T	P	Credit
3	0	1	4

### 1.1 MINOR COURSES

#### 1.1 CHEMISTRY - A. INORGANIC CHEMISTRY - I

#### 1.2 CHEMISTRY - B. ORGANIC CHEMISTRY – I

#### 1.3 CHEMISTRY- C. PHYSICAL CHEMISTRY-I

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

#### Learning objective:

- ❖ Atomic theory and its evolution.
- ❖ Learning scientific theory of atoms, concept of wavefunction.
- ❖ Elements in periodic table; physical and chemical characteristics, periodicity.
- ❖ Atomic structure, chemical bonding, and molecular geometry based on accepted models.
- ❖ Understand atomic theory of matter, composition of atom.
- ❖ Identity of given element, relative size, charges of proton, neutron and electrons, and their assembly to form different atoms.
- ❖ Physical and chemical characteristics of elements in various groups and periods according to ionic size, charge, etc. and position in periodic table.
- ❖ Characterize bonding between atoms, molecules, interaction and energetic, hybridization and shapes of atomic, molecular orbitals, bond parameters, bond distances and energies.
- ❖ Valence bond theory incorporating concepts of hybridization predicting geometry of molecules.
- ❖ Importance of hydrogen bonding, metallic bonding.
- ❖ Basic of organic molecules, structure, bonding, reactivity and reaction mechanisms.

- ❖ molecules and nomenclature.
- ❖ Reactivity, stability of organic molecules, structure, reaction stereochemistry
- ❖ Electrophile, nucleophiles, free radicals, electronegativity, resonance, and intermediates along the reaction pathways.
- ❖ Mechanism of organic reactions (effect of nucleophile / leaving group, solvent), substitution vs. elimination
- ❖ Physical properties of each state of matter and laws related to describe the states.
- ❖ Calculation of lattice parameters.

## SECTION A: INORGANIC CHEMISTRY

### UNIT-1 Atomic Structure:

(5 Classes of 60 minutes each)

Brief revision of Bohr model and its limitations, atomic spectra of Hydrogen and Hydrogen-like atoms, Quantization of angular momentum, dual nature of electrons, de Broglie equation, wave functions, Quantum numbers and their significance, concept of orbit and orbitals. Radial probability diagrams and shapes of s, p and d orbitals. Pauli's Exclusion Principle, Hund's rule of maximum multiplicity, Aufbau's principle and its limitations, Electronic configuration of atoms, Variation of orbital energy with atomic number.

### UNIT-2: Periodicity of Elements:

(5 Classes of 60 minutes each)

Details on modern Periodic Table with reference to the periodic changes of atomic, ionic and covalent radii. Ionisation energies, successive ionization energies, factors affecting ionization energy and application of ionization energy. Electron affinity and electron negativity, Pauling, Mulliken, Alfred Rachow scales of electronegativity. Bond order, partial charge, hybridization, group electronegativity, Effective nuclear charge, shielding or screening effect, Slater's rule, variation of effective nuclear charge in periodic table.

### UNIT-3: Chemical Bonding:

(8 Classes of 60 minutes each)

Type of chemical bonding and its characteristics:

*Ionic bond:* General characteristics, type of ions, size effect, radius ratio rule and its limitation, packing of ions in crystals, Madelung constant, Born-Haber cycle and its application, Solvation energy.

*Covalent bond:* Lewis structure, Shapes of simple molecules containing lone/bond-pairs of electrons, multiple bonding, sigma and pi-bond approach, Valence Shell Electron Pair Repulsion Theory (VSEPR), Valence Bond theory (Heitler-London approach). Molecular orbital theory. Molecular orbital diagrams of simple homonuclear/heteronuclear diatomic molecules,  $N_2$ ,  $O_2$ ,  $B_2$ ,  $F_2$ ,  $CO$ ,  $NO$  and their ions. (ideas of s-p mixing and orbital interaction to be given.) Hybridization of atomic orbitals (s, p and d only), shapes of s, p and d hybrid orbitals,  $BeF_2$ ,  $BF_3$ ,  $NH_3$ ,  $H_3O^+$ ,  $SF_4$ ,  $ClF_3$ ,  $ICl_2^-$ .

Covalent character in ionic compounds and Ionic character in covalent compounds. Bond moment and Dipole moment. Ionic character from dipole moment and electronegativity difference.

## Section B. ORGANIC CHEMISTRY – I

### UNIT-4: Basic Concepts of Organic Chemistry: (8 classes of 60 minutes each)

Organic Compounds: Classifications and nomenclature, hybridization, shapes of molecules, influence of hybridization on bond properties. Electronic displacements: Inductive, electromeric, resonance and mesomeric effects, hyperconjugation and their applications.

Organic acids and bases and their relative strengths. Homolytic and heterolytic fission with suitable examples. Curly arrow rules, formal charges, Electrophiles and Nucleophiles, Nucleophilicity and basicity, Types, shape and relative stabilities of reaction intermediates (Carbocations, Carbanions, Free radicals, Carbenes and Nitrenes). Organic reactions and their mechanism: Addition, Elimination and Substitution reactions.

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Preparation, properties and reactions of alkenes and alkynes: Elimination reactions, Mechanism of E1, E2, E1cB reactions. Saytzeff's and Hofmann's eliminations. 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, ethylbenzene, acidity of alkynes

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

## Section C. PHYSICAL CHEMISTRY-I

### UNIT-6: Introduction to Classical Thermodynamics (7 class of 60 minutes each)

Intensive and extensive variables; state and path functions; isolated, closed and open systems; Laws of thermodynamics, zeroth law of thermodynamics. First law: Concept of heat ( $q$ ), work ( $w$ ), internal energy ( $U$ ), enthalpy ( $H$ ), relation between heat capacities, 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: Heat of reactions, standard states; enthalpy of formation of molecules and ions and enthalpy of combustion and its applications; calculation of bond energy, bond dissociation energy and resonance energy from thermochemical data, effect of temperature (Kirchhoff's equations), pressure on enthalpy of reactions.

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3. Atkins, P.W. and DePaula, J. *Physical Chemistry*, Tenth Edition, Oxford University Press, 2014.
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9. F.A. Carey, R.J. Sundberg, *Advanced Organic Chemistry, Part A: Structure and mechanism*, Kluwer Academic Publisher, (2000).

**Semester I Practical  
(1 Credit)**

**Inorganic Chemistry Laboratory (Minor): MNC45CHM101(P)25**

**Titrimetric Analysis**

- (i) Calibration and use of apparatus.
- (ii) Preparation of solutions of different Molarity/Normality of titrants.
- (iii) Use of primary and secondary standard solutions.

**Acid-Base Titrations (any one of the following)**

- (i) Estimation of carbonate and hydroxide present together in mixture.
- (ii) Estimation of carbonate and bicarbonate present together in a mixture.
- (iii) Estimation of free alkali present in different soaps/detergents

**CHN501: Organic Chemistry Laboratory I (Minor)**

1. Purification of organic compounds by crystallization using the following solvents:  
a. Water b. Alcohol c. Alcohol-Water
2. Determination of the melting points of given organic compounds and unknown organic compounds (using Kjeldahl method and electrically heated melting point apparatus).
3. Effect of impurities on the melting point—mixed melting point of two unknown organic compounds.
4. Determination of boiling point of liquid compounds. (boiling point lower than and more than 100°C by distillation and capillary method)
5. Chromatography : Separation of a mixture of two amino acids by ascending and horizontal paper chromatography

**Mark distribution in practical:**(1 credit)

Inorganic Chemistry	Organic Chemistry	Lab. Note Book	Viva voce	Total
6 Marks	12 Marks	3 Marks	4Marks	25 Marks

**Recommended Books/References:**

1. Mendham, J., *A.I.Vogel's Quantitative Chemical Analysis*, Sixth Edition, Pearson, 2009.
2. Svehala G. and Sivasankar I.B, *Vogel's Qualitative Inorganic Analysis*, Pearson, India, 2012.
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4. Furniss, B.S.; Hannaford, A.J.; Smith, P.W.G.; Tatchell, A.R. *Practical Organic Chemistry*, 5th Ed., Pearson (2012)

(List of experiments and references are suggestive. However, more experiments can be added/list of experiments can be revised as per available facilities).

**MULTI DISCIPLINARY COURSE (MDC)**

**MDC-I: Introductory Chemistry**

**Paper: Introductory Chemistry**

**(45 Hrs)**

<b>L</b>	<b>T</b>	<b>P</b>	<b>Cr</b>
<b>3</b>	<b>0</b>	<b>0</b>	<b>3</b>

Course Code: MDC45CHM101(T)25

**Course Objectives:**

By studying this course, the students will be able to understand

- ❖ Atomic theory and its evolution.
- ❖ Learning the scientific theory of atoms.
- ❖ Elements in the periodic table, physical and chemical characteristics, and periodicity.
- ❖ To predict the atomic structure, chemical bonding, and molecular geometry based on accepted models.
- ❖ To understand the atomic theory of matter, consider the composition of an atom.
- ❖ Identity of given element, relative size, charges of proton, neutron, and electrons, and their assembly to form different atoms.
- ❖ Defining isotopes, isobars, and isotones.
- ❖ Physical and chemical characteristics of elements in various groups and periods.
- ❖ Nature of bonding various molecules/ions.
- ❖ Behaviour of gases.
- ❖ Solutions, their strength, and colligative properties.

❖ Fundamentals of organic chemistry.

**1. Atomic structure: (8 Hrs)**

Bohr's atomic theory, Calculation of radius of atom and calculation of energy of electron in hydrogen-like atoms, Electromagnetic radiation and electromagnetic spectrum, hydrogen spectrum and its origin, Limitations of Bohr's atomic theory, de-Broglie theory, Heisenberg's uncertainty principle, quantum numbers, Aufbau principle, Hund's rule, Pauli's exclusion principle, electronic configuration of atoms and ions.

**2. Periodicity: (6 Hrs)**

Modern periodic law and modern periodic table, Classification of elements into blocks, atomic radius, Ionization energy, Electron affinity, Electronegativity and their variation in the periodic table, Diagonal relationship, Inert pair effect.

**3. Chemical bonding: (6 Hrs)**

General idea about chemical bonds and their types- ionic bond, covalent bond and coordinate bond, Valence bond theory of covalent bond, Explanation of shapes of molecules/ions VSEPR theory and hybridisation, Covalent character in ionic bond, Ionic character in covalent bond, Intermolecular forces.

**4. Gaseous state: (6 Hrs)**

Ideal gas and ideal gas equation, Kinetic theory of gases, Real gases and their deviation from ideal gas behaviour, van der Waals equation and its derivation, Significance and units of terms involved in van der Waals equation.

**5. Solutions: (6 Hrs)**

Solutions and their classifications, Concentration of solution and various terms used to express the strength of solution, Calculations related to strength of solution, Colligative properties of solution and related numerical problems.

**6. Introduction to organic chemistry: (8 Hrs)**

Organic compounds and their classification, Functional group, Homologous series, Types of carbon chains, carbon atoms & hydrogen atoms, IUPAC nomenclature of organic compounds, Hybridisation and shapes of organic molecules, General idea about structural isomerism and stereoisomerism in organic compounds, Aromaticity and its implications.

**7. Organic reaction mechanism: (5 Hrs)**

Fission of covalent bonds, Electrophiles and nucleophiles, Electronic displacements in organic molecules, Resonance, Organic reaction intermediates- carbocation, carbanion & free radicals,

Types of organic reactions.

### Course Outcome:

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

- ❖ Atomic theory and its evolution.
- ❖ Learning the scientific theory of atoms.
- ❖ Elements in the periodic table, physical and chemical characteristics, and periodicity.
- ❖ To predict the atomic structure, chemical bonding, and molecular geometry based on accepted models.
- ❖ To understand the atomic theory of matter, consider the composition of an atom.
- ❖ Identity of given element, relative size, charges of proton, neutron, and electrons, and their assembly to form different atoms.
- ❖ Defining isotopes, isobars, and isotones.
- ❖ Physical and chemical characteristics of elements in various groups and periods.
- ❖ Nature of bonding various molecules/ions.
- ❖ Behaviour of gases.
- ❖ Solutions, their strength, and colligative properties.
- ❖ Fundamentals of organic chemistry.

### Suggested Readings:

1. Kumar Indrajit, Undergraduate Introductory Chemistry, Pragati Prakashan Meerut, 2023.
2. Lee, J. D. *Concise Inorganic Chemistry*, Wiley, 5th Edn.
3. Atkins, P. W. and De Paula, J. *Physical Chemistry*, Tenth Edition, Oxford University Press, 2014.
4. R. N. Morrison & R. N. Boyd, *Organic Chemistry*, 6th Edn., Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
5. S. H. Pine, *Organic Chemistry*, Fifth Edition, McGraw Hill, (2007)
6. F. A. Carey, *Organic Chemistry*, Seventh Edition, Tata McGraw Hill (2008).
7. J. Clayden, N. Greeves, S. Warren, *Organic Chemistry*, 2nd Ed., (2012), Oxford University Press.

### SKILL ENHANCEMENT COURSE (SEC)

**SEC-1 : Water Remediation & Conservation Studies (45 Hrs)**

**Course Code: SEC45CHM101(T)25**

L	T	P	Cr
2	1	0	3

### Learning objectives:

On course aims :

1. Learn about the sources of water pollutants and the mechanisms of detoxification, bio-remediation and need of green chemistry.
2. Understand the importance of water conservation and erosion of soil and how to control the erosion.

### **UNIT-1: Water pollutants**

Sources of water pollutants, pollutants, Industrial and human contribution, WHO recommendation about potable water, current scenario of drinking water quality, chemistry of toxicants like arsenic, fluoride, chromium, lead and mercury, cause and effects of water pollution, remediation, techniques involved such as adsorption, coagulation-filtration, Nalgonada techniques, reverse osmosis, activated charcoal detoxification, applications of non-toxic oxides and mixed oxides, regeneration and recycling, mechanisms of detoxification, bio-remediation, need of green chemistry, future scope.

### **UNIT-2: Water conservation and erosion of soil**

Introduction to water conservation and erosion of soil, forms of water erosion, factors affecting water erosion, types of water erosion, mechanics of water erosion control, agronomical measures of water erosion control, Terraces for water erosion control, Modeling of water-shed processes, Case study of water-shed modeling for water conservation and water quality.

### **Learning outcomes:**

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

1. Learn about the sources of water pollutants and the mechanisms of detoxification, bio-remediation and need of green chemistry.
2. Understand the importance of water conservation and erosion of soil and how to control the erosion.

### **Recommended Books/references:**

1. CITTENDEN J. C., TRUSSELL J.R., HAND D.W., HOWE K. J., TCHOBANOGLIOUS G., *Water Treatment: Principles and Design*, MWH publication.
2. DE, A.K. *Environmental Chemistry*, Wiley Eastern
3. CLARSON D., DARA S. S., *A text book of Environmental Chemistry and Pollution Control*, S Chand & Co.
4. EDZWALD J., *Water Quality & Treatment: A Hand book on Drinking Water*, Water Resources and Environmental Engineering Series)

(List of references is suggestive. However, more references can be added).

## SEMESTER-II

CHEMISTRY MAJOR- 2

COURSE CODE: MJC45CHM102(T)25

(45 classes of 1 hour each)

L	T	P	Credit
3	0	1	4

**2.1 CHEMISTRY: A. MAJ II: INORGANIC CHEMISTRY-II**

**2.2 CHEMISTRY –B MAJ II: ORGANIC CHEMISTRY – II**

**2.3 CHEMISTRY –C MAJ II: PHYSICAL CHEMISTRY – II**

(Theory)

**3 Credits**

### SECTION A: INORGANIC CHEMISTRY

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

#### **Learning objective:**

- ❖ Familiarization with various states of matter.
- ❖ Physical properties of each state of matter and laws related to describe the states.
- ❖ Calculation of lattice parameters.
- ❖ Importance of hydrogen bonding, metallic bonding.
- ❖ Define oxidation and reduction.
- ❖ Identify oxidizing and reducing agents.
- ❖ Understand redox reaction.
- ❖ Define and identify aromatic compounds base on Huckel's rule.
- ❖ Describe the planer ring shaped structure and stability of the aromatic compounds.
- ❖ Explain the unique reactivity of aromatic compounds including electrophilic substitution reaction.

### Section A. INORGANIC CHEMISTRY - II

**UNIT-1: Metallic bonding and Weak chemical forces: (7 classes of 60 minutes each)**

- (i) Metallic Bond: Qualitative idea of valence bond and band theories, Semiconductors, Insulators, defects in solids. (ii) 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.

**Unit 2: Oxidation and Reduction Reaction:**  
each)

(6 classes of 60 minutes

Electronic concept of oxidation number, concept of oxidation-reduction, redox equations, standard electrode potential and its applications to inorganic reactions, principles involved in volumetric analysis to be carried out in the class.

**Section B. ORGANIC CHEMISTRY – II**

**UNIT-3: Aromatic Hydrocarbons (9 classes of 60 minutes each)**

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.

**Section C. PHYSICAL CHEMISTRY – II**

**UNIT-4: Gaseous State**

(8 classes of 60 minutes each)

Deviations from ideal gas behavior, compressibility factor and its variation with pressure for different gases. Causes of deviation from ideal behavior. Van der Waals equation of state, its derivation and application in explaining real gas behaviour; Berthelot and Dieterici equation; virial equation of state; van der Waals equation expressed in virial form, Boyle temperature. Isotherms of real gases and their comparison with van der Waals isotherms, continuity of states, critical state, critical and van der Waals constants, law of corresponding states. Kinetic molecular model of a gas: postulates and derivation of the kinetic gas equation; collision frequency; collision diameter; mean free path and viscosity of gases, including their temperature and pressure dependence, relation between mean free path and coefficient of viscosity, calculation of  $\sigma$  from  $\eta$ ; variation of viscosity with temperature and pressure. Maxwell distribution and its use in evaluating molecular velocities (average, root mean square and most probable) and average kinetic energy, law of equipartition of energy, degrees of freedom and molecular basis of heat capacities.

**UNIT-5: Liquid State**

(7 classes of 60 minutes each)

Structure and physical properties of liquids; vapour pressure, surface tension, viscosity, and their dependence on temperature, Effect of addition of various solutes on surface tension and viscosity; temperature variation of surface tension and viscosity of liquids; cleansing action of detergents; structure of water

**UNIT- 6 : Solid State**

(8 classes of 60 minutes each)

Nature of the solid state; law of constancy of interfacial angles; law of rational indices; Miller Page 21 of 102 indices; elementary ideas of symmetry, symmetry elements and symmetry

operations; qualitative idea of point and space groups; seven crystal systems and fourteen Bravais lattices; X-ray diffraction, Bragg's law; a simple account of rotating crystal method and powder pattern method. Analysis of powder diffraction patterns of NaCl, CsCl and KCl. Defects in crystals. Glasses and liquid crystals

### **Recommended Books/References:**

1. Atkins, P. W. & Paula, J. de Atkin's Physical Chemistry 8th Ed., Oxford University Press (2006).
2. Ball, D. W. Physical Chemistry Thomson Press, India (2007).
3. Castellan, G. W. Physical Chemistry 4th Ed. Narosa (2004).
4. Mortimer, R. G. Physical Chemistry 3rd Ed. Elsevier: NOIDA, UP (2009).
5. Barrow, G. M. Physical Chemistry 5th Ed. Tata McGraw Hill (2007).
6. Lee, J.D. Concise Inorganic Chemistry, Wiley, 5th Edn.
7. Douglas, B.E., McDaniel, D.H., Alexander J.J., Concepts & Models of Inorganic Chemistry, (Third Edition) John Wiley & Sons, 1999.
8. Atkins, P.W. and DePaula, J. Physical Chemistry, Tenth Edition, Oxford University Press, 2014.
9. Rodger, G. E. Inorganic and Solid State Chemistry, Cengage Learning, 2002.

## **Semester II (Major 2) Practical (1 Credit)**

**COURSE CODE: MJC45CHM102(P)25**

### **Physical Chemistry Laboratory –**

(List of experiments and references are suggestive. However, more experiments can be added/list of experiments can be revised as per available facilities).

#### **1. Surface tension measurements**

- a) Determine the surface tension by (i) drop number, and (ii) drop weight method.
- b) Study the variation of surface tension of detergent solutions with concentration.

#### **2. Viscosity measurements using Ostwald's viscometer**

- a) Determination of viscosity of aqueous solutions of (i) polymer, (ii) ethanol, and (iii) sugar at room temperature.
- b) Viscosity of sucrose solution with the concentration of solute.

#### **3. pH metry**

- a) Effect on pH of addition of HCl/NaOH to solutions of acetic acid, sodium acetate and their mixtures.
- b) Preparation of buffer solutions of different pH (i) Sodium acetate-acetic acid, (ii) Ammonium chloride-ammonium hydroxide
- c) pH metric titration of (i) strong acid vs. strong base, (ii) weak acid vs. strong base.
- d) Determination of the dissociation constant of a weak acid.

(List of experiments and references are suggestive. However, more experiments can be added/list of experiments can be revised as per available facilities).

**Mark distribution in practical:** (1 credit)

Physical Chemistry	Inorganic Chemistry	Lab. Note Book	Viva voce	Total
12	6	3	4	25

**CHEMISTRY MINOR- 2**

**COURSE CODE: MNC45CHM102(T)25**

**(45 classes of 1 hour each)**

**2 MINOR COURSES**

L	T	P	Credit
3	0	1	4

**2.1 CHEMISTRY A: INORGANIC CHEMISTRY-II**

**2.2 CHEMISTRY B: ORGANIC CHEMISTRY – II**

**2.3 CHEMISTRY C: PHYSICAL CHEMISTRY – II**

**Paper II**

**3 credits**

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

**Learning objective:**

- ❖ Familiarization with various states of matter.
- ❖ Physical properties of each state of matter and laws related to describe the states.
- ❖ Calculation of lattice parameters.
- ❖ Importance of hydrogen bonding, metallic bonding.
- ❖ Define oxidation and reduction.
- ❖ Identify oxidizing and reducing agents.
- ❖ Understand redox reaction.
- ❖ Define and identify aromatic compounds base on Huckel's rule.
- ❖ Describe the planer ring shaped structure and stability of the aromatic compounds.
- ❖ Explain the unique reactivity of aromatic compounds including electrophilic substitution reaction.

**Section A. INORGANIC CHEMISTRY - II**

**UNIT-1: Metallic bonding and Weak chemical forces: (7 classes of 60 minutes each)**

(i) Metallic Bond: Qualitative idea of valence bond and band theories, Semiconductors, Insulators, defects in solids. (ii) 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.

**Unit 2: Oxidation and Reduction Reaction:**  
each)

(6 classes of 60 minutes

Electronic concept of oxidation number, concept of oxidation-reduction, redox equations, standard electrode potential and its applications to inorganic reactions, principles involved in volumetric analysis to be carried out in the class.

**Section B. ORGANIC CHEMISTRY – II**

**UNIT-3: Aromatic Hydrocarbons (9 classes of 60 minutes each)**

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.

**Section C. PHYSICAL CHEMISTRY – II**

**UNIT-4: Gaseous State**

(8 classes of 60 minutes each)

Deviations from ideal gas behavior, compressibility factor and its variation with pressure for different gases. Causes of deviation from ideal behavior. Van der Waals equation of state, its derivation and application in explaining real gas behaviour; Berthelot and Dieterici equation; virial equation of state; van der Waals equation expressed in virial form, Boyle temperature. Isotherms of real gases and their comparison with van der Waals isotherms, continuity of states, critical state, critical and van der Waals constants, law of corresponding states. Kinetic molecular model of a gas: postulates and derivation of the kinetic gas equation; collision frequency; collision diameter; mean free path and viscosity of gases, including their temperature and pressure dependence, relation between mean free path and coefficient of viscosity, calculation of  $\sigma$  from  $\eta$ ; variation of viscosity with temperature and pressure. Maxwell distribution and its use in evaluating molecular velocities (average, root mean square and most probable) and average kinetic energy, law of equipartition of energy, degrees of freedom and molecular basis of heat capacities.

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(7 classes of 60 minutes each)

Structure and physical properties of liquids; vapour pressure, surface tension, viscosity, and their dependence on temperature, Effect of addition of various solutes on surface tension and viscosity; temperature variation of surface tension and viscosity of liquids; cleansing action of detergents; structure of water

## UNIT- 6 : Solid State

(8 classes of 60 minutes each)

Nature of the solid state; law of constancy of interfacial angles; law of rational indices; Miller Page 21 of 102 indices; elementary ideas of symmetry, symmetry elements and symmetry operations; qualitative idea of point and space groups; seven crystal systems and fourteen Bravais lattices; X-ray diffraction, Bragg's law; a simple account of rotating crystal method and powder pattern method. Analysis of powder diffraction patterns of NaCl, CsCl and KCl. Defects in crystals. Glasses and liquid crystals

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5. Barrow, G. M. Physical Chemistry 5th Ed. Tata McGraw Hill (2007).
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8. Atkins, P.W. and DePaula, J. Physical Chemistry, Tenth Edition, Oxford University Press, 2014.
9. Rodger, G. E. Inorganic and Solid State Chemistry, Cengage Learning, 2002.

## Semester II (Minor 2) Practical (1 Credit)

COURSE CODE: MNC45CHM102(P)25

### Physical Chemistry Laboratory –

(List of experiments and references are suggestive. However, more experiments can be added/list of experiments can be revised as per available facilities).

#### 1. Surface tension measurements

- a) Determine the surface tension by (i) drop number, and (ii) drop weight method.
- b) Study the variation of surface tension of detergent solutions with concentration.

#### 2. Viscosity measurements using Ostwald's viscometer

- a) Determination of viscosity of aqueous solutions of (i) polymer, (ii) ethanol, and (iii) sugar at room temperature.
- b) Viscosity of sucrose solution with the concentration of solute.

#### 3. pH metry

- a) Effect on pH of addition of HCl/NaOH to solutions of acetic acid, sodium acetate and their mixtures.
- b) Preparation of buffer solutions of different pH (i) Sodium acetate-acetic acid, (ii) Ammonium chloride-ammonium hydroxide

- c) pH metric titration of (i) strong acid vs. strong base, (ii) weak acid vs. strong base.  
 d) Determination of dissociation constant of a weak acid.

(List of experiments and references are suggestive. However, more experiments can be added/list of experiments can be revised as per available facilities).

**Mark distribution in practical:** (1 credit)

Physical Chemistry	Inorganic Chemistry	Lab. Note Book	Viva voce	Total
12	6	3	4	25

**MULTI DISCIPLINARY COURSE (MDC)**

**MDC-2**

**COURSE CODE : MDC45CHM102(T)25**

**(30 classes of 1 hour each)**

L	T	P	Credit
2	1	0	3

**I. Learning Objectives**

On completion of this course, the student will be able

- LO-1. To understand the use and applications 12 principles of Green Chemistry, identify greener solvents and use of renewable energy sources of sustainable chemistry. To define the importance of inorganic elements in vital systems. To understand the importance of minerals and essentially trace elements and beneficial elements of living system.
- LO-2. Understanding water's unique properties helps explain a lot about water's behavior. Student's working knowledge of water quality and characteristics of water sources. Students understand the terms: micelle, hard water, soft water, temporary hardness, and permanent hardness. Students acquire knowledge of the cleaning capacity of soap in hard and soft water. Based on the acquired skill, students will be able to classify the given water as hard water or soft water. Students acquire skills to perform the experiment in the real lab.
- LO-3. To get basic understanding of Food additives sugar substitutes, sweeteners, food colors, antioxidants, stabilizers, Biomaterial etc. used in food industry.
- LO-4. To get knowledge of classes of adhesives, their preparation and bonding mechanisms.

**II. Course Outcomes**

On Completion of this course, the student has been able to

- CO-1 To understand environmental impact and sustainability of chemical processes and products, through the use of green chemistry principle. To define the importance of inorganic elements in vital systems. Explain the importance of minerals and essentially trace elements and beneficial elements of living system.
- CO-2 To understand the general properties of water and develop awareness about water quality criteria and standards, Knowledge of basic concepts and techniques of soap and detergent industry and their relation to public health and environment.
- CO-3 It will help to Remember and identify the additives in food and their functions.
- CO-4 To understand and remembers the classes of adhesives, their preparation and bonding mechanisms.

### III. Course Content

#### UNIT – 1: Green and Sustainable Chemistry

(10 Hrs)

##### 1. Green and Sustainable Chemistry

Twelve principle of green chemistry with their explanation and examples, Use and examples of sustainable chemistry based on the principles, Green solvents –Super critical fluid, SC CO<sub>2</sub> and water as solvent, Energy requirement for reactions-renewable sources of energy, Use of microwave and Ultrasonic energy.

##### 2. Bio inorganic Chemistry

Essential and trace elements and bioinorganic chemistry, periodic survey of essential and trace elements: biological importance and relative abundance of the elements, the cell and distribution of the elements in the cell, The role of metal ions in the life process with special reference metal-protein systems and metalloenzymes, Communication and Sensing Roles of Metal ions, The role of metal ions in the basic biological reactions, Biological functions of bio-metals.

#### UNIT – 2:

(10 HRS)

##### 1. Water chemistry

Physical and chemical properties of water, temporary and permanent hardness of water and its removal process, Drawbacks of Acidity, alkalinity and turbidity in water, C.O.D. and B.O.D., Chlorination of water.

##### 2. Soap and detergents

Soaps - Types of soaps. Cleansing action of soaps. Synthetic detergents - Classification. Detergent additives. Comparison between soaps and detergents, Classification of detergents Anionic detergents, Cationic detergents, Non – ionic detergents; Amphoteric detergents. Soaps, Alkyl Sulphate; Alkyl Sulphonates; Alkyl Aryl Sulphonates, Amide Sulphonates, Ecofriendly Detergents.

#### UNIT – 3: Food chemistry

(5 Hrs)

Food additives: Enhancers, sugar substitutes, sweeteners, food colors, antioxidants, acids and bases used in food.

Food chelating agents, emulsifiers, thickening agents, gel builders, stabilizers, common food toxicants, flavors, Biomaterial: Uses of bacteria, yeasts and moulds in food industry

**UNIT – 4: Introduction to Polymers & Adhesives****(5 Hrs)****1. Polymers**

Definition: Monomer, Polymer, Polymerization, Classification of Polymers

**2. Adhesives**

Types of Bonding, Classification of adhesive, Preparation of adhesive, Starch adhesive, Protein adhesive. Synthetic resin adhesive, Use of Adhesive.

**IV. Suggestive Readings**

1. Environmental Chemistry – II Edition by A.K. De
2. Environmental Science by Turk A., Turk, J. Wittes J.T. and Wittes, R.E. (1978)
3. Ecology & Environment by P.D. Sharma.
4. Environmental Science: An Introduction by G. T. Miller-1991
5. Ajay Kr. Gupta, Handbook on Soaps, Detergents & Acid Slurry, 3rd revised edition; NIIR Board publication. ISBN: 9789381039472
6. P. K. Chattopadhyay, Modern Technology of Soaps, Detergents & Toiletries (with Formulae & Project Profiles) 4th Revised Edition, NIIR Board publication; ISBN: 9789381039700
7. H. Panda, Herbal Soaps & Detergents Handbook, NIIR Board publication; ISBN: 9789381039007
8. V.K. Ahluwalia, Green Chemistry: Environmentally Benign Reactions, CRC, 2008.
9. Food Chemistry Meyer L.H., 2006 publication
10. Fundamentals of Polymers - Raw Materials to Finish Products, Niranjana Karak
11. Adhesive Technology and Formulations Handbook.

**SKILL ENHANCEMENT COURSE (SEC)****SEC-2****COURSE CODE: SEC45CHM102(T) 25**

<b>L</b>	<b>T</b>	<b>P</b>	<b>Cr</b>
3	1	0	4

**Biofertilizer****(30 lectures of 60 minutes each)****Learning outcomes:**

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

1. Develop their understanding on the concept of bio-fertilizer
2. Identify the different forms of biofertilizers and their uses
3. Compose the Green manuring and organic fertilizers
4. Develop the integrated management for better crop production by using both

nitrogenous and phosphate bio fertilizers

**UNIT-1: Biofertilizer**

**(8 Hrs)**

General account about the microbes used as biofertilizer – Rhizobium – isolation, identification, mass multiplication, carrier based inoculants, Actinorrhizal symbiosis. *Azospirillum*: isolation and mass multiplication – carrier based inoculant, associative effect of different microorganisms. *Azotobacter*: classification, characteristics–crop response to *Azotobacter* in oculum, maintenance and mass multiplication.

**UNIT-2: Cyanobacteria**

**(7 Hrs)**

Cyanobacteria (blue green algae), *Azolla* and *Anabaena azollae* association, nitrogen fixation, factors affecting growth, blue green algae and *Azolla* in rice cultivation.

**UNIT-3: Mycorrhizal association**

**(8 Hrs)**

Mycorrhizal association: Types of mycorrhizal association, taxonomy, occurrence and distribution, phosphorus nutrition, growth and yield – colonization of VAM – isolation and inoculum production of VAM, and its influence on growth and yield of crop plants.

**UNIT-4: Organic farming**

**(7 Hrs)**

Green manuring and organic fertilizers, Recycling of bio-degradable municipal, agricultural and Industrial wastes – biocompost making methods, types and method of vermin composting– field Application.

**Suggested Readings**

1. Dubey,R.C. (2005). *A Textbook of Biotechnology*, S. Chand & Co, NewDelhi.
2. John Jothi Prakash, E. (2004). *Outlines of Plant Biotechnology*. Emkay Publication, NewDelhi.
3. Kumaresan,V. (2005). *Biotechnology*, Saras Publications, NewDelhi.
4. NIIR Board. (2012). *The complete Technology Book on Biofertilizer and organic farming*. 2<sup>nd</sup> Edition. NIIR Project Consultancy Services.
5. Sathe, T.V. (2004) *Vermiculture and Organic Farming*. Daya publishers.
6. Subba Rao N.S. (2017). *Biofertilizers in Agriculture and Forestry*. Fourth Edition, Medtech.