UGC CBCS
UG COURSE CURRICULUM
AND
SYLLABI
AS PER NEP-2020

CHEMISTRY

NORTH LAKHIMPUR COLLEGE

(AUTONOMOUS)

SYLLABUS

FOR

UNDER GRADUATE (UG) COURSE

IN

CHEMISTRY

UNDER

CHOICE BASED CREDIT SYSTEM

&

AS PER NEP 2020

NORTH LAKHIMPUR COLLEGE
(AUTONMOUS)
2023

Semester wise Distribution of courses
Under B.A / B.Sc.(Honors) as per NEP-2020

Semester	Discipline Specific Core (DSC)/ Major (Core)	Discipline Specific Elective (DSE)/ Open Elective Course (OEC)/ Minor	Multidisciplinary/ Interdisciplinary (MDC)	Ability Enhancement Compulsory Courses (AECC)	Skill Enhancement Courses (SEC)	Internship	Value Addition Courses (VAC)/ Dissertation/Thesis	Research Project	Total
I	DSC-I (5 credit) **General Chemistry (Inorganic + Organic + Physical)**	DSE-I (5 credit) **General Chemistry (Inorganic + Organic + Physical)**	IDC/MDC-I (3 credit) **Energy & Environment**	Communicative English-I (2 credit)	SEC-I (3 credit) **Good Laboratory Practices**	-	VAC –I (3 credit)	-	21
II	DSC-II (5 credit) **General Chemistry (Inorganic + Organic + Physical)**	DSE-II (5 credit) **General Chemistry (Inorganic + Organic + Physical)**	IDC/MDC-II (3 credit) **Food nutrition and preservation**	Language and Literature (MIL/Regional Language) (2 credit)	SEC-II (3 credit) **Basic Analytical Chemistry**	-	VAC –II (3credit)	-	21
T + P	4 +1	4+1	3+0 or 2+1	2+0	1+2		3+0		

		Award of Under Graduate Certificate with the completion of additional 4 Credit vocational course/Internship project (after 1 year: 42 credits)							
III	DSC-III (6 credit) **Inorganic Chemistry**	DSE-III (4 credit) **General Chemistry (Inorganic + Physical)**	IDC/MDC-III (3 credit) **Water remediation and conservation studies**	AECC (2 credit)	SEC-III (3 credit) **Fuel Chemistry**				24
	DSC-IV (6 credit) **General Chemistry (Organic +Physical)**	-	-	-	-				
IV	DSC-V (6 credit) **Organic Chemistry**	DSE-IV (3 credit) **General Chemistry (Inorganic + Organic + Physical)**	-	AECC (2 credit)	VAC-III **(EVS, Compulsory)** (2 Credit)				22
	DSC-VI (6 credit) **(Inorganic + Physical)**	DSE-V (3 credit) **[Practical]**	-	-	-		-		
Award of Under Graduate Diploma with the completion of additional 4 Credit vocational course/Internship project (after 2 years: 88 credits)									

V	DSC-VII (6 credit)	DSE-VI (4 credit)	-	-		Internship (4 credit)	-		20
	DSC-VIII (6 credit)	-	-	-	-		-		
VI	DSC-IX (6 credit)	DSE-VII (2 credit)	-	-	-		-		22
	DSC-X (6 credit)	DSE-VIII (2 credit)	-	-	-		-		
	DSC-XI (6 credit)	-	-	-	-		-		
		Award of Bachelor of Arts/ Science (Honours in Discipline) (after 3 years: 130credits)							
VII	DSC-XII (6 credit)	DSE-VIII (2 credit)	-						22
	DSC-XIII (6 credit)	DSE-IX (2 credit)							
	DSC-XIV								

	(6 credit)								
VIII	DSC-XV (6 credit)							Research Project) (10 credit)	22
	DSC-XVI (6 credit)								
Award of Bachelor of Arts/ Science (Honours in Discipline/ Research) (after 4 years: 174 credits)									

Ability Enhancement Compulsory Courses (AECC):

Ability Enhancement Compulsory Courses (AECC) shall be offered as follows:

Semester I AECC-I: Communicative English
Semester II AECC-II: Language and Literature (MIL/Regional Language)
Semester III AECC-III: Critical Reading/Writing Skill (English)
Semester IV AECC-IV: Critical Reading/Writing Skill/ Book Reading (MIL/Regional Language

Value Addition Courses (VAC) courses:

Student shall select any of the Value Addition Courses (VAC) courses from a basket of courses as listed below:
Semester I VAC-I: (i) Ethics and Culture
(ii) Sports psychology
(iii) Human Rights

(iv) NCC
(V) Nutrition and Healthy living
Semester II VAC-II: (i) Mindfulness for wellbeing and peak performance
(ii) Yoga
(iii) Gandhian thoughts
(iv) NSS
Semester IV VAC-III: Environmental Science (Compulsory)

SEMESTER-I
CHEMISTRY
(Major)
Course Title: (General Chemistry)
Course Code: MJ-T4-CHE-101
Credit: 4, Contact Hours: 60
[L=3, T=1, P=0]
Full Marks =80 IA=24 End Semester=56

Expected Learning objective:
(Inorganic Part)

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 understand atomic theory of matter, composition of atom.
5. Physical and chemical characteristics of elements in various groups and periods according to ionic size, charge, etc. and position in periodic table.

(Organic Part)

1. Knowledge of basic organic chemistry, definition.
2. Influence of hybridization etc.
3. Knowledge of elimination reaction, electrophilic and nucleophilic addition.

(Physical Part)

1. Familiarization with various states of matter.
2. Physical properties of each liquid state of matter and laws related to describe the states.
3. Behavior of real gases, its deviation from ideal behavior, equation of state, isotherm, and law of corresponding states.
4. Liquid state and its physical properties related to temperature and pressure variation.
5. Properties of liquid as solvent for various household and commercial use.

Self-study:

1. Electronic configuration of various elements in periodic table
2. Predicting structure of molecules
3. Periodicity of elements in various groups and periods and position in periodic table.
4. Classification and Nomenclature of organic compounds, Hybridization, Shapes of molecules.
5. Chemistry of alkanes: Formation of alkanes
6. Inductive, electrometric, resonance and mesomeric effects, hyperconjugation and their applications
7. Kinetic theory of gases, kinetic gas equation, Real and Ideal Gases.
8. Surface Tension, Viscosity- definitions and dimensions.

Group-A
(Inorganic Chemistry =19 marks)

Atomic Structure: **Marks = 10**

Bohr's theory, its limitations and atomic spectrum of hydrogen atom. Wave mechanics: de Broglie equation, Heisenberg's Uncertainty Principle and its significance, Schrödinger's wave equation, significance of ψ and ψ^2. Quantum numbers and their significance. Normalized and orthogonal wave functions. Sign of wave functions. Radial and angular wave functions for hydrogen atom. Radial and angular distribution curves. Shapes of *s, p, d* and *f* orbitals. Contour boundary and probability diagrams.

Pauli's Exclusion Principle, Hund's rule of maximum multiplicity, Aufbau's principle and its limitations, Variation of orbital energy with atomic number.

Periodicity of Elements: **Marks = 9**

s, p, d, f block elements, the long form of periodic table. Detailed discussion of the following properties of the elements, with reference to *s* and *p*-block.

(a) Effective nuclear charge, shielding or screening effect, Slater rules, variation of effective nuclear charge in periodic table.

(b) Atomic radii (van der Waals)

(c) Ionic and crystal radii.

(d) Covalent radii (octahedral and tetrahedral)

(e) Ionization enthalpy, Successive ionization enthalpies and factors affecting ionization energy. Applications of ionization enthalpy.

(f) Electron gain enthalpy, trends of electron gain enthalpy.

(g) Electronegativity, Pauling's/ Mulliken's/ Allred Rachow's/ and Mulliken-Jaffé's electronegativity scales. Variation of electronegativity with bond order, partial charge, hybridization, group electronegativity. Sanderson's electron density ratio.

Group-B
(Organic Chemistry = 19 Marks)

Unit I: Basic Organic Chemistry Marks = 9

Organic Compounds*:* Influence of hybridization on bond properties.

Electronic effects*:* Inductive, electrometric, resonance and mesomeric effects, hyperconjugation and their applications; Electrophiles and Nucleophiles; Nucleophlicity and basicity; Types, shape and their relative stability of Carbocations, Carbanions, Free radicals and Carbenes, Nitrenes.

Organic acids and bases; their relative strength,
Energy profile diagrams of one step, two steps & three steps reactions, Activation energy

Unit II: Chemistry of Aliphatic Hydrocarbons Marks =10

A. Carbon-Carbon sigma bond
Chemistry of alkanes: Formation of alkanes, Wurtz Reaction, Wurtz-Fittig Reactions, Corey House Reaction, Free radical substitutions: Halogenation -relative reactivity and selectivity.

B. Carbon-Carbon pi bonds:
Formation of alkenes and alkynes by elimination reactions, Mechanism of E1, E2, E1cb reactions. Saytzeff and Hofmann eliminations. Special emphasis on preparation of alkenes by syn elimination – Pyrolysis of esters, Chugaev, Wittig and Heck Reaction.

Reactions of alkenes: Electrophilic additions and their mechanisms. Regioselective (directional selectivity) and Streoselective addition reactions. Mechanism of hydroboration-oxidation, reduction (catalytic and chemical), syn and anti-hydroxylation (oxidation), Simple effect of Streoselectivity & Streospecificity; Kinetically Controlled & Thermodynamically Controlled reactions. 1,2-and 1,4-addition reactions in conjugated dienes and, Diels-Alder reaction.

Reactions of alkynes: Acidity, Electrophilic and Nucleophilic additions. Hydration to form carbonyl compounds, Alkylation of terminal alkynes.

Group-C
(Physical Chemistry = Marks 18)

Unit I: Gaseous state Marks = 10

Behavior of real gases: Deviations from ideal gas behaviour, compressibility factor, *Z*, 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, mention of other equations of state (Berthelot, Dietrici); virial equation of state; van der Waals equation expressed in virial form and calculation of Boyle temperature. Isotherms of real gases and their comparison with van der Waals isotherms, continuity of states, critical state, relation between critical constants and van der Waals constants, law of corresponding states.

Unit II: Liquid state Marks =8

Qualitative treatment of the structure of the liquid state; Radial distribution function; physical properties of liquids; vapour pressure, surface tension and coefficient of viscosity, and their determination. Effect of addition of various solutes on surface tension and viscosity. Explanation of cleansing action of detergents. Temperature variation of viscosity of liquids and comparison with that of gases. Qualitative discussion of structure of water.

Reference Books

1. Lee, J.D. *Concise Inorganic Chemistry* ELBS, 1991.
2. Douglas, B.E. and McDaniel, D.H. *Concepts & Models of Inorganic Chemistry* Oxford, 1970
3. Atkins, P.W. & Paula, J. *Physical Chemistry*, 10th Ed., Oxford University Press, 2014.
4. Day, M.C. and Selbin, J. *Theoretical Inorganic Chemistry*, ACS Publications, 1962.
5. Rodger, G.E. *Inorganic and Solid-State Chemistry*, Cengage Learning India Edition, 2002.
6. Morrison, R. N. & Boyd, R. N. Organic Chemistry, Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
7. Finar, I. L. Organic Chemistry (Volume 1), Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).

8. Finar, I. L. Organic Chemistry (Volume 2: Stereochemistry and the Chemistry of Natural Products), Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
9. Eliel, E. L. & Wilen, S. H. Stereochemistry of Organic Compounds; Wiley London, 1994.
10. Kalsi, P. S. Stereochemistry Conformation and Mechanism; New Age International, 2005.
11. Atkins, P. W. & Paula, J. de Atkin's Physical Chemistry Ed., Oxford University Press (2006).
12. Ball, D. W. Physical Chemistry Thomson Press, India (2007).
13. Castellan, G. W. Physical Chemistry 4th Ed. Narosa (2004).
14. Mortimer, R. G. Physical Chemistry 3rd Ed. Elsevier: NOIDA, UP (2009).
15. Negi,A.S; Anand,S.C. *A Text book of Physical Chemistry* New Age International Publishers
16. Pahari,S *Physical Chemistry Vol I &II* New Central Book Agency (P) Ltd.
17. Puri,Sharma,Pathiana *Principles of Physical Chemistry* Vishal Publishing Co.

SEMESTER-I
CHEMISTRY
(Major)
Course Title: Chemistry Practical
Course Code: MJ-P1-CHE-101
Credit: 1, Contact Hours: 30
[L=0, T=0, P=1]
Full Marks =20 IA=0 End Semester=20

Group-A
(Inorganic Chemistry)

Acid-Base Titrations
(i) Estimation of carbonate and hydroxide present together in mixture.
(ii) Estimation of carbonate and bicarbonate present together in a mixture.

Group-B
(Organic Chemistry)

1. Purification of organic compounds by crystallization using the following solvents:
    a. Water
    b. Alcohol
    c. Alcohol-Water

2. (Experiment)
    (a) Determination of the melting points of above compounds and unknown organic compounds (Kjeldahl method and electrically heated melting point apparatus)
    (b) Effect of impurities on the melting point – mixed melting point of two unknown organic compounds

Group-C
(Physical Chemistry)

1. **Surface tension measurements.**
a. Determine the surface tension of various liquids by drop number method.
b. Study the variation of surface tension of detergent solutions with concentration.

2. **Viscosity measurement using Ostwald's viscometer**.
a. Determination of viscosity of aqueous solutions of (i) polymer (ii) ethanol and (iii) sugar at room temperature.
b. Study the variation of viscosity of sucrose solution with the concentration of solute.

Reference Books

1. Mann, F.G. & Saunders, B.C. *Practical Organic Chemistry*, Pearson Education (2009)
2. Furniss, B.S.; Hannaford, A.J.; Smith, P.W.G.; Tatchell, A.R. *Practical Organic Chemistry, 5th Ed.*, Pearson (2012)
3. Mendham, J., A. I. Vogel's *Quantitative Chemical Analysis 6th Ed.*, Pearson, 2009.
4. Nad, A.K., Mahapatra, B., Ghoshal, A., An Advanced Course in Practical Chemistry, New Central Book Agency (P) Ltd., Kolkata, India.
5. Das, Subhas C, Advanced Practical Chemistry for 3-Year Honours Course. Khosla, B. D.; Garg, V. C. & Gulati, A. *Senior Practical Physical Chemistry*, R. Chand & Co.: New Delhi (2011).
6. Garland, C. W.; Nibler, J. W. & Shoemaker, D. P. *Experiments in Physical Chemistry 8th Ed*.; McGraw-Hill: New York (2003).
7. Halpern, A. M. & McBane, G. C. *Experimental Physical Chemistry 3rd Ed.;* W.H. Freeman & Co.: New York (2003).
8. Yadav, J.B., *Advanced Practical Physical Chemistry 32nd Ed*; Goel Publishing Ho

SEMESTER-I
CHEMISTRY
(Minor)
Course Title: General Chemistry
Course Code: MN-T4-CHE-101
Credit: 4, Contact Hours: 60
[L=3, T=1, P=0]
Full Marks =80 IA=24 End Semester=56

Expected Learning objective:

- Understanding the fundamental concepts of atomic structure, including the composition of atoms and their subatomic particles.
- Understanding the principles of electronic configuration, valence electrons, and energy levels.
- Ability to predict and explain chemical behavior based on atomic structure, such as ionization, electron affinity, and atomic bonding.
- Understanding the reactive Intermediates: Carbocations, Carbanions and free radicals. Relative strengths of organic acids and bases.
- Knowledge of three-dimensional molecular structures, including stereoisomerism.
- Understanding the concept of conformational isomerism
- Understanding the properties and equations of states of real gases.
- Knowledge of the kinetic molecular theory and its application to gas behavior.
- Understanding the properties of liquids like surface tension, viscosity etc.

Section A: Inorganic Chemistry
Marks =20

Unit I: Atomic Structure **Marks 10**

Review of: Bohr's theory and its limitations, dual behaviour of matter and radiation, de-Broglie's relation, Heisenberg Uncertainty principle. Hydrogen atom spectra. Need of a new approach to atomic structure.

What is Quantum mechanics? Time independent Schrodinger equation and meaning of various terms in it. Significance of Ψ and Ψ^2, Schrödinger equation for hydrogen atom. Radial and angular parts of the hydogenic wave functions (atomic orbitals) and their variations for 1*s*, 2*s*, 2*p*, 3*s*, 3*p* and 3*d* orbitals (Only graphical representation). Radial and angular nodes and their significance. Radial distribution functions and the concept of the most probable distance with special reference to 1s and 2s atomic orbitals. Significance of quantum numbers, orbital angular momentum and quantum numbers m_l and m_s. Shapes of *s*, *p* and *d* atomic orbitals, nodal planes. Discovery of spin, spin quantum number (*s*) and magnetic spin quantum number (m_s). Electronic configurations of the atoms/ions.

Unit II: **Periodicity of Elements:** **Marks = 10**

s, p, d, f block elements, the long form of periodic table. Detailed discussion of the following properties of the elements, with reference to *s* and *p*-block.

(h) Effective nuclear charge, shielding or screening effect, Slater rules, variation of effective nuclear charge in periodic table.

(i) Atomic radii (van der Waals)

(j) Ionic and crystal radii.

(k) Covalent radii (octahedral and tetrahedral)

(l) Ionization enthalpy, Successive ionization enthalpies and factors affecting ionization energy. Applications of ionization enthalpy.

(m) Electron gain enthalpy, trends of electron gain enthalpy.

Electronegativity, Pauling's/ Mulliken's/ Allred Rachow's/ and Mulliken-Jaffé's electronegativity scales. Variation of electronegativity with bond order, partial charge, hybridization, group electronegativity.

Section B: Organic Chemistry
Marks =18

Unit I: Fundamentals of Organic Chemistry **Marks 10**

Physical Effects, Electronic Displacements: Inductive Effect, Electromeric Effect, Resonance and Hyperconjugation. Cleavage of Bonds: Homolysis and Heterolysis. Structure, shape and reactivity of organic molecules: Nucleophiles and electrophiles. Reactive Intermediates: Carbocations, Carbanions and free radicals. Strength of organic acids and bases: Comparative study with emphasis on factors affecting *p*K values. Aromaticity: Benzenoids and Hückel's rule.

Unit II: Stereochemistry **Marks 8**

Conformation with respect to ethane, butane and cyclohexane. Configuration: Geometrical and Optical isomerism; Enantiomerism, Diastereomerism and Meso Compounds.

Section C: Physical Chemistry
Marks = 18

Unit I: Gaseous state **Marks 10**

Behavior of real gases: Deviations from ideal gas behaviour, compressibility factor, *Z*, 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, Van der Waals equation expressed in virial form and calculation of Boyle temperature. Isotherms of real gases and their comparison with van der Waals

isotherms, continuity of states, critical state, relation between critical constants and van der Waals constants, law of corresponding states.

Unit II: Liquid state **Marks 8**

Physical properties of liquids: vapour pressure, surface tension and coefficient of viscosity, and their determination. Explanation of cleansing action of detergents. Dependance of surface tension and viscosity of liquids with temperature.

Reference Books:

1. J. D. Lee: A new Concise Inorganic Chemistry, E L. B. S.
2. F. A. Cotton & G. Wilkinson: Basic Inorganic Chemistry, John Wiley.
3. Douglas, McDaniel and Alexader: Concepts and Models in Inorganic Chemistry, John Wiley.
4. James E. Huheey, Ellen Keiter and Richard Keiter: Inorganic Chemistry: Principles of Structure and Reactivity, Pearson Publication.
5. T. W. Graham Solomon: Organic Chemistry, John Wiley and Sons.
6. Peter Sykes: A Guide Book to Mechanism in Organic Chemistry, Orient Longman.
7. E. L. Eliel: Stereochemistry of Carbon Compounds, Tata McGraw Hill.
8. I. L. Finar: Organic Chemistry (Vol. I & II), E. L. B. S.
9. R. T. Morrison & R. N. Boyd: Organic Chemistry, Prentice Hall.
10. Arun Bahl and B. S. Bahl: Advanced Organic Chemistry, S. Chand
11. A.S.Negi and S.C. Anand, A textbook of Physical Chemistry, New Age International Publisher

SEMESTER-I
CHEMISTRY
(Minor)
Course Title: Chemistry Practical
Course Code: MN-P1-CHE-101
Credit: 1, Contact Hours: 60
[L=0, T=0, P=2]
Full Marks =20 IA=0 End Semester=20

Section A: Inorganic Volumetric Analysis:

i. Estimation of Fe (II) ions by titrating it with $K_2Cr_2O_7$ using internal indicator.
ii. Estimation of oxalic acid by titrating it with $KMnO_4$.
iii. Estimation of water of crystallization in Mohr's salt by titrating with $KMnO_4$.

Section B: Organic Chemistry:

Detection of Elements in the given sample

i. Detection of characterized element (N, S, Cl, Br, I) in an organic compound.

Chromatography Experiments

ii. Separation of mixtures by Chromatography: Measure the R_f value in each case (combination of two compounds to be given)

(a) Identify and separate the components of a given mixture of 2 amino acids (glycine, aspartic acid, glutamic acid, tyrosine or any other amino acid) by paper chromatography

(b) Identify and separate the sugars present in the given mixture by paper chromatography.

Section C: Physical Chemistry:

i) Determination of Surface Tension of Common Liquids using stalagmometer.
ii) Determination of viscosity of common liquids using Ostwald's viscometer.

Reference Books:

1. Mendham, J., A. I. Vogel's *Quantitative Chemical Analysis 6th Ed.*, Pearson, 2009.
2. Das, Subhas C, Advanced Practical Chemistry for 3-Year Honours Course.
3. Mann, F.G. & Saunders, B.C. *Practical Organic Chemistry*, Pearson Education (2009)
4. Yadav, J.B., *Advanced Practical Physical Chemistry 32nd Ed*; Goel Publishing Ho

SEMESTER-I
CHEMISTRY
Multidisciplinary Course (MDC)
Course Title: Energy and Environment
Course Code: MD-T3-CHE-101
Credit: 3, Contact Hours: 45
[L=2, T=1, P=0]
Full Marks =60 IA=18 End Semester= 42

Expected Learning objective:

- Understanding the components of the environment
- Understanding the importance of environmental conservation and sustainable practices.
- Understanding the sources, types, and effects of air pollution.
- Understanding the sources, types, and consequences of water pollution.
- Knowledge of common water pollutants, including biological, chemical, and physical contaminants.
- Understanding the processes of water contamination, such as eutrophication and groundwater pollution.
- Understanding the various forms of energy, including fossil fuels, renewable energy sources, and nuclear energy.
- Knowledge of energy conversion processes and their efficiency.

Unit I: Environment and its Segments **Marks 7**

Ecosystem, components of ecosystem, structure of ecosystem, function of an ecosystem, major regions of atmosphere.

Unit II: Air Pollution **Marks 10**

Air pollutants, types of air pollutants, atmospheric pollutants, Green house effect, CFCs, smog, effects of air pollution, air pollution control, global warming, effects on forests, crops, Ozone layer depletion, ozone holes.

Unit III: Water Pollution **Marks 10**

Water, sources water, water pollution, Fresh water, surface water, groundwater pollution, marine pollution, thermal pollution, eutrophication, marine eutrophication, waste water treatment, purification of water, characteristics of potable water.

Unit IV: Energy **Marks 15**

Energy resources, types of energy, conventional (non-renewable) energy sources, coal, advantages and disadvantages of solid coal, petroleum, longevity of petroleum, disadvantages of petroleum, natural gas, nuclear energy, wind energy, hydro electric power, wave power, ocean thermal energy conservation, nuclear pollution, effects of

radiation on human health, effects of radioactive pollution, prevention and control of radioactive waste, disposal of radioactive wave.

Reference Books:

1. E. Stocchi: Industrial Chemistry, Vol -I, Ellis Horwood Ltd. UK.
2. B. K. Sharma: Industrial Chemistry, Goel Publishing House, Meerut.
3. B. C. Das: Industrial Chemicals and environment, Kalyani Publishers.

SEMESTER-I
CHEMISTRY
Skill Enhancement Course (SEC)
Course Title: Good Laboratory Practices
Course Code: SE-T1-CHE-101
Credit: 1, Contact Hours: 15
[L=1, T=0, P=0]
Full Marks =40 IA=12 End Semester= 28

Learning outcomes

After completing this course, the learner will be able to:

- Apply practical skills in science courses with the understanding of general laboratory Practices
- Use various micro techniques used in chemistry
- Apply various techniques to study chemical compounds, salts
- Explore various research issues and their solutions

Unit I: General Laboratory Practices **Marks 14**

Common calculations in chemistry laboratories. Understanding the details on the label of reagent bottles. Preparation of solutions. Molarity and normality of common acids and bases. Dilutions. Percentage solutions. Molar, molal and normal solutions. Technique of handling micropipettes; Knowledge about common toxic chemicals and safety measures in their handling.

Unit II: Instrument-Techniques and laboratory preparation procedure. **Marks 14**

Use of micropipette, analytical balances, pH meter, conductivity meter, rotary evaporator, potentiometer. Use of purified water in lab experiments, Cleaning and drying of glasswares, Preparation of crystals from given salt. Preparation of Dyes, Demonstration of preparation of material using Sol-gel procedure. Introduction to Chromatographic Techniques.

Suggested Readings

1. Seiler, J.P. (2005). Good Laboratory Practices: the why and how. Springer-Verlag Berlin and Heidelberg GmbH & Co. K; 2nd ed.
2. Garner, W.Y., Barge M.S., Ussary. P.J. (1992). Good Laboratory Practice Standards: Application for field and Laboratory studies. Wiley VCH.

SEMESTER-I
CHEMISTRY
Skill Enhancement Course (SEC)
Course Title: SEC Practical
Course Code: SE-P2-CHE-101
Credit: 2, Contact Hours: 60
[L=0, T=0, P=2]
Full Marks =40 IA=0 End Semester= 40

1. **Preparation of solutions of different strengths (**Percentage solutions, Molar, molal and normal solutions)
2. **Use of micropipettes**
3. **Use of pH meter, Conductivity Meter, Potentiometer**
4. **Chromatographic techniques (Paper & TLC)**
    a) Paper chromatographic separation of Co(II) & Ni(II)
    b) Paper chromatographic separation of Fe(III) and Al(III)
    c) Separation of a mixture of two amino acids by paper chromatography
    d) Separation of a mixture of two sugars by paper chromatography
    e) Separation of a mixture of o-and p-nitrophenol or o-and p-aminophenol by thin layer chromatography (TLC)

Suggested Readings

1. Mendham, J., A.I.Vogel's *Quantitative Analysis* 6th Ed., Pearson, 2009 CBCS: B. Sc. (Honours) with CHEMISTRY
2. Garner, W.Y., Barge M.S., Ussary. P.J. (1992). Good Laboratory Practice Standards: Application for field and Laboratory studies. Wiley VCH.
3. Furniss, B.S.; Hannaford, A.J.; Smith, P.W.G.; Tatchell, A.R. *Practical Organic Chemistry, 5th Ed.,* Pearson (2012)

SEMESTER-II
CHEMISTRY
(Major)
Course Title: (General Chemistry)
Course Code: MJ-T4-CHE-201
Credit: 4, Contact Hours: 60
[L=3, T=1, P=0]
Full Marks =80 IA=24 End Semester=56

Learning objective:

1. To predict the atomic structure, chemical bonding, and molecular geometry based on accepted models.
2. Characterize bonding between atoms, molecules, interaction and energetics (ii) hybridization and shapes of atomic, molecular orbitals, bond parameters, bond-distances and energies.
3. Valence bond theory incorporating concepts of hybridization predicting geometry of molecules.
4. Importance of hydrogen bonding, metallic bonding. Stereochemistry of organic molecules – conformation and configuration, asymmetric molecules and nomenclature.
5. Aromatic compounds and aromaticity, mechanism of aromatic reactions.
6. Solids, lattice parameters – its calculation, application of symmetry, solid characteristics of simple salts.
7. Ionic equilibria – electrolyte, ionization, dissociation.
8. Salt hydrolysis (acid-base hydrolysis) and its application in chemistry

Self-study:

1. Bohr's Theory, its limitations
2. Heisenberg's Uncertainty Principle
3. Hydrogen bonding, its applications
4. Advanced soft-wares/Models used for predicting stereochemistry/study of energy minimization of organic molecules.
5. Relative stability of cyclic hydrocarbon, Bayer's strain theory etc.
6. Oswald's dilution law, Common ion effect, Solubility and solubility product Buffer solution.
7. Determination of lattice parameters of given salt.
8. Study of X-Ray diffraction pattern and finding out reference from JCPDS file.
9. Numerical related to salt hydrolysis, ionic equilibria.

Group-A
(Inorganic Chemistry)
Marks 18

UNIT-I: Chemical Bonding **Marks 13**

(i) *Ionic bond:* General characteristics, types of ions, size effects, radius ratio rule and its limitations. Packing of ions in crystals. Born-Landé equation with derivation and importance of Kapustinskii expression for lattice energy. Madelung constant, Born-Haber cycle and its application, Solvation energy.

(ii) *Covalent bond:* Lewis structure, Valence Bond theory (Heitler-London approach). Energetics of hybridization, equivalent and non-equivalent hybrid orbitals. Bent's rule, Resonance and resonance energy, Molecular orbital theory. Molecular orbital diagrams of diatomic and simple polyatomic molecules N_2, O_2, C_2, B_2, F_2, CO, NO, and their ions; HCl, BeF_2, CO_2, (idea of s-p mixing and orbital interaction to be given). Formal charge, Valence shell electron pair repulsion theory (VSEPR), shapes of simple molecules and ions containing lone pairs and bond pairs of electrons, multiple bonding (σ and π bond approach) and bond lengths.

Covalent character in ionic compounds, polarizing power and polarizability. Fajan's rules and consequences of polarization.

Ionic character in covalent compounds: Bond moment and dipole moment. Percentage ionic character from dipole moment and electronegativity difference.

Metallic Bond: Qualitative idea of valence bond and band theories. Semiconductors and insulators, defects in solids.

(iii) *Weak Chemical Forces:* van der Waals forces, ion-dipole forces, dipole-dipole interactions, induced dipole interactions, Instantaneous dipole-induced dipole interactions. Repulsive forces, Hydrogen bonding (theories of hydrogen bonding, valence bond treatment) Effects of chemical force, melting and boiling points, solubility energetics of dissolution process.

Oxidation-Reduction: **Marks 5**

Redox equations, Standard Electrode Potential and its application to inorganic reactions.

Group-B
(Organic Chemistry)
Marks 19

Unit I Aromatic Hydrocarbons **Marks 9**

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

Unit II: Stereochemistry **Marks 10**

Definition and classification of stereoisomerism

Geometrical isomerism: Restricted rotation about C=C bonds, Physical & Chemical properties of Geometrical isomers, Cis–trans and, syn-anti isomerism, E/Z notations with C.I.P rules.

Optical Isomerism: Optical Activity, Specific Rotation, Chirality/Asymmetry, Enantiomers, Molecules with two or more chiral-centres, Distereoisomers, meso structures & Epimers, Racemic mixture and resolution, Threo & Erythro forms, Relative and absolute configuration:

D/L and R/S designations.

Unit III: Cycloalkanes and Conformational analysis:

Cycloalkanes: Preparation and their relative stability, Baeyer strain theory, Conformation analysis of alkanes (Ethane and Butane): Relative stability: Energy diagrams of cyclohexane: Chair, Boat and Twist boat forms; Relative stability with energy diagrams.

Group-C
(Physical Chemistry)
Marks 19

Unit I: Solid state **Marks 10**

Nature of the solid state, law of constancy of interfacial angles, law of rational indices, Miller 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.

Unit II: Ionic equilibrium **Marks 9**

Strong, moderate and weak electrolytes, degree of ionization, factors affecting degree of Strong, moderate and weak electrolytes, degree of ionization, factors affecting degree of ionization, ionization constant and ionic product of water. Ionization of weak acids and bases, pH scale, common ion effect; dissociation constants of mono-, di- and tri-protic acids.

Salt hydrolysis, hydrolysis constants, degree of hydrolysis and pH for different salts. Buffer solutions; Henderson equation, buffer capacity, buffer range, buffer action, applications of buffers in analytical chemistry, Solubility and solubility product.

Qualitative treatment of acid – base titration curves (calculation of pH at various stages). Theory of indicators; selection of indicators and their limitations. Multistage equilibria in polyelectrolytes.

Reference Books:

1. Atkins, P. W. & Paula, J. de Atkin's Physical Chemistry 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. Negi,A.S; Anand,S.C. *A Text book of Physical Chemistry* New Age International Publishers
6. Pahari,S, *Physical Chemistry Vol I &II* New Central Book Agency (P) Ltd.
7. Puri, Sharma, Pathiana; *Principles of Physical Chemistry* Vishal Publishing Co.
8. Lee, J.D. *Concise Inorganic Chemistry* ELBS, 1991.
9. Douglas, B.E. and McDaniel, D.H. *Concepts & Models of Inorganic Chemistry* Oxford, 1970
10. Atkins, P.W. & Paula, J. *Physical Chemistry*, 10th Ed., Oxford University Press, 2014.
11. Day, M.C. and Selbin, J. *Theoretical Inorganic Chemistry*, ACS Publications, 1962.
12. Rodger, G.E. *Inorganic and Solid-State Chemistry*, Cengage Learning India Edition, 2002.

SEMESTER-II
CHEMISTRY
(Major)
Course Title: Chemistry Practical
Course Code: MJ-P1-CHE-201
Credit: 1, Contact Hours: 30
[L=0, T=0, P=1]
Full Marks =20 IA=0 End Semester=40

Group-A
(Inorganic Chemistry)

Quantitative Analysis

i. Estimation of Fe (II) or oxalic acid using standardized $KMnO_4$ solution.
ii. Estimation of Fe (II) with $K_2Cr_2O_7$ using diphenylamine as internal indicator.

Group-B
(Organic Chemistry)

Chromatography (experiment):

i. Separation of a mixture of two amino acids by paper chromatography
ii. Separation of a mixture of two sugars by paper chromatography
iii. Separation of a mixture of o-and p-nitrophenol or o-and p-aminophenol by thin layer chromatography (TLC)

Group-C
(Physical Chemistry)

pH metry

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

Reference book:

1. Mendham, J., A. I. Vogel's *Quantitative Chemical Analysis 6th Ed.*, Pearson, 2009.
2. Das, Subhas C, Advanced Practical Chemistry for 3-Year Honours Course.
3. Mann, F.G. & Saunders, B.C. *Practical Organic Chemistry*, Pearson Education (2009)
4. Yadav, J.B., *Advanced Practical Physical Chemistry 32nd Ed*; Goel Publishing Ho

SEMESTER-II
CHEMISTRY
(Minor)
Course Title: General Chemistry
Course Code: MN-T4-CHE-201
Credit: 4, Contact Hours: 60
[L=3, T=1, P=0]
Full Marks =80 IA=18 End Semester=56

Expected learning outcome:

1. To predict the atomic structure, chemical bonding, and molecular geometry based on accepted models.
2. Characterize bonding between atoms, molecules, interaction and energetics, hybridization and shapes of atomic, molecular orbitals, bond parameters, bond-distances and energies.
3. Valence bond theory incorporating concepts of hybridization predicting geometry of molecules.
4. Importance of hydrogen bonding, metallic bonding. Stereochemistry of organic molecules – conformation and configuration, asymmetric molecules and nomenclature.
5. Aromatic compounds and aromaticity, mechanism of aromatic reactions.
6. Solids, lattice parameters – its calculation, application of symmetry, solid characteristics of simple salts.
7. Ionic equilibria – electrolyte, ionization, dissociation.
8. Salt hydrolysis (acid-base hydrolysis) and its application in chemistry

Section A: Inorganic Chemistry
Marks 20

Unit I: Chemical Bonding and Molecular Structure **Marks 15**

Ionic Bonding: General characteristics of ionic bonding. Energy considerations in ionic bonding, lattice energy and solvation energy and their importance in the context of stability and solubility of ionic compounds. Statement of Born-Landé equation for calculation of lattice energy, Born-Haber cycle and its applications, polarizing power and polarizability. Fajan's rules, ionic character in covalent compounds, bond moment, dipole moment and percentage ionic character.

Covalent bonding: VB Approach: Shapes of some inorganic molecules and ions on the basis of VSEPR and hybridization with suitable examples of linear, trigonal planar, square planar, tetrahedral, trigonal bipyramidal and octahedral arrangements. Concept of resonance and resonating structures in various inorganic and organic compounds.

MO Approach: Rules for the LCAO method, bonding and antibonding MOs and their characteristics for s-s, s-p and p-p combinations of atomic orbitals, nonbonding

combination of orbitals, MO treatment of homonuclear diatomic molecules of 1st and 2nd periods (including idea of s-p mixing) and heteronuclear diatomic molecules such as CO, NO and NO^+. Comparison of VB and MO approaches.

Oxidation-Reduction: **Marks 5**

Redox equations, Standard Electrode Potential and its application to inorganic reactions.

Section B: Organic Chemistry
Marks 18

Unit I: Aliphatic Hydrocarbons **Marks 18**

Alkanes:

Preparation: Catalytic hydrogenation, Wurtz reaction, Kolbe's synthesis, from Grignard reagent.

Reactions: Free radical Substitution: Halogenation.

Alkenes: (Up to 5 Carbons):

Preparation: Elimination reactions: Dehydration of alkenes and dehydrohalogenation of alkyl halides (Saytzeff's rule).

Reactions: cis-addition (*alk*. $KMnO_4$) and trans-addition (bromine), Addition of HX (Markownikoff's and anti Markownikoff's addition), Hydration, Ozonolysis.

Alkynes: (Up to 5 Carbons):

Preparation: Acetylene from CaC_2 and conversion into higher alkynes; by dehalogenation of tetra halides and dehydrohalogenation of vicinal dihalides.

Reactions: formation of metal acetylides, addition of bromine and alkaline KMnO4, ozonolysis and oxidation with hot alk. $KMnO_4$.

Section C: Physical Chemistry
Marks 18

Unit I: Solid state **Marks 10**

Nature of the solid state, law of constancy of interfacial angles, law of rational indices, Miller 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.

Unit II: Ionic equilibrium **Marks 8**

Strong, moderate and weak electrolytes, degree of ionization, factors affecting degree of ionization, ionization constant and ionic product of water. Ionization of weak acids and bases, pH scale, common ion effect. Salt hydrolysis-calculation of hydrolysis

constant, degree of hydrolysis and pH for different salts. Buffer solutions. Solubility and solubility product of sparingly soluble salts – applications of solubility product principle.

Reference Books:

1. J. D. Lee: A new Concise Inorganic Chemistry, E L. B. S.
2. F. A. Cotton & G. Wilkinson: Basic Inorganic Chemistry, John Wiley
3. James E. Huheey, Ellen Keiter and Richard Keiter: Inorganic Chemistry: Principles of Structure and Reactivity, Pearson Publication.
4. I. L. Finar: Organic Chemistry (Vol. I & II), E. L. B. S.
5. R. T. Morrison & R. N. Boyd: Organic Chemistry, Prentice Hall.
6. Arun Bahl and B. S. Bahl: Advanced Organic Chemistry, S. Chand.
7. G. M. Barrow: Physical Chemistry Tata McGraw-Hill (2007).
8. G. W. Castellan: Physical Chemistry 4th Edn. Narosa (2004).

SEMESTER-II
CHEMISTRY
(Minor)
Course Title: Chemistry Practical
(General Organic Chemistry)
Course Code: MN-P1-CHE-201
Credit: 1, Contact Hours: 30
[L=0, T=0, P=2]
Full Marks =20 IA=0 End Semester= 20

Section A: Oxidation-Reduction Titrimetry

(i) Estimation of Fe (II) or oxalic acid using standardized $KMnO_4$ solution.
(ii) Estimation of Fe (II) with $K_2Cr_2O_7$ using diphenylamine as internal indicator.

Section B: Organic Chemistry:

i. *Purification* of organic compounds by crystallization (from water and alcohol) and distillation.
ii. *Criteria of Purity*: Determination of melting and boiling points.
iii. Effect of impurities on the melting point – mixed melting point of two unknown organic compounds

***Section C: Physical Chemistry*:**

i. *Measurement of pH* of different solutions like aerated drinks, fruit juices, shampoos and soaps (use dilute solutions of soaps and shampoos to prevent damage to the glass electrode) using pH-meter.

ii *Preparation of buffer solutions*:
(*a*) Sodium acetate-acetic acid or,
(*b*) Ammonium chloride-ammonium hydroxide

iii. pH metric titration of (i) strong acid vs. strong base, (ii) weak acid vs. strong base.

Reference Book:

1. Mendham, J., A. I. Vogel's *Quantitative Chemical Analysis 6th Ed.*, Pearson, 2009.
2. Das, Subhas C, Advanced Practical Chemistry for 3-Year Honours Course.
3. Mann, F.G. & Saunders, B.C. *Practical Organic Chemistry,* Pearson Education (2009)
4. Yadav, J.B., *Advanced Practical Physical Chemistry 32nd Ed*; Goel Publishing Ho

SEMESTER-II
CHEMISTRY
Multidisciplinary Course (MDC)
Course Title: Food nutrition and preservation
Course Code: MD-T3-CHE-201
Credit: 3, Contact Hours: 45
[L=2, T=1, P=0]
Full Marks =60 IA=18 End Semester= 42

Expected learning outcome:

- Understanding the basic principles of food nutrition and its importance for human health.
- Knowledge of the major macronutrients (carbohydrates, proteins, and fats) and micronutrients (vitamins and minerals) found in food.
- Knowledge of the energy content of macronutrients and the role of calories in nutrition.
- Understanding the role of essential nutrients, such as vitamins and minerals, in maintaining optimal health.
- Understanding the consequences of nutrient deficiencies and excesses on human health.
- Understanding the principles and methods of food preservation
- Ability to select and apply appropriate food preservation techniques to maintain the nutritional quality and safety of food products.

Unit I: Introduction: **Marks 10**

Nutrition (Under nutrition, over nutrition, optimal nutrition) and Nutrients (Nutrition, Malnutrition and mental development).

Unit II: Energy considerations in nutrition **Marks 10**

Food, preliminary idea of basal metabolism, energy expenditure "off work", energy expenditure for work, respiratory quotients of foodstuffs, measurements of energy requirements, recommended dietary allowances for an Indians.

Unit III: Elements of nutrition **Marks 10**

Components of an adequate diet, preliminary idea of carbohydrates, lipids and proteins, vitamins and their importance in human bodies, dietary fibres, balanced diet, nutrition for health in India.

Unit IV: Food preservation **Marks 12**

Food preservation: definition, objectives and principles of food preservation. Different methods of food preservation. Preserved Products: Jam, Jelly, Marmalade, Sauces, Pickles, Squashes, Syrups-types, composition and manufacture, selection, cost,

storage, uses and nutritional aspects, Food Standards: ISI, Agmark, FPO, MPO, PFA, FSSAI.

Reference Books:

1. Srilakshmi B (2017): Nutrition Science,6th Multicolour Ed. New Age International (P) Ltd.
2. RodayS (2012): Food Science and Nutrition, 2nd Ed. Oxford University Press.
3. Mann J and Truswell (2017): Essentials of Human Nutrition, 5th Ed. Oxford University Press.
4. Jain JL e*tal* (2021) Fundamentals of Biochemistry, 7^{th} Ed, S. Chand and company ltd.

SEMESTER-II
CHEMISTRY
Skill Enhancement Course (SEC)
Course Title: Basic Analytical Chemistry
Course Code: SE-T1-CHE-201
Credit: 1, Contact Hours: 15
[L=1, T=0, P=0]
Full Marks =40 IA= 12 End Semester=28

Expected learning outcome:

- Understanding the fundamental principles and techniques used in analytical chemistry.
- Understanding the Importance of accuracy, precision and sources of error in analytical measurements
- Understanding the importance of soil analysis in assessing soil fertility and quality.
- Knowledge of different soil properties, such as pH, nutrient content, organic matter, and texture.
- Understanding the techniques used for soil sampling and sample preparation.
- Understanding the importance of water analysis in assessing water quality and safety.
- Knowledge of different parameters analyzed in water, such as pH, dissolved oxygen, and chemical contaminants.
- Understanding the principles and applications of chromatography in chemical analysis.

Unit I: Introduction **Marks 8**

Introduction to Analytical Chemistry and its interdisciplinary nature. Concept of sampling. Importance of accuracy, precision and sources of error in analytical measurements. Presentation of experimental data and results, from the point of view of significant figures.

Unit II: Basic Concepts of Soil Analysis **Marks 10**

Composition of soil, Concept of pH and pH measurement, Complexometric titrations, Chelation, Chelating agents, use of indicators, pH of soil samples, Method of estimation of Calcium and Magnesium ions.

Unit III: Basic Concepts of Water Analysis **Marks 10**

Definition of pure water, sources responsible for contaminating water, water sampling methods, water purification methods, pH, acidity and alkalinity of a water sample, Dissolved oxygen (DO) of a water sample.

Reference Books

1. Willard, H.H., Merritt, L.L., Dean, J. & Settoe, F.A. *Instrumental Methods of Analysis*, 7th Ed. Wadsworth Publishing Company Ltd., Belmont, California, USA,1988.
2. Skoog, D.A., Holler, F.J. & Crouch, S. *Principles of Instrumental Analysis*, Cengage Learning India Edition, 2007.
3. Skoog, D.A.; West, D.M. & Holler, F.J. *Analytical Chemistry: An Introduction 6th Ed.*, Saunders College Publishing, Fort Worth, Philadelphia (1994).

SEMESTER-II
CHEMISTRY
Skill Enhancement Course (SEC)
Course Title: SEC Practical
Basic Analytical Chemistry
Course Code: SE-P2-CHE-201
Credit: 2, Contact Hours: 60
[L=0, T=0, P=2]
Full Marks =40 IA=0 End Semester= 40

1. Analysis of soil: determination of pH of soil, total soluble salt, estimation of calcium, magnesium, phosphate, nitrate
2. Determination of pH, acidity and alkalinity of a water sample.
3. Determination of dissolved oxygen (DO) of a water sample.
4. Determination of chemical oxygen demand (COD).
5. Determination of Biological oxygen demand (BOD).

SEMESTER-III
CHEMISTRY
(Major)
Course Title: (Inorganic Chemistry)
Course Code: MJ-T4-CHE-301
Credit: 4, Contact Hours: 60
[L=3, T=1, P=0]
Full Marks =80 IA=24 End Semester=56

Expected Learner Outcome: Students will gain an understanding of ---
i. Predict the purification of metal, study of compounds with emphasis on structure, bonding, preparation and properties.
ii. Real world applications, shapes etc of noble gas.
iii. Structural aspects and applications of inorganic polymer

Self-study:

1. Chief modes of occurrence of metals based on standard electrode potentials Predicting structure of molecules.
2. Brönsted-Lowry concept of acid-base reactions.
3. Occurrence and uses of noble gases

Unit I: General Principles of Metallurgy **Marks 10**
Chief modes of occurrence of metals based on standard electrode potentials. Ellingham diagrams for reduction of metal oxides using carbon and carbon monoxide as reducing agent. Electrolytic Reduction, Hydrometallurgy.
Methods of purification of metals: Electrolytic Kroll process, Parting process, van Arkel-de Boer process and Mond's process, Zone refinig

Unit II: Acids and Bases **Marks 10**
Brönsted-Lowry concept of acid-base reactions, solvated proton, relative strength of acids, types of acid-base reactions, levelling solvents, Lewis's acid-base concept, Classification of Lewis acids, Hard and Soft Acids and Bases (HSAB) Application of HSAB principle.

Unit III: Chemistry of *s* and *p* Block Elements: **Marks 16**
Inert pair effect, Relative stability of different oxidation states, diagonal relationship and anomalous behaviour of first member of each group. Allotropy and catenation. Complex formation tendency of *s* and *p* block elements. Study of the following compounds with emphasis on structure, bonding, preparation, properties and uses. Boric acid and borates, boron nitrides, borohydrides (diborane) carboranes and graphitic compounds, silanes, Oxides and oxoacids of nitrogen, Phosphorus and chlorine. Peroxo acids of sulphur, interhalogen compounds, polyhalide ions, pseudohalogens and basic properties of halogens.

Unit IV: Noble gases **Marks 10**
Occurrence and uses, rationalization of inertness of noble gases, Clathrates; preparation and properties of XeF2, XeF4 and XeF6; Nature of bonding in noble gas compounds (Valence bond treatment and MO treatment for XeF2). Molecular shapes of noble gas compounds (VSEPR theory).

Unit V: Inorganic Polymers **Marks 10**

Types of inorganic polymers, comparison with organic polymers, synthesis, structural aspects and applications of silicones and siloxanes. Borazines, silicates and phosphazenes, and polysulphates.

Reference Books:

1. Lee, J.D. *Concise Inorganic Chemistry*, ELBS, 1991.
2. Douglas, B.E; Mc Daniel, D.H. & Alexander, J.J. *Concepts & Models of Inorganic Chemistry 3rd Ed.*, John Wiley Sons, N.Y. 1994.
3. Greenwood, N.N. & Earnshaw. *Chemistry of the Elements*, Butterworth- Heinemann. 1997.
4. Cotton, F.A. & Wilkinson, G. *Advanced Inorganic Chemistry*, 5th ed.,Wiley, VCH, 1999.
5. Rodger, G.E. *Inorganic and Solid State Chemistry*, Cengage Learning India Edition, 2002.
6. Miessler, G. L. & Donald, A. Tarr. *Inorganic Chemistry* 4th Ed., Pearson, 2010
7. Atkin, P. *Shriver & Atkins' Inorganic Chemistry* 5th Ed. Oxford University Press (2010).
CBCS: B. Sc. (Major) with CHEMISTRY

SEMESTER-III
CHEMISTRY
(Major)
Course Title: Chemistry Practical
INORGANIC CHEMISTRY
Course Code: MJ-P2-CHE-301
Credit: 2, Contact Hours: 60
[L=0, T=0, P=2]
Full Marks =40 IA=0 End Semester=40

A. Iodo / Iodimetric Titrations

(i) Estimation of Cu(II) and $K_2Cr_2O_7$ using sodium thiosulphate solution (Iodimetrically).
(ii) Estimation of available chlorine in bleaching powder iodometrically.

B. Inorganic preparations
(i) Cuprous Chloride, Cu_2Cl_2
(ii) Preparation of Manganese(III) phosphate, $MnPO_4.H_2O$
(iii) Preparation of Aluminium potassium sulphate $KAl(SO_4)_2.12H_2O$ (Potash alum) or Chrome alum.

Reference Books
1. Mendham, J., *A. I. Vogel's Quantitative Chemical Analysis 6th Ed.,* Pearson, 2009.

SEMESTER-III
CHEMISTRY
(Major)
Course Title: (General Chemistry)
Course Code: MJ-T4-CHE-302
Credit: 4, Contact Hours: 60
[L=3, T=1, P=0]
Full Marks =80 IA=24 End Semester=56

Group-A
(Organic Chemistry)

Expected Learner Outcome: Students will gain an understanding of ---

- The prediction of mechanism for organic reactions
- How to design synthesis of organic molecule.
- The reactivity and stability of organic molecule based on structure
- An idea of alcohols, phenols and their derivatives etc
- The application of mathematical tools to calculate thermodynamic properties
- The concept of free energy change and spontaneity.
- Thermodynamics derivation of relation between Gibbs free energy of reaction and reaction quotient.

Self-study:

1. Nucleophilic Substitution reactions
2. Simple methods of preparation of alcohol
3. Concept of Intensive and extensive variables
4. Criteria of thermodynamic equilibrium, degree of advancement of reaction

Unit I: Chemistry of Halogenated Hydrocarbons **Marks 14**

Part A

Alkyl halides: Methods of preparation including Hunsdiecker Reaction, nucleophilic substitution reactions – S_N1, S_N2 and S_Ni mechanisms with stereochemical aspects and effect of solvent etc.; nucleophilic substitution vs. elimination.

Aryl halides: Preparation, including preparation from diazonium salts. nucleophilic aromatic substitution; SNAr, Benzyne mechanism. Relative reactivity of alkyl, allyl/benzyl, vinyl and aryl halides towards nucleophilic substitution reactions.

Part B

Organometallic compounds of Mg and Li – Use in synthesis of organic compounds.

Unit II: Alcohols, Phenols, Ethers and Epoxides **Marks 14**

Alcohols*:* preparation, properties and relative reactivity of 1°, 2°, 3° alcohols, Bouvaelt-Blanc Reduction; Preparation and properties of glycols: Oxidation by OsO_4 ,alkaline $KMnO_4$, periodic acid and lead tetraacetate Pinacol-Pinacolone rearrangement;

Trihydric alcohols: Glycerol /Preparation & Properties.

Phenols*:* Preparation and properties; Acidity and factors effecting it, Ring substitution reactions, Reimer–Tiemann and Kolbe's–Schmidt Reactions, Fries and Claisen

rearrangements with mechanism;

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

Group-B
(Physical Chemistry)

Unit I: Chemical Thermodynamics **Marks 12**

Intensive and extensive variables; state and path functions; isolated, closed and open systems; zeroth law of thermodynamics.

First law: Concept of heat, *q*, work, *w*, internal energy, *U*, and statement of first law; 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: Heats 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) and pressure on enthalpy of reactions. Adiabatic flame temperature, explosion temperature.

Second Law: Concept of entropy; thermodynamic scale of temperature, statement of the second law of thermodynamics; molecular and statistical interpretation of entropy. Calculation of entropy change for reversible and irreversible processes.

Third Law: Statement of third law, concept of residual entropy, calculation of absolute entropy of molecules.

Free Energy Functions: Gibbs and Helmholtz energy; variation of S, G, A with T, V, P; Free energy change and spontaneity. Relation between Joule-Thomson coefficient and other thermodynamic parameters; inversion temperature; Gibbs-Helmholtz equation; Maxwell relations; thermodynamic equation of state.

Unit II: Systems of Variable Composition **Marks 8**

Partial molar quantities, dependence of thermodynamic parameters on composition; Gibbs-Duhem equation, chemical potential of ideal mixtures, change in thermodynamic functions in mixing of ideal gases.

Unit III: Chemical Equilibrium **Marks 8**

Chemical equilibria in ideal gases, concept of fugacity. Thermodynamic derivation of relation between Gibbs free energy of reaction and reaction quotient. Equilibrium constants and their quantitative dependence on temperature, pressure and concentration. Free energy of mixing and spontaneity; thermodynamic derivation of relations between the various equilibrium constants K_p , K_c and K_x. Le Chatelier principle (quantitative treatment).

Reference Books:

9. J. D. Lee: A new Concise Inorganic Chemistry, E L. B. S.
10. F. A. Cotton & G. Wilkinson: Basic Inorganic Chemistry, John Wiley
11. James E. Huheey, Ellen Keiter and Richard Keiter: Inorganic Chemistry: Principles of Structure and Reactivity, Pearson Publication.
12. I. L. Finar: Organic Chemistry (Vol. I & II), E. L. B. S.
13. R. T. Morrison & R. N. Boyd: Organic Chemistry, Prentice Hall.

14. Arun Bahl and B. S. Bahl: Advanced Organic Chemistry, S. Chand.
15. G. M. Barrow: Physical Chemistry Tata McGraw-Hill (2007).
16. G. W. Castellan: Physical Chemistry 4th Edn. Narosa (2004

SEMESTER-III
CHEMISTRY
(Major)
Course Title: Chemistry Practical
General Chemistry
Course Code: MJ-P2-CHE-302
Credit: 2, Contact Hours: 30
[L=0, T=0, P=2]
Full Marks =40 IA=0 End Semester=40

Group-A
(Organic Chemistry)

Topic: Chromatography

a. Separation of a mixture of two amino acids by paper chromatography
b. Separation of a mixture of two sugars by paper chromatography
c. Separation of a mixture of o-and p-nitrophenol or o-and p-aminophenol by thin layer chromatography (TLC)

Group-B
(Physical Chemistry)

(a) Determination of heat capacity of a calorimeter for different volumes using change of enthalpy data of a known system (method of back calculation of heat capacity of calorimeter from known enthalpy of solution or enthalpy of neutralization).
(b) Determination of heat capacity of the calorimeter and enthalpy of neutralization of hydrochloric acid with sodium hydroxide.
(c) Calculation of the enthalpy of ionization of ethanoic acid.
(d) Determination of heat capacity of the calorimeter and integral enthalpy (endothermic and exothermic) solution of salts.
(e) Determination of basicity/proticity of a polyprotic acid by the thermochemical method in terms of the changes of temperatures observed in the graph of temperature versus time for different additions of a base. Also calculate the enthalpy of neutralization of the first step.
(f) Determination of enthalpy of hydration of copper sulphate.
(g) Study of the solubility of benzoic acid in water and determination of ΔH.

Reference book:

1. Mendham, J., A. I. Vogel's *Quantitative Chemical Analysis 6th Ed.*, Pearson, 2009.
2. Das, Subhas C, Advanced Practical Chemistry for 3-Year Honours Course.
3. Mann, F.G. & Saunders, B.C. *Practical Organic Chemistry,* Pearson Education (2009)
4. Yadav, J.B., *Advanced Practical Physical Chemistry 32nd Ed*; Goel Publishing Ho

SEMESTER-III
CHEMISTRY
(Minor)
Course Title: General Chemistry
Course Code: MN-T3-CHE-301
Credit: 3, Contact Hours: 45
[L=2, T=1, P=0]
Full Marks =60 IA=18 End Semester=42

Expected Learning Outcome:

- *Understanding the characteristics and properties of transition metals.*
- *Knowledge of the electronic configurations and periodic trends in the transition series.*
- *Understanding the concept of coordination compounds, ligands, and coordination numbers.*
- *Knowledge of different types of coordination isomerism and their implications.*
- *Understanding the structure, properties, and nomenclature of aromatic compounds.*
- *Understanding the structure, properties, and nomenclature of alkyl and aryl halides.*
- *Knowledge of different types of halogenation reactions.*
- *Understanding the concepts of energy, enthalpy, and entropy.*
- *Knowledge of* Kirchhoff's equation *and their applications.*
- *Understanding the concept of chemical equilibrium and equilibrium constant.*
- *Knowledge of Le Chatelier's principle and its application to chemical equilibrium.*

Section A: Inorganic Chemistry

Unit I: *Transition Series* Elements (*3d* series) **Marks 7**

General group trends with special reference to electronic configuration, variable valency, colour, magnetic and catalytic properties, ability to form complexes and stability of various oxidation states (Latimer diagrams) for Mn, Fe and Cu.

Lanthanoids and actinoids: Electronic configurations, oxidation states, colour, magnetic properties, lanthanide contraction, separation of lanthanides (ion exchange method only).

Unit II: *Coordination Chemistry* **Marks 7**

Valence Bond Theory (VBT): Inner and outer orbital complexes of Cr, Fe, Co, Ni and Cu (coordination numbers 4 and 6). Structural and stereoisomerism in complexes with coordination numbers 4 and 6. Drawbacks of VBT. IUPAC (2005) system of nomenclature.

Section B: Organic Chemistry

Unit I Aromatic Hydrocarbons **Marks 7**

Preparation: (Case benzene): from phenol, by decarboxylation, from acetylene, from benzene sulphonic acid.
Reactions: (Case benzene): Electrophilic substitution: nitration, halogenation and sulphonation. Friedel-Craft's reaction (alkylation and acylation) (up to 4 carbons on benzene). Side chain oxidation of alkyl benzenes (up to 4 carbons on benzene).

Unit II: Alkyl and Aryl Halides **Marks 7**

Alkyl Halides: (Up to 5 Carbons): Types of Nucleophilic Substitution (S_N1, S_N2 and S_Ni) reactions. Preparation: from alkenes and alcohols. Reactions: hydrolysis, nitrite & nitro formation, nitrile & isonitrile formation. Williamson's ether synthesis: Elimination vs substitution.
Aryl Halides: *Preparation*: (Chloro, bromo and iodo-benzene case): from phenol, Sandmeyer & Gattermann reactions. *Reactions* (Chlorobenzene): Aromatic nucleophilic substitution (replacement by –OH group) and effect of nitro substituent. Benzyne Mechanism: KNH_2/NH_3 (or $NaNH_2/NH_3$). Reactivity and Relative strength of C-Halogen bond in alkyl, allyl, benzyl, vinyl and aryl halides.

Section C: Physical Chemistry

Unit I: Chemical Energetics **Marks 7**

Review of thermodynamics and the Laws of Thermodynamics.
Important principles and definitions of thermochemistry. Concept of standard state and standard enthalpies of formations, integral and differential enthalpies of solution and dilution. Calculation of bond energy, bond dissociation energy and resonance energy from thermochemical data. Variation of enthalpy of a reaction with temperature– Kirchhoff's equation.

Unit II: Chemical Equilibrium **Marks 7**

Free energy change in a chemical reaction. Thermodynamic derivation of the law of chemical equilibrium. Distinction between ΔG and ΔG^o, Le Chatelier's principle. Relationships between K_p, K_c and K_x for reactions involving ideal gases.

Reference Books:

1. J. D. Lee: A new Concise Inorganic Chemistry, E L. B. S.
2. F. A. Cotton & G. Wilkinson: Basic Inorganic Chemistry, John Wiley.
3. Douglas, McDaniel and Alexader: Concepts and Models in Inorganic Chemistry, John Wiley.
4. James E. Huheey, Ellen Keiter and Richard Keiter: Inorganic Chemistry: Principles of Structure and Reactivity, Pearson Publication.
5. T. W. Graham Solomon: Organic Chemistry, John Wiley and Sons.
6. Peter Sykes: A Guide Book to Mechanism in Organic Chemistry, Orient Longman.
7. E. L. Eliel: Stereochemistry of Carbon Compounds, Tata McGraw Hill.
8. I. L. Finar: Organic Chemistry (Vol. I & II), E. L. B. S.
9. R. T. Morrison & R. N. Boyd: Organic Chemistry, Prentice Hall.
10. Arun Bahl and B. S. Bahl: Advanced Organic Chemistry, S. Chand

SEMESTER-III
CHEMISTRY
(Minor)
Course Title: Chemistry Practical
Course Code: MN-P2-CHE-301
Credit: 2, Contact Hours: 60
[L=0, T=0, P=2]
Full Marks =40 IA= 0 End Semester=40

***Section A: Inorganic Volumetric Analysis*:**

i. Estimation of Fe (II) ions by titrating it with $K_2Cr_2O_7$ using internal indicator.
ii. Estimation of oxalic acid by titrating it with $KMnO_4$.
iii. Estimation of water of crystallization in Mohr's salt by titrating with $KMnO_4$.

***Section B: Organic Chemistry*:**

i. Detection of characterized element (N, S, Cl, Br, I) in an organic compound.
ii. Separation of mixtures by Chromatography: Measure the R_f value in each case (combination of two compounds to be given)
(a) Identify and separate the components of a given mixture of 2 amino acids (glycine, aspartic acid, glutamic acid, tyrosine or any other amino acid) by paper chromatography
(b) Identify and separate the sugars present in the given mixture by paper chromatography.

***Section C: Physical Chemistry*:**

Thermo chemistry and Chemical equilibrium

i. Determination of heat capacity of calorimeter for different volumes.
ii. Determination of enthalpy of neutralization of hydrochloric acid with sodium hydroxide.

Reference Books:

1. Mendham, J., A. I. Vogel's *Quantitative Chemical Analysis 6th Ed.*, Pearson, 2009.
2. Das, Subhas C, Advanced Practical Chemistry for 3-Year Honours Course.
3. Mann, F.G. & Saunders, B.C. *Practical Organic Chemistry*, Pearson Education (2009)
4. Yadav, J.B., *Advanced Practical Physical Chemistry 32nd Ed*; Goel Publishing Ho

SEMESTER-III
CHEMISTRY
Multidisciplinary Course (MDC)
Course Title: Water remediation and conservation studies
Course Code: MD-T3-CHE-301
Credit: 3, Contact Hours: 45
[L=2, T=1, P=0]
Full Marks =60 IA=18 End Semester= 42

Expected Learning Outcome:

- Understanding the importance of water remediation and conservation in addressing water pollution and scarcity issues.
- Understanding the different methods and technologies used in water remediation
- Knowledge of the principles and applications of water treatment technologies
- Understanding the importance of water conservation in sustainable water resource management.
- Knowledge of different water conservation strategies

UNIT-I: Introduction **Marks 14**

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, causes and effects of water pollution.

UNIT-II: Remediation **Marks 14**

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-III: Conservation **Marks 14**

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 watershed processes.

Recommended Books/references:

1. Cittenden J. C., Trussell J. R., Hand D. W., Howe K. J., Tchobanoglous 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. Soil and water analytical method; Edzwald J., Water Quality & Treatment: A Handbook on Drinking Water (Water Resources and Environmental Engineering Series)

SEMESTER-III
CHEMISTRY
Skill Enhancement Course (SEC)
Course Title: FUEL CHEMISTRY
Course Code: MN-T1-CHE-301
Credit: 1, Contact Hours: 15
[L=1, T=0, P=0]
Full Marks =40 IA=12 End Semester= 28

Expected Learning Outcome:

- Understanding the different sources of energy, including fossil fuels, renewable energy, and nuclear energy.
- Understanding the formation, composition, and properties of coal.
- Understanding the formation, exploration, and extraction of petroleum.
- Knowledge of the refining processes and products derived from petroleum.
- Understanding the petrochemical industry and its role in producing various chemicals and plastics.
- Understanding the role and importance of lubricants in machinery and equipment.
- Knowledge of the types and properties of lubricants

Unit I: **Marks 4**

Review of energy sources (renewable and non-renewable).
Classification of fuels and their calorific value.

Unit II: **Marks 5**

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.

Unit III: **Marks 10**

Petroleum and Petrochemical Industry: Composition of crude petroleum; Different types of petroleum products and their applications. Principle and process of fractional distillation, Cracking – Thermal and catalytic cracking; Qualitative treatment of non-petroleum fuels-LPG, CNG, LNG, bio-gas, fuels derived from biomass, fuel from waste; synthetic fuels – gaseous and liquids.

Unit IV: **Marks 4**

Petrochemicals: Vinyl acetate, Propylene oxide, Isoprene, Butadiene, Toluene and its derivatives Xylene.

Unit V: **Marks 5**

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.

Reference Books:

1. E. Stocchi: Industrial Chemistry, Vol -I, Ellis Horwood Ltd. UK.
2. P. C. Jain, M. Jain: Engineering Chemistry, Dhanpat Rai & Sons, Delhi.
3. B. K. Sharma: Industrial Chemistry, Goel Publishing House, Meerut.

SEMESTER-III
CHEMISTRY
Skill Enhancement Course (SEC)
Course Title: SEC Practical
FUEL CHEMISTRY
Course Code: SE-P2-CHE-301
Credit: 2, Contact Hours: 60
[L=0, T=0, P=2]
Full Marks =40 IA=0 End Semester= 40

1. Determination of flash point & fire point of given fuel sample.
2. Determination of calorific value of given fuel sample/coal sample using bomb calorimeter.
3. Determination of the iodine number of oil.
4. Determination of the saponification number of oil.

SEMESTER-IV
CHEMISTRY
(Major)
Course Title: (Organic Chemistry)
Course Code: MJ-T4-CHE-401
Credit: 4, Contact Hours: 60
[L=3, T=1, P=0]
Full Marks =80 IA=24 End Semester=56

Expected Learner Outcome: Students will gain an understanding of ---
i. The prediction of mechanism for organic reactions
ii. How to design synthesis of organic molecule.
iii. The reactivity and stability of organic molecule based on structure
iv. An idea of carbonyl compounds, acids and their derivatives etc.
v. Methods of structure elucidation of alkaloids and terpenoids

Self-study:
1. Preparation, physical properties and reactions of monocarboxylic acids
2. Occurrence, classification of alkaloids and terpenoids.

Unit I: Carbonyl Compounds: Marks 15

Structure, reactivity and preparation;
Nucleophilic additions, Nucleophilic addition-elimination reactions with ammonia derivatives with mechanism; Mechanisms of Aldol and Benzoin condensation, Knoevenagel condensation, Claisen-Schmidt, Perkin, Cannizzaro and Wittig reaction, Beckmann and Benzil-Benzilic acid rearrangements, haloform reaction and Baeyer Villiger oxidation, α- substitution reactions, Clemmensen, Wolff-Kishner, MPV, $LiAlH_4$, $NaBH_4$, PDC, PCC, SeO_2, $Pb(OAc)_4$ & HIO_4. (Synthetic applications only)
Addition reactions of unsaturated carbonyl compounds: Michael addition.
Unsaturated Aldehydes (Acrolein, Crotonaldehyde, Cinnamaldehyde) Unsaturated Ketone (MVK)

Active methylene compounds: Keto-enol tautomerism. Preparation and synthetic applications of diethyl malonate and ethyl acetoacetate.

Unit II: Carboxylic Acids and their Derivatives: Marks 15

Preparation, physical properties and reactions of monocarboxylic acids (Acidity and factors affecting it): Typical reactions of dicarboxylic acids, hydroxy acids and unsaturated acids: succinic, phthalic, lactic, malic, tartaric, citric, maleic and fumaric acids; Preparation and reactions of acid chlorides, anhydrides, esters and amides; Comparative study of nucleophilic sustitution at acyl group -Mechanism of acidic and alkaline hydrolysis of esters, Claisen condensation, Dieckmann and Reformatsky reactions, Hofmannbromamide degradation and Curtius rearrangement.

Unit III: Sulphur containing compounds: Marks 8

Preparation and reactions of thiols, thioethers and sulphonic acids.

Unit IV: Alkaloids **Marks 10**

Natural occurrence, General structural features, Isolation and their physiological action Hoffmann's exhaustive methylation, Emde's modification, Structure elucidation and synthesis of Hygrine and Nicotine. Medicinal importance of Nicotine, Hygrine, Quinine, Morphine, Cocaine, and Reserpine**.**

Unit V: Terpenes **Marks 8**

Occurrence, classification, isoprene rule; Elucidation of structure and synthesis of Citral, Neral and α-terpineol.

Reference Books:

1. Morrison, R. T. & Boyd, R. N. *Organic Chemistry*, Dorling Kindersley (India) Pvt.Ltd. (Pearson Education).

2. Finar, I. L. *Organic Chemistry* (*Volume 1*), Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).

3. Graham Solomons, T.W. *Organic Chemistry*, John Wiley & Sons, Inc.

SEMESTER-IV
CHEMISTRY
(Major)
Course Title: Chemistry Practical
Organic Chemistry
Course Code: MJ-P2-CHE-401
Credit: 2, Contact Hours: 30
[L=0, T=0, P=2]
Full Marks =40 IA=0 End Semester=40

1. Functional group tests for alcohols, carbonyl, and carboxylic acid group.

2. **Organic preparations:**
i. Acetylation of one of the following compounds: amines (aniline, *o*-, *m*-, *p*- toluidines and *o*-, *m*-, *p*-anisidine) and phenols (β-naphthol, vanillin, salicylic acid) by method:
   a. Using conventional method.
   b. Using green approach

ii. Benzolyation of one of the following amines (aniline, *o*-, *m*-, *p*toluidines and *o*-, *m*-, *p*-anisidine) and one of the following phenols (β-naphthol, resorcinol, p- cresol) by Schotten-Baumann reaction.

iii. Oxidation of ethanol/ isopropanol (Iodoform reaction).

iv. Nitration of the following:
   a. Acetanilide/nitrobenzene by conventional method
   b. Salicylic acid by green approach (using ceric ammonium nitrate).

v. Reduction of *p*-nitrobenzaldehyde by sodium borohydride.

vi. Hydrolysis of amides and esters.

vii. Aldol condensation using either conventional or green method.

viii. Benzil-Benzilic acid rearrangement.

The above derivatives should be prepared using 0.5-1g of the organic compound. The solid samples must be collected and may be used for recrystallization, melting point and TLC.

Reference Books

1. Mann, F.G. & Saunders, B.C. *Practical Organic Chemistry*, Pearson Education (2009)
2. Furniss, B.S.; Hannaford, A.J.; Smith, P.W.G.; Tatchell, A.R. *Practical Organic Chemistry, 5th Ed.*, Pearson (2012)
3. Ahluwalia, V.K. & Aggarwal, R. *Comprehensive Practical Organic Chemistry:Preparation and Quantitative Analysis*, University Press (2000).
4. Ahluwalia, V.K. & Dhingra, S. *Comprehensive Practical Organic Chemistry: Qualitative Analysis*, University Press (2000)

SEMESTER-IV
CHEMISTRY
(Major)
Course Title: (General Chemistry)
Course Code: MJ-T4-CHE-402
Credit: 4, Contact Hours: 60
[L=3, T=1, P=0]
Full Marks =80 IA=24 End Semester=56

Section A: Inorganic Chemistry

Expected Learner Outcome: Students will gain an understanding of ---

1. Quantitative aspect of ligand field and MO theory, stability of various oxidation states and emf of transition elements
2. General group trends of transition elements
3. Types of catalysis, Michaelis – Menten mechanism, mechanism of catalysed reaction at solid state.
4. Steady - state approximation in reaction mechanism.
5. Concept of phases, phase diagrams for systems of solid- liquid equilibria involving eutectic, congruent and incongruent mp, solid solution etc

Self-study:

1. IUPAC nomenclature of coordination compounds
2. Electronic configuration of actinoides and lanthanoids.
3. IUPAC nomenclature of coordination compounds
4. Electronic configuration of actinoides and lanthanoids.

Unit I: Coordination Chemistry **Marks 12**

IUPAC nomenclature of coordination compounds, isomerism in coordination compounds. Stereochemistry of complexes with 4 and 6 coordination numbers. Chelate effect, polynuclear complexes. Labile and inert complexes. Werner's theory, valance bond theory (inner and outer orbital complexes), electroneutrality principle and back bonding. Crystal field theory, measurement of 10Dq (Δo), CFSE in weak and strong fields, pairing energies, factors affecting the magnitude of 10Dq (Δo, Δt). Octahedral vs. tetrahedral coordination, tetragonal distortions from octahedral geometry, Jahn-Teller theorem, square planar geometry. Qualitative aspect of Ligand field and MO Theory.

Unit II: Transition Elements **Marks 8**

General group trends with special reference to electronic configuration, colour, variable valency, magnetic and catalytic properties, ability to form complexes. Stability of various oxidation states and e.m.f. (Latimer and Bsworth diagrams). Difference between the first, second and third transition series. Chemistry of Ti, V, Cr, Mn, Fe and Co in various oxidation states (excuding their metallurgy)

Unit III: Lanthanoids and Actinoids **Marks 8**

Electronic configuration, oxidation states, colour, spectral and magnetic properties, Lanthanide contraction, separation of lanthanides (ion-exchange method only)

Section B: Physical Chemistry

Unit II: Chemical Kinetics **Marks 14**

Order and molecularity of a reaction, rate laws in terms of the advancement of a reaction, differential and integrated form of rate expressions up to second order reactions, experimental methods of the determination of rate laws, kinetics of complex reactions (integrated rate expressions up to first order only): (i) Opposing reactions (ii) parallel reactions and (iii) consecutive reactions and their differential rate equations (steady-state approximation in reaction mechanisms) (iv) chain reactions. Temperature dependence of reaction rates; Arrhenius equation; activation energy. Collision theory of reaction rates, Lindemann mechanism, qualitative treatment of the theory of absolute reaction rates.

Unit IV: Solutions and Colligative Properties **Marks 14**

Dilute solutions; lowering of vapour pressure, Raoult's and Henry's Laws and their applications. Excess thermodynamic functions.

Thermodynamic derivation using chemical potential to derive relations between the four colligative properties [(i) relative lowering of vapour pressure, (ii) elevation of boiling point, (iii) Depression of freezing point, (iv) osmotic pressure] and amount of solute. Applications in calculating molar masses of normal, dissociated and associated solutes in solution.

Reference Books:

1. J. D. Lee: A new Concise Inorganic Chemistry, E L. B. S.
2. F. A. Cotton & G. Wilkinson: Basic Inorganic Chemistry, John Wiley
3. James E. Huheey, Ellen Keiter and Richard Keiter: Inorganic Chemistry: Principles of Structure and Reactivity, Pearson Publication.
4. G. M. Barrow: Physical Chemistry Tata McGraw-Hill (2007).
5. G. W. Castellan: Physical Chemistry 4th Edn. Narosa (2004

SEMESTER-IV
CHEMISTRY
(Major)
Course Title: Chemistry Practical
General Chemistry
Course Code: MJ-P2-CHE-402
Credit: 2, Contact Hours: 60
[L=0, T=0, P=2]
Full Marks =40 IA=0 End Semester=40

Inorganic

A. Gravimetric Analysis:

i. Estimation of nickel(ii) using Dimethylglyoxime
ii. Estimation of copper as CuSCN
iii. Estimation of iron as Fe2O3 by precipitating iron as Fe (OH)3

B. Inorganic Preparation:

i. Tetraamminecopper(II) sulphate
ii. Tetraamminecarbonatocobalt (III) ion
iii. Potassium tris(oxalate)ferrate (III)

Physical

i. Determination of critical solution temperature and composition of the phenol-water system and to study the effect of impurities on it.
ii. Distribution of acetic/ benzoic acid between water and cyclohexane.
iii. Study the kinetics of acid hydrolysis of methyl acetate with hydrochloric acid. (Integrated rate method)
iv. Saponification of ethyl acetate.
v. Compare the strengths of HCl and H2SO4 by studying kinetics of hydrolysis of methyl acetate.
vi. Verify the Freundlich and Langmuir isotherms for adsorption of acetic acid/oxalic acid on activated charcoal.

Reference Books:

i. Khosla, B. D.; Garg, V. C. & Gulati, A. *Senior Practical Physical Chemistry*, R. Chand & Co.: New Delhi (2011).
ii. Garland, C. W.; Nibler, J. W. & Shoemaker, D. P. *Experiments in Physical Chemistry 8th Ed.*; McGraw-Hill: New York (2003).
iii. Halpern, A. M. & McBane, G. C. *Experimental Physical Chemistry 3rd Ed.;* W.H. Freeman & Co.: New York (2003).
iv. Yadav, J.B., *Advanced Practical Physical Chemistry 32nd Ed*; Goel Publishing Hour
v. Mendham, J., A. I. Vogel's *Quantitative Chemical Analysis 6th Ed.*, Pearson, 2009.
vi. Das, Subhas C, Advanced Practical Chemistry for 3-Year Honours Course.

SEMESTER-IV
CHEMISTRY
(Minor)
Course Title: General Chemistry
Course Code: MN-T3-CHE-401
Credit: 3, Contact Hours: 45
[L=2, T=1, P=0]
Full Marks =60 IA=18 End Semester=42

Expected Learning Outcome:

- Understanding the principles and concepts of crystal field theory in coordination compounds.
- Knowledge of the splitting of d-orbitals and the crystal field stabilization energy (CFSE).
- Understanding the structure, properties, and nomenclature of alcohols, phenols, and ethers.
- Knowledge of different methods of preparation, properties and reactions of alcohols, phenols, and ethers.
- Understanding the concept of electrical conductance and conductivity.
- Ability to calculate and interpret conductance values, perform conductometric titrations, and analyze conductance data.

Unit I: Crystal Field Theory **Marks 14**

Crystal Field Theory (CFT): Crystal field effect, octahedral symmetry. Crystal field stabilization energy (CFSE), Crystal field effects for weak and strong fields. Tetrahedral symmetry. Factors affecting the magnitude of D. Spectrochemical series. Comparison of CFSE for Oh and Td complexes, Tetragonal distortion of octahedral geometry. Jahn-Teller distortion, Square planar coordination.

Section *B: Organic Chemistry*

Unit I: Alcohols, Phenols and Ethers (Up to 5 Carbons) **Marks 7**

Alcohols: Preparation: Preparation of 1^0, 2^0 and 3^0 alcohols: using Grignard reagent, Ester hydrolysis, Reduction of aldehydes, ketones, carboxylic acid and esters. Reactions: With sodium, HX (Lucas test), esterification, oxidation (with PCC, *alk*. $KMnO_4$, acidic dichromate, conc. HNO_3). Diols: (Up to 6 Carbons) oxidation of diols. Pinacol-Pinacolone rearrangement.

Phenols: (Phenol case): Preparation: Cumene hydroperoxide method, from diazonium salts. Reactions: Electrophilic substitution: Nitration, halogenation and sulphonation. Reimer-Tiemann Reaction, Schotten – Baumann Reaction.

Ethers (aliphatic and aromatic): Cleavage of ethers with HI.

Unit II **Marks 7**

Aldehydes and ketones (aliphatic and aromatic): (Formaldehye, acetaldehyde, acetone and benzaldehyde): Preparation: from acid chlorides and from nitriles. Reactions – Reaction with HCN, ROH, $NaHSO_3$, NH_2-G derivatives. Iodoform test. Aldol Condensation, Cannizzaro's Reaction, Wittig Reaction, Benzoin Condensation. Clemensen Reduction and Wolff Kishner Reduction. Meerwein-Pondorff Verley Reduction.

Section C: Physical Chemistry

Unit I: Solutions **Marks 7**

Thermodynamics of ideal solutions: Ideal solutions and Raoult's law, deviations from Raoult's law – non-ideal solutions. Vapour pressure-composition and temperature composition curves of ideal and non-ideal solutions. Distillation of solutions. Azeotropes. artial miscibility of liquids: Critical solution temperature; effect of impurity on partial miscibility of liquids. Immiscibility of liquids- Principle of steam distillation. Nernst distribution law and its applications, solvent extraction.

Unit II: Conductance **Marks 7**

Conductivity, equivalent and molar conductivity and their variation with dilution for weak and strong electrolytes. Kohlrausch's law of independent migration of ions. Transference number and its experimental determination using Hittorf and Moving boundary methods. Ionic mobility. Applications of conductance measurements: determination of degree of ionization of weak electrolyte, solubility and solubility products of sparingly soluble salts, ionic product of water, hydrolysis constant of a salt. Conductometric titrations (only acid base).

Reference Books:

1. I. L. Finar: Organic Chemistry (Vol. I & II), E. L. B. S.
2. R. T. Morrison & R. N. Boyd: Organic Chemistry, Prentice Hall.
3. Arun Bahl and B. S. Bahl: Advanced Organic Chemistry, S. Chand.
4. G. M. Barrow: Physical Chemistry Tata McGraw-Hill (2007).
5. G. W. Castellan: Physical Chemistry 4th Edn. Narosa (2004).
6. R. H. Petrucci: General Chemistry 5th Ed. Macmillan Publishing Co.: New York (1985).
7. Ball, D. W. Physical Chemistry Thomson Press, India (2007).
8. Castellan, G. W. Physical Chemistry 4^{th} Ed. Narosa (2004).

SEMESTER-IV
CHEMISTRY
(Minor)
Course Title: Chemistry Practical
General Chemistry
Course Code: MN-P2-CHE-401
Credit: 3, Contact Hours: 90
[L=0, T=0, P=3]

1. *Section A: Inorganic Chemistry*:

Semi-micro qualitative analysis using H_2S of mixtures- not more than four ionic species (Two anions and two cations and excluding insoluble salts) out of the following:
Cations: Pb^{2+}, Ag^{+}, Bi^{3+}, Cu^{2+}, Cd^{2+}, Sn^{2+}, Fe^{3+}, Al^{3+}, Co^{2+}, Cr^{3+}, Ni^{2+}, Mn^{2+}, Zn^{2+}, Ba^{2+}, Sr^{2+}, Ca^{2+}, Mg^{2+}, NH_4^{+}.
Anions: CO_3^{2-}, NO_2^{-}, NO_3^{-}, PO_4^{3-}, BO_3^{3-}, I^{-}, Br^{-}, Cl^{-}, SO_4^{2-}
Spot tests should be done whenever possible.

2. *Section B: Organic Chemistry*:

Systematic Qualitative Organic Analysis of Organic Compounds possessing mono-functional groups (-COOH, phenolic, aldehydic, ketonic, amide, nitro, amines) and preparation of one derivative.

2. *Section C: Experiments on Solution and Conductance's*:

1. Determination of the critical solution temperature and composition of the phenol water system and study of the effect of impurities on it.
2. Determination of cell constants.
3. Performing the following conductometric titrations:
    a. Strong acid vs. strong base or
    b. Weak acid vs. strong base

Reference Books:
1. A. I. Vogel, Qualitative Inorganic Analysis, Prentice Hall, 7th Ed.
2. Khosla, B. D.; Garg, V. C. & Gulati, A., Senior Practical Physical Chemistry, R. Chand & Co.: New Delhi (2011).