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)
2024

Program Specific Outcomes (PSOs) for B.Sc. Chemistry:

1. **Fundamental Knowledge in Chemistry:**
    i. Graduates will demonstrate a strong foundation in the core areas of chemistry, including organic, inorganic, physical, and analytical chemistry.
    ii. They will be able to apply principles and concepts from these areas to solve complex chemical problems.
2. **Laboratory Skills and Techniques:**
    i. Graduates will be proficient in conducting experiments, using modern instruments, and employing appropriate techniques in a chemistry laboratory.
    ii. They will be able to analyze and interpret experimental data accurately and safely.
3. **Research and Problem-Solving Abilities:**
    i. Graduates will develop the ability to design, conduct, and evaluate research in chemistry.
    ii. They will be skilled in applying critical thinking and problem-solving approaches to address scientific questions and real-world issues.
4. **Chemical Safety and Ethics:**
    i. Graduates will be aware of and adhere to chemical safety regulations and ethical guidelines in both academic and professional settings.
    ii. They will understand the environmental and societal impacts of chemical processes and products.
5. **Interdisciplinary Knowledge and Skills:**
    i. Graduates will integrate knowledge from chemistry with other disciplines such as physics, biology, and environmental science to address interdisciplinary problems.
    ii. They will be able to collaborate effectively in multidisciplinary teams.
6. **Communication and Professional Skills:**
    i. Graduates will be able to communicate chemical information clearly and effectively in both written and oral forms to scientific and non-scientific audiences.
    ii. They will develop professional skills such as teamwork, leadership, and time management.
7. **Preparation for Advanced Studies and Careers:**
    i. Graduates will be well-prepared for higher education (e.g., M.Sc., Ph.D.) in chemistry or related fields.
    ii. They will have the knowledge and skills necessary for careers in industry, research, education, or government sectors.

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, 4T+1P) **General Chemistry (Inorganic + Organic + Physical)**	DSE-I (5 credit, 4T+1P) **General Chemistry (Inorganic + Organic + Physical)**	IDC/MDC-I (3 credit, 3T + 0P) **Energy & Environment**	AECC-I Communicative English-I (2 credit, 2T+0P)	SEC-I (3 credit, 1T+2P) **Good Laboratory Practices**	-	VAC –I (2 credit, 2T + 0P)	-	**20**
II	DSC-II (5 credit, 4T+1P) **General Chemistry (Inorganic + Organic + Physical)**	DSE-II (5 credit, 4T+1P) **General Chemistry (Inorganic + Organic + Physical)**	IDC/MDC-II (3 credit, 3T + 0P) **Food nutrition and preservation**	AECC-II Language and Literature (MIL/Regional Language) (2 credit, 2T+0P)	SEC-II (3 credit, 1T+2P) **Basic Analytical Chemistry**	-	VAC – II (2 credit, 2T + 0P)	-	**20**
T + P (Marks)	4 +1 (80+20)	4+1 (80+20)	3+0 or 2+1 (60)	2+0	1+2 (40+40)		2+0		

		Award of Undergraduate Certificate (after 1 year: 40 credits): Students exiting the programme after securing 40 credits will be awarded UG certificate in the relevant Discipline/Subject provided they secure 4 credits in work based vocational courses offered during summer term or internship/Apprenticeship in addition to 6 credits from skill-based courses earned during 1st and 2nd semester.							
III	DSC-III (4 credit, 3T+1P) **Inorganic Chemistry**	DSE-III (2 credit, 1T+1P) Minor Other Departments	IDC/MDC-III (3 credit, 3T + 0P) **Water remediation and conservation studies**	AECC (2 credit, 2T + 0P)	SEC-III (3 credit, 1T + 2P) **Fuel Chemistry**				**20**
	DSC-IV (4 credit, 3T+1P) **Organic Chemistry**	DSE-IV (2 credit, 2T+0P) (Minor) Self-Department **Physical Chemistry / Basic Computational Chemistry**	-	-	-				
T + P (Marks)	3 +1 (60+20)	1(40) +1(20) 2(40)	3+0 or 2+1 (60)	2+0	1+2 (40+40)				

IV	DSC-V (4 credit, 4T+0P) **Inorganic Chemistry**	DSE-V (4credit, 0T+ 4P) **General Chemistry Practical / Computational Chemistry Practical I**	-	AECC (2 credit)	VAC-III (2 Credit, 2T+0P) **(EVS, Compulsory)**				**20**
	DSC-VI (4 credit, 4T+0P) **Organic Chemistry**		-	-	-		-		
	DSC-VII (4 credit, 4T+0P) **Physical Chemistry**								
T + P (Marks)	4 +0 (80)	0+4 (80)			2+0 (40)				
Award of Undergraduate Certificate (after 2 years: 80 credits): Students exiting the programme after securing 80 credits will be awarded UG Diploma in the relevant Discipline/Subject provided they secure additional 4 credit in skill based vocational courses offered during 1st year or second year summer term.									

V	DSC-VIII (5 credit, 5T + 0P) **Inorganic Chemistry**	DSE-VI (Self-Department) (3 credit, 0T + 3P) **General Chemistry Practical / Computational Chemistry Practical II**	-		**Internship** (4 credit)	-		**20**
	DSC-IX (4 credit, 4T + 0P) **Organic Chemistry**	-	-	-		-		
	DSC-X (4 Credit, 4T + 0P) **Physical Chemistry**							
VI	DSC-XI (5 credit, 5T +0P) **Inorganic Chemistry**	DSE-VII (3 credit, 3T + 0P) **Chemistry and Environment - (Option I)** **Chemistry in ancient India- (Option II)**	-	-		-		**20**
	DSC-XII (4 credit, 4T + 0P) **Organic Chemistry**		-	-		-		
	DSC-XIII (4 credit, 4T + 0P) **Physical Chemistry**	-	-	-		-		
	DSC-IX (4 Credit, 0T + 4P) **Chemistry general Practical**							
		Award of Bachelor of Arts/ Science (Honours in Discipline) (after 3 years: 120credits)						

VII	DSC-XV (5 credit, 5T + 0P) **Inorganic Chemistry**	DSE-VIII (3 credit, 3T + 0P) **Research Methodology/ Tools and Techniques in Research Methodology**	-					**20**
	DSC-XVI (5 credit, 5T + 0P) **Organic Chemistry**	DSE-IX (3 credit, 0T + 3P) **General Chemistry Practical I / General Chemistry Practical II**						
	DSC-XVII (4 credit, 4T + 0P) **Physical Chemistry**							
VIII	DSC-XVIII (3 credit, 3T+0P) **Inorganic Chemistry**	DSE -X (2 Credit, 2T + 0P) **Spectroscopy -II/ Spectroscopic Techniques in Forensic Science**					**Research Project** (12 credit)	**20**
	DSC-XIX (3 credit, 3T + 0P) **Organic Chemistry**							
	Optional Papers for students who don't opt for Research Project							
	DSC-XX (4 Credit, 4T +0P) **Analytical Methods in Chemistry**							
	DSC-XXI (4 Credit, 4T +0P) **Physical Chemistry**							
	DSC-XXII (4 Credit, 0T +4P) **Advanced Analytical PR.**							
Award of Bachelor of Arts/ Science (Honors in Discipline/ Research) (after 4 years: 160 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

Objective of the course:

1. To learn about the periodic table, physical and chemical characteristics, periodicity.
2. To learn about elimination reaction, electrophilic and nucleophilic addition
3. To learn about the behavior of real gases, its deviation from ideal behavior, equation of state, isotherm, and law of corresponding states.

Expected Learning Outcome:

(Inorganic Part) Students will understand:

1. The atomic theory and its evolution.
2. The scientific theory of atoms, concept of wave function.
3. About the elements in periodic table; physical and chemical characteristics, periodicity.
4. The atomic theory of matter, composition of atom.
5. The 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. Students will get the knowledge of basic organic chemistry and definition.
2. Students will understand the influence of hybridization etc.
3. Students will get the knowledge of elimination reaction, electrophilic and nucleophilic addition.

(Physical Part)

1. Students will become Familiar with various states of matter.
2. Students will understand the physical properties of each liquid state of matter and laws related to describe the states.
3. Students will understand the about the behavior of real gases, their deviation from ideal behavior, equation of state, isotherm, and law of corresponding states.
4. Students will understand the about the liquid state and how their physical properties are related to temperature and pressure variation.
5. Students will understand the about the 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: **11 Lectures, 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: **11 Lectures, 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 11Lectures, 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 11 Lectures, 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 11 Lectures, 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 5 Lectures**,** 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 Textbook 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

Objective of the course:

- 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.
- 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 kinetic molecular theory and its application to gas behavior.
- Understanding the properties of liquids like surface tension, viscosity etc.

Expected Learning Outcome:

- There will be development of the ability to predict and explain chemical behavior based on atomic structure, such as ionization, electron affinity, and atomic bonding.
- Students will gain knowledge of three-dimensional molecular structures, including stereoisomerism.
- Students will gain knowledge of kinetic molecular theory and its application to gas behavior.
- Students will understand the properties of liquids like surface tension, viscosity etc.

Section A: Inorganic Chemistry
Marks =20

Unit I: Atomic Structure **11 Lectures, 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:** **11 Lectures, 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 **11 Lectures, 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 **6 Lectures, 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 **11 Lectures, 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 **10 Lectures, 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 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 elements (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

Objective of the course:

- 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.

Expected Learning outcome:

- Students will understand the importance of environmental conservation and sustainable practices.
- Students will understand the processes of water contamination, such as eutrophication and groundwater pollution.
- Students will understand the various forms of energy, including fossil fuels, renewable energy sources, and nuclear energy.
- Students will gain the knowledge of energy conversion processes and their efficiency.

Unit I: Environment and its Segments **8 Lectures, Marks 7**

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

Unit II: Air Pollution **11 Lectures, Marks 10**

Air pollutants, types of air pollutants, atmospheric pollutants, greenhouse 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 **11 Lectures, Marks 10**

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

Unit IV: Energy **15 Lectures, 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

Objective of the course:

- To equip the students with practical skills in science courses with the understanding of general laboratory Practices, importance of micro techniques used in chemistry.

Expected 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 **7 Lectures, 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 **8 Lectures, 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

Objective of the course:

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

Expected Learning Outcome:

1. **Students will learn about the** hybridization and shapes of atomic, molecular orbitals, bond parameters, bond- distances and energies.
2. Students will learn about the Aromatic compounds and aromaticity, mechanism of aromatic reactions.
3. Students will learn about Ionic equilibria – electrolyte, ionization, dissociation, 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 **14 Lectures, 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: **3 Lectures, Marks 5**

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

Group-B
(Organic Chemistry)
Marks 19

Unit I Aromatic Hydrocarbons **8 Lectures, Marks 7**

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 **8 Lectures, Marks 7**

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: **6 Lectures, Marks 5**

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 **11 Lectures, 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 **10 Lectures, 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 Textbook 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

1. Study the effect on pH of addition of HCl/NaOH to solutions of acetic acid, sodium acetate and their mixtures.
2. Preparation of buffer solutions of different pH
    a. Sodium acetate-acetic acid
    b. Ammonium chloride-ammonium hydroxide
3. 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

Objective of the Course

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

Expected learning outcome:

1. Students will learn the Valence bond theory, concepts of hybridization and the technique of predicting geometry of molecules with the help of VSEPR theory.
2. Students will learn the importance of hydrogen bonding and metallic bonding. Stereochemistry of organic molecules – conformation and configuration, asymmetric molecules, and nomenclature.
3. Students will learn about ionic equilibrium, Salt hydrolysis (acid-base hydrolysis) and its application in chemistry.

Section A: Inorganic Chemistry
Marks 20

Unit I: Chemical Bonding and Molecular Structure **16 Lectures, 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 2^{nd} 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: **3 Lectures, Marks 5**

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

Section B: Organic Chemistry
Marks 18

Unit I: Aliphatic Hydrocarbons **18 Lectures, 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 **11 Lectures, 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 **12 Lectures, 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

Objective of the Course:

- 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.

Expected learning outcome:

- Students will understand the basic principles of food nutrition and its importance for human health.
- Students will understand the energy content of macronutrients and the role of calories in nutrition.
- Students will understand the consequences of nutrient deficiencies and excesses on human health.
- The study will help in the development of the ability of the students to select and apply appropriate food preservation techniques to maintain the nutritional quality and safety of food products.

Unit I: Introduction: **11 Lectures, Marks 10**

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

Unit II: Energy considerations in nutrition **11 Lectures, 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 **11 Lectures, 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 **12 Lectures, 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. Roday S (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, 7th 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

Objective of the Course:

- 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.

Expected learning outcome:

- Students will understand the fundamental principles and techniques used in analytical chemistry, the Importance of accuracy, precision, and sources of error in analytical measurements.
- Students will gain knowledge of different soil properties, such as pH, nutrient content, organic matter, and texture.
- Students will gain knowledge of different parameters analyzed in water, such as pH, dissolved oxygen, and chemical contaminants.
- Students will understand the principles and applications of chromatography in chemical analysis.

Unit I: Introduction **3 Lectures, 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 **5 Lectures, 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 **7 Lectures, 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

Objective of the Course:

To make Students learn about the techniques involved in water and soil analysis.

Expected Learners Outcome:

- Students will learn to determine pH, Quantities of Ca, Mg, PO_4^{3-}, NO_3^-.
- Students will learn to determine BOD, COD as well as DO in the supplied water samples.

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-T3-CHE-301
Credit: 3, Contact Hours: 45
[L=2, T=1, P=0]
Full Marks =60 IA=18 End Semester=42

Objective of the Course: To make the student familiar with the chemistry of s, p block elements, Acids-Bases, & metallurgy.

Expected Learner Outcome: Students will gain an understanding of ---
i. Principle of purification of metal, study of compounds with special emphasis on structure, bonding, preparation, and properties.
ii. Chemistry of s and p-block elements.
iii. Acids-Bases and the factors affecting the strengths of acids/bases, HSAB principle.

Self-study:
1. Different Metallurgical Processes.
2. Different Theories of acids & bases.
3. Electronic Configuration and Periodicities of s and p block elements.

Unit I: General Principles of Metallurgy 12 Lectures, 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 refining.

Unit II: Acids and Bases 12 Lectures, Marks 12
Arrhenius Theory, 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: 21 Lectures, Marks 20
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, pseudo halogens and basic properties of halogens.

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 edition., 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).

SEMESTER-III
CHEMISTRY
(Major)
Course Title: Chemistry Practical
INORGANIC CHEMISTRY
Course Code: MJ-P1-CHE-301
Credit: 1, Contact Hours: 30
[L=0, T=0, P=2]
Full Marks =20 IA=0 End Semester=20

Objective of the Course:
To make Students learn about iodometric titrations, various Inorganic Preparations.

Expected Learners Outcome:

- Students will learn to do Iodo / Iodimetric Titrations.
- Students will learn to do Inorganic Preparations in laboratories.
- Students will learn to estimate available chlorine in bleaching powder iodometrically.

A. Iodo / Iodimetric Titrations **Marks 12**

(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 **Marks 6**

(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.

Viva **Marks 2**

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

SEMESTER-III
CHEMISTRY
(Major)
Course Title: (Organic Chemistry)
Course Code: MJ-T3-CHE-302
Credit: 3, Contact Hours: 45
[L=2, T=1, P=0]
Full Marks =60 IA=18 End Semester=42

Objective of the Course:

- To give the students an idea about the mechanism for organic reactions
- To make students familiar with the Synthetic Utility of active methylene Compounds
- To give the students an idea of alcohols, phenols, carbonyl compounds and their derivatives etc.

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

- The prediction of mechanism for organic reactions.
- Study of Nucleophilic Substitution reactions.
- Synthetic Utility of active methylene Compounds.
- The reactivity and stability of organic molecules based on structure.
- An idea of alcohols, phenols, carbonyl compounds and their derivatives etc

Self-study:

- Nucleophilic Substitution reactions
- Simple methods of preparation of alcohol

Unit I: Chemistry of Halogenated Hydrocarbons 12 Lectures, Marks 12

Part A

Alkyl halides: Methods of preparation including Hunsdiecker Reaction, nucleophilic substitution reactions – SN1, SN2 and SNi 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 **12 Lectures, Marks 12**

Alcohols*:* preparation, properties and relative reactivity of 1°, 2°, 3° alcohols, PDC , PCC, Bouvaelt-Blanc Reduction;

Preparation and properties of glycols: Oxidation by OsO_4 ,alkaline $KMnO_4$,, $Pb(OAc)_4$ & HIO_4, Pinacol-Pinacolone rearrangement.

Trihydric alcohols*:* Glycerol /Preparation & Properties.

Phenols*:* Acidity of phenol and factors effecting it, Ring substitution reactions, Reimer–Tiemann and Kolbe's–Schmidt Reactions, Fries and Claisen rearrangements with mechanism.

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

Unit III: Carbonyl Compounds: **15 Lectures, Marks - 14**

Part A

Structure, reactivity and preparation:

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

Part B

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

6 Lectures, Marks - 4

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.
4. Kalsi, P. S. *Textbook of Organic Chemistry 1st Ed.*, New Age International (P)Ltd. Pub.
5. Clayden, J.; Greeves, N.; Warren, S.; Wothers, P.; *Organic Chemistry*, Oxford University Press.

SEMESTER-III
CHEMISTRY
(Major)
Course Title: Chemistry Practical
General Chemistry
Course Code: MJ-P1-CHE-302
Credit: 1, Contact Hours: 30
[L=0, T=0, P=1]
Full Marks =20 IA=0 End Semester=20

Objective of the Course:
To let the students learn about the importance of Paper chromatography, TLC as separation techniques, also about the experimental methods involved in the determination of thermodynamic parameters.

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

- The importance of Paper chromatography and TLC in the Separation of components in each mixture.
- Experimental methods for the determination of thermodynamic parameters like various enthalpy changes, heat capacity etc.

Group-A **Marks 10**
(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) **Marks 8**
(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.

Viva **Marks 2**

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)DSE III
Course Title: General Chemistry (Inorganic, Organic and Physical 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

Objective of the course:

- Understanding the concept of coordination compounds, ligands, and coordination numbers.
- To provide the knowledge of different types of coordination isomerism and their implications.
- Understanding the structure, properties, and nomenclature of alkyl and aryl halides.
- To provide the knowledge of different types of halogenation reactions.
- Understanding the concepts of energy, enthalpy, and entropy.
- To provide the knowledge of Kirchhoff's equation and their applications.
- Understanding the concept of chemical equilibrium and equilibrium constant.
- To provide the knowledge of Le Chatelier's principle and its application to chemical equilibrium.

Expected Learning Outcome: Students will be able to understand:

- The concept of coordination compounds, ligands, and coordination numbers.
- Different types of coordination isomerism and their implications.
- About different types of halogenation reactions.
- Kirchhoff's equation and their applications.
- The concept of chemical equilibrium and equilibrium constant.
- About Le Chatelier's principle and its application to chemical equilibrium.

Section A: Inorganic Chemistry

Unit I: *Coordination Chemistry* ***5*** **Lectures, Marks 10**

Valence Bond Theory (VBT): IUPAC (2005) system of nomenclature. 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.

Section B: Organic Chemistry

Unit I: Alkyl and Aryl Halides **5 Lectures, Marks 10**

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.

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 $NaNH_2/NH_3$).

Section C: Physical Chemistry

Unit I: Conductance **5 Lectures, Marks 8**

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 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. 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 Guidebook 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-P1-CHE-301
Credit: 1, Contact Hours: 30
[L=0, T=0, P=1]
Full Marks =20 IA= 0 End Semester=20

***Section A: Organic Chemistry*:** **9**

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

***Section B: Physical Chemistry*:** **9**

Perform the following conductometric titrations:
a. Strong acid vs. strong base or,
b. Weak acid vs. strong base

Viva **2**

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
(Major) DSE IV
OPTION I
Course Title: (Physical Chemistry: Chemical Thermodynamics)
Course Code: DS-T2-CHE-301A
Credit: 2, Contact Hours: 30
[L=1, T=1, P=0]
Full Marks =40 IA=12 End Semester=28

Objective of the course: To make the students understand about

- Mathematical tools for the calculation of thermodynamic properties.
- The concept of free energy change and spontaneity.
- The importance of Gibbs free energy of reaction and reaction quotient in the prediction of spontaneity of chemical reactions.

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

- 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:

- Concept of Intensive and extensive variables
- Criteria of thermodynamic equilibrium, degree of advancement of reaction

Unit I: Chemical Thermodynamics **22 Lectures, Marks 20**

Zeroth law of thermodynamics.

First law of thermodynamics: 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 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.

Second Law: Concept of entropy; 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.

Unit II: Systems of Variable Composition **8 Lectures, 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.

Reference Books:

1. G. M. Barrow: Physical Chemistry Tata McGraw-Hill (2007).
2. G. W. Castellan: Physical Chemistry 4th Edn. Narosa (2004
3. Negi, A. S; Anand, S. C. A Textbook of Physical Chemistry New Age International Publishers
4. Pahari, S, Physical Chemistry Vol I &II New Central Book Agency (P) Ltd.
5. Puri, Sharma, Pathania, Principles of Physical Chemistry Vishal Publishing Co.

SEMESTER-III
CHEMISTRY
(Major) DSE IV
OPTION II

Course Title: (Physical Chemistry: Basic Computational Chemistry)

Course Code: DS-T2-CHE-301B

Credit: 2, Contact Hours: 30
[L=1, T=1, P=0]
Full Marks =40 IA=12 End Semester=28

Objective of the course: To make the students understand about

- Provide a foundational understanding of what computational chemistry is and its importance in modern chemical research.
- To teach the fundamental theories behind computational methods, including quantum mechanics, molecular mechanics, and statistical mechanics.
- To Demonstrate how computational chemistry can be used to solve real-world chemical problems.

Expected Learner Outcome: Students will gain an understanding of

- Algorithms, programming languages
- Writing simple programs in BASIC language
- Molecular modelling

Unit 1: Introduction to Computational Chemistry: 10 Lectures, Marks 8

Overview of computational chemistry, Historical development and significance, Information provided by computational chemistry.

Unit 2: Introduction to molecular modeling: 10 Lectures, Marks 10

Concepts of coordinate systems (Cartesian and Z-matrix), potential energy surface, global and local minima. Force Field (Bond stretching, Angle bending, non-bonded interactions), Ab initio methods, Hartree-Fock theory, post-Hartree-Fock methods (MP2, CI, CC), Density Functional Theory (DFT), Basic idea about Monte Carlo and Molecular dynamics simulations.

Unit 3: Introduction to computer hardware and software 10 Lectures, Marks 10

Model of a computer, Basic idea of algorithm, Input devices, output devices, storage devices, Memory, Central processing Unit, I/O unit, Elementary ideas about operating system (Windows and Linux), Programming languages: BASIC and FORTRAN. Introductory Ideas to write simple programs applicable to Chemistry: Calculate the volume of an ideal gas and van der Waals gas for given Temperature and Pressure, pH of a solution for a given H^+ ion concentration,

thermodynamic quantities of a monoatomic gas (Internal energy, heat capacity, entropy and free energy), Matrix algebra (addition and multiplication), Value of determinant.

Recommended Textbooks:

1. Computational Chemistry, Errol Lewars, Kluwer Academic Publisher
2. Fundamentals of Computers, V. Rajaraman and Neeharika Adabala, Prentice-Hall of India.
3. Understanding Molecular Simulation, Daan Frenkel, Academic Press.
4. Introduction to Computational Chemistry, Frank Jensen, John-Wiley and Sons.

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

Objective of the course:

- To give an idea about the importance of water remediation and conservation in addressing water pollution and scarcity issues, different methods and technologies used in water remediation, the principles, and applications of water treatment technologies, and to give knowledge of different water conservation techniques.

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 **15 Lectures, 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 **15 Lectures, Marks 14**

Remediation, techniques involved such as adsorption, coagulation-filtration, Nalgonda techniques, reverse osmosis, activated charcoal detoxification, applications of non-toxic oxides and mixed oxides, regeneration and recycling, mechanisms of detoxification, bioremediation, need of green chemistry, future scope.

UNIT-III: Conservation **15 Lectures, 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 textbook 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: SE-T1-CHE-301
Credit: 1, Contact Hours: 15
[L=1, T=0, P=0]
Full Marks =40 IA=12 End Semester= 28

Objective of the course:
To give students an idea about:

- The different sources of energy, including fossil fuels, renewable energy, and nuclear energy.
- The refining processes and products derived from petroleum.
- The petrochemical industry and its role in producing various chemicals and plastics.
- The role and importance of lubricants in machinery and equipment as well as their properties.

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: **2 Lectures, Marks 4**

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

Unit II: **3 Lectures, 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: **5 Lectures, 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, biogas, fuels derived from biomass, fuel from waste; synthetic fuels – gaseous and liquids.

Unit IV: **2 Lectures, Marks 4**

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

Unit V: **3 Lectures, 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.
4. Dr. Biswajit Saikia: Fuel Chemistry, Mahaveer Publication

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.

[Students will do any two experiments in the examination with 20 marks for each experiment.]

SEMESTER-IV
CHEMISTRY
(Major)DSC-V
Course Title: (Inorganic 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

Objective of the Course:

To make students understand about various oxidation states and emf of transition elements, General trends of transition elements along the periods and groups, Chemistry of Lanthanides, Actinides as well as noble gases.

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

1. Stability of various oxidation states and emf of transition elements.
2. General group trends of transition elements.
3. Chemistry of Lanthanides and Actinides.
4. Steady - state approximation in reaction mechanism.
5. Practical Importance of noble gas compounds.

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: Transition Elements **25 Lectures, Marks 20**

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 Frost diagrams). Difference between the first, second and third transition series. Chemistry of Ti, V, Cr, Mn, Fe and Co in various oxidation states (excluding their metallurgy)

Unit II: Lanthanoids and Actinoids **10 Lectures, Marks 10**

Electronic configuration, oxidation states, colour, spectral and magnetic properties, Lanthanide contraction and its consequences, separation of lanthanides, Complex formation by Lanthanides and actinides.

Unit III: Noble Gases **10 Lectures, 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 b ond treatment and MO treatment for XeF2). Molecular shapes of noble gas compounds (VSEPR theory).

Unit IV: Nuclear Chemistry: **15 Lectures, Marks: 16**

Nuclear structure, Mass defect, Packing Fraction, Binding energy and stability of nuclei, Nuclear transmutations and Artificial radioactivity, Laws of radioactive decay, Nuclear reactions including fission and fusion reactions, Nuclear reactor and its components, Measurement of radioactivity, Analytical applications of Nuclear Reactions and Radioactive tracers - in **s**tudying reaction mechanism, in diagnosis and treatment of diseases, in industry, in agriculture, in analytical chemistry, in determination of the age of the earth by rock dating method and determination of the age of recent objects by radio carbon dating method.

Recommended Textbooks:

1. Inorganic Chemistry, Shriver & Atkins, 5th Edition Oxford
2. Inorganic Chemistry, W.W. Porterfield, 2nd Edition, Academic Press
3. Inorganic Chemistry: Principles of structure and reactivity, 4th Edition; J.E. Huheey, E.A. Keiter, R.L. Keiter, O.K. Medhi

SEMESTER-IV
CHEMISTRY
(Major)DSC-VI
Course Title: (Organic 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

Objective of the course:

To give students an idea about the reactivity and stability of Carboxylic Acids, Sulphur compounds and their derivatives, the methods of structure elucidation of alkaloids and terpenoids as well as the importance of pharmaceutical chemistry.

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

i. The reactivity and stability of Carboxylic Acids.
ii. An idea of Sulphur compounds and their derivatives.
iii. Methods of structure elucidation of alkaloids and terpenoids
iv. Health, disease, and modern medicine in biological chemistry.

Self-study:

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

Unit I: Carboxylic Acids and their Derivatives: 20 Lectures, Marks 16

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 II: Sulphur containing compounds: 5 Lectures, Marks 6

Preparation and reactions of thiols, thioethers and sulphonic acids.

Unit III: Alkaloids 10 Lectures, Marks 12

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 IV: Terpenes **5 Lectures, Marks 6**

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

Unit V: Pharmaceutical Compounds: Structure and Importance: 20 Lectures, Marks - 16

Classification, structure, and therapeutic uses of antipyretics: Paracetamol (with synthesis), Analgesics: Ibuprofen (with synthesis), Antimalarials: Antacids: Ranitidine; Antibacterial: Providone—Iodine Solution, Synthesis, and mode of action of Suphanilamides and other Sulphadrugs (sulphapyridine, sulphathiazole) Chloroquine (with synthesis). An elementary treatment of Antibiotics and detailed study of chloramphenicol, Medicinal values of curcumin (Haldi), azadirachtin (neem), vitamin C.

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.
4. Kalsi, P. S. *Textbook of Organic Chemistry 1st Ed.*, New Age International (P)Ltd. Pub.
5. Clayden, J.; Greeves, N.; Warren, S.; Wothers, P.; *Organic Chemistry*, OxfordUniversity Press.
6. Singh, J.; Ali, S.M. & Singh, J. *Natural Product Chemistry*, Prajati Parakashan (2010).

SEMESTER-IV
CHEMISTRY
(Major)DSC-VII
Course Title: (Physical Chemistry)
Course Code: MJ-T4-CHE-403
Credit: 4, Contact Hours: 60
[L=3, T=1, P=0]
Full Marks =80 IA=24 End Semester=56

Objective of the course:
To give the students an idea about the different types of catalysts, enzyme catalysis, Steady State Approximation as well as the Concept of phases, phase diagrams for systems of solid- liquid equilibria involving eutectic, congruent and incongruent melting points, solid solution etc.

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

1. Types of catalysis, Michaelis – Menten mechanism, mechanism of catalysed reaction at solid state.
2. Steady - state approximation in reaction mechanism.
3. Concept of phases, phase diagrams for systems of solid- liquid equilibria involving eutectic, congruent and incongruent mp, solid solution etc

Unit I: Chemical Kinetics 18 Lectures, Marks 20

Order and molecularity 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 second order reactions 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, Explosion Limits. Temperature dependence of reaction rates; Arrhenius equation; activation energy. Collision theory of reaction rates, Lindemann mechanism

Unit II: Solutions and Colligative Properties 18 Lectures, Marks 15

Dilute solutions; lowering of vapour pressure, Raoult's and Henry's Laws and their applications. 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. Van't Hoff Factor.

Unit III: Surface Chemistry:

Catalysis **12 Lectures, Marks-10**

Types of catalyst, specificity and selectivity, mechanisms of catalyzed reactions at solid surfaces; Homogeneous and Heterogeneous Catalytic reactions, Enzyme catalysis, Michaelis-Menten mechanism, acid-base catalysis.

Adsorption **12 Lectures, Marks - 11**

Physical adsorption, chemisorption, adsorption isotherms. Freundlich and Langmuir adsorption isotherms, Determination of surface area of adsorbents using Langmuir adsorption isotherm, Applications of adsorptions.

Reference Books:

1. G. M. Barrow: Physical Chemistry Tata McGraw-Hill (2007).
2. G. W. Castellan: Physical Chemistry 4th Edn. Narosa (2004)
3. Chemical Kinetics – K. J. Laidler, Pearson Education India.
4. Physical Chemistry of Surfaces – A. W. Adamson, Wiley India Pvt. Ltd.
5. Physical Chemistry – P.W. Atkins, Oxford University Press.

SEMESTER-IV
CHEMISTRY
(Major)
Course Title: Chemistry Practical
(General Chemistry)
Course Code: MJ-P4-CHE-401A
Credit: 4, Contact Hours: 120
[L=0, T=0, P=4]
Full Marks =80 IA=0 End Semester=80

Inorganic

A. Gravimetric Analysis: **Marks 18**

i. Estimation of nickel(ii) using Dimethylglyoxime
ii. Estimation of copper as CuSCN
iii. Estimation of iron as Fe_2O_3 by precipitating iron as $Fe(OH)_3$

B. Inorganic Preparation: **Marks 18**

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

Physical **Marks 18**

i. Study the kinetics of acid hydrolysis of methyl acetate with hydrochloric acid. (Integrated rate method)
ii. Saponification of ethyl acetate.
iii. Verify the Freundlich and Langmuir isotherms for adsorption of acetic acid/oxalic acid on activated charcoal.

Organic

Organic preparations: Marks 18

a. 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:
Using conventional method, Using green approach.
b. 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.
c. Oxidation of ethanol/ isopropanol (Iodoform reaction).
d. Nitration of the following:
Acetanilide/nitrobenzene by conventional method
Salicylic acid by green approach (using ceric ammonium

nitrate).

e. Benzil-Benzilic acid rearrangement.

Viva **Marks 8**

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.

vii. Mann, F.G. & Saunders, B.C. *Practical Organic Chemistry*, Pearson Education (2009)

viii. Furniss, B.S.; Hannaford, A.J.; Smith, P.W.G.; Tatchell, A.R. *Practical Organic Chemistry, 5th Ed.*, Pearson (2012)

ix. Ahluwalia, V.K. & Aggarwal, R. *Comprehensive Practical Organic Chemistry: Preparation and Quantitative Analysis,* University Press (2000).

x. Ahluwalia, V.K. & Dhingra, S. *Comprehensive Practical Organic Chemistry: Qualitative Analysis,* University Press (2000)

SEMESTER-IV
CHEMISTRY
(Major)
Course Title: Chemistry Practical
(Computational Chemistry Practical I)
Course Code: MJ-P4-CHE-401B
Credit: 4, Contact Hours: 120
[L=0, T=0, P=4]
Full Marks =80 IA=0 End Semester=80

A. Use of molecular graphics programme like AVOGADRO, ARGUSLAB, PCMODEL (Serena software series) in the construction of molecular models, generation of gaussian input files.

B. Handling of Gaussian programme for optimization and the determination of molecular parameters like electronic energy, bond distances, dipole moments, quadruple moments, Point Groups, Mulliken Charges, Frontier orbitals and their energies etc. Visualization of molecules using visualization software.

C. Use of Gaussian in the study of
   i. Simple molecules like CH_4, C_2H_6, H_2O, BF_3, C_6H_6, NH_3, H_3O+, BF_4 etc.
   ii. Study of reactive intermediates and their stability orders.
   iii. Thermochemical calculations, enthalpy, entropy, and Gibbs free energy. Determination of enthalpy of formation, enthalpy of combustions of molecules like CH_4, C_2H_6, Benzene and comparison of the results with the experimental results.
   iv. Binding energies of molecules.
   v. Comparation of results in the *ab initio* Hartee-Fock and Density functional theory methods using different basis sets.
   vi. Effect of conjugation on the stabilities of molecules. Hence the study of possible absorptions of molecules in the UV-Visible region.
   vii. Correlated calculations using MP2 and CCSD for small molecules.

Recommended Books:

1. Essentials of Computational Chemistry: Theories and Models by Christopher J. Cramer.
2. Exploring chemistry with electronic structure methods: a guide to using Gaussian by Foresman, James B.

SEMESTER-V
CHEMISTRY
(Major)DSC-VIII
Course Title: (Inorganic Chemistry)
Course Code: MJ-T5-CHE-501
Credit: 5, Contact Hours: 75
[L=4, T=1, P=0]
Full Marks =100 IA=30 End Semester=70

Objective of the Course: To give the students an idea about:

- The fundamental concepts of coordination chemistry include ligands, coordination numbers, and coordination spheres.
- The nomenclature and structural types of coordination compounds.
- CFSE, chelate effect, and steric considerations.
- Methods of preparation of inorganic polymers and the factors influencing their properties.
- The mechanisms of metal ion transport and storage in biological systems.

Expected learning Outcome:

The Contents of the syllabus will enable students to

1. Comprehend the fundamental concepts of coordination chemistry, including ligands, coordination numbers, and coordination spheres.
2. Learn the nomenclature and structural types of coordination compounds.
3. Understand and apply crystal field theory (CFT) and ligand field theory (LFT) to describe the bonding and properties of coordination compounds.
4. Understand the factors affecting the stability of coordination compounds, such as Crystal field stabilization energy (CFSE), chelate effect, and steric considerations.
5. Understand the structural features of inorganic polymers, including chain and network structures.
6. Gain knowledge of the synthesis methods of inorganic polymers and the factors influencing their properties.
7. Understand the essential roles of metal ions in biological systems, including structural, catalytic, and regulatory functions.
8. Learn about the mechanisms of metal ion transport and storage in biological systems.

Unit I: Coordination Chemistry I **15 Lectures, Marks 16**

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.

Unit II: Coordination Chemistry II **15 Lectures, Marks 15**

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 III: Inorganic Polymers **15 Lectures, Marks 12**

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

Unit IV: Bioinorganic Chemistry I **20 Lectures, Marks 15**

Metal ion present in biological systems, classification of elements according to their action in biological system. Geo chemical effect on distribution of metals. Sodium/ K-pump, carbonic anhydrase and carboxypeptidase. Excess and deficiency of some trace metals. Toxicity of metal ions (Hg, Pb, Cd and As), reasons for toxicity, use of chelating agents in medicine. Iron and its application in bio-systems, Haemoglobin, storage and transfer of iron.

Unit V: Theoretical Principles in Qualitative Analysis (H_2S Scheme) Lecture 10, Marks 12

Basic principles involved in analysis of cations and anions and solubility products, common ion effect. Principles involved in separation of cations into groups and choice of group reagents. Interfering anions (fluoride, borate, oxalate and phosphate) and need to remove them after Group II**.**

Recommended Textbooks:

1. Bioinorganic Chemistry by K. Hussain Reddy, New Age International Publisher.
2. The Inorganic Chemistry of Biological Processes, Hughes, M.N., 2nd edition, Wiley (1981)
3. Bio-coordination Chemistry, D.E. Fenton, Oxford University Monograph Series 1995.
4. Inorganic Chemistry, Gary L.Miessler & Donald A. Tarr 3rd Ed, Pearson
5. Inorganic Chemistry, C.E. Housecraft & A.G. Sharpe, 2nd Ed, Pearson
6. Huheey, J.E., Inorganic Chemistry, Prentice Hall,1993
7. Cotton, F.A. & Wilkinson,G, Advanced Inorganic Chemistry, 5th Ed. Wiley-VCH,1999
8. Greenwood, N.N. & Earnshaw A., Chemistry of Elements, Butterworth-Heinemann,1977
9. Atkin, P. Shriver & Atkins' Inorganic Chemistry 5th Ed. Oxford University Press (2010).
10. R. Sarkar. General Inorganic Chemistry (Part-2), New Central Book Agency(P) Ltd.

SEMESTER-V
CHEMISTRY
(Major)DSC-IX
Course Title: (Organic Chemistry)
Course Code: MJ-T4-CHE-502
Credit: 4, Contact Hours: 60
[L=3, T=1, P=0]
Full Marks =80 IA=24 End Semester=56

Objective of the Course: To develop the knowledge on the preparation and properties of different classes nitrogen containing compounds. Emphasis is given to polymers and heterocyclic compounds of both synthetic and natural origin.

Expected Learner Outcome: Students will gain an understanding of
i. Preparation and properties of different classes nitrogen containing compounds.
ii. Preparation of Heterocyclic compounds, polynuclear hydrocarbons
ii. Biodegradable polymer and applications.

Unit I: Nitrogen Containing Functional Groups **15 Lectures, Marks - 16**

Preparation and important reactions of nitro and nitrite compounds, nitriles and isonitriles
Amines: Effect of substituent and solvent on basicity; Preparation and properties: Gabriel phthalimide synthesis, Hoffmann degradation, Carbylamine reaction, Mannich reaction; Distinction between 1°, 2° and 3° amines with Hinsberg reagent and nitrous acid, Libbermann Test.

Diazonium Salts: Preparation and their synthetic applications.
Diazomethane & Diazoacetic Ester with synthetic application.

Unit II: Polynuclear Aromatic Hydrocarbons **12 Lectures, Marks - 12**
Preparation and structure elucidation & Reactions of Polynuclear hydrocarbons: naphthalene phenanthrene and anthracene, and important derivatives of naphthalene and anthracene.

Unit III:
Heterocyclic Compound **20 Lectures, Marks - 16**
Classification and nomenclature, Structure, aromaticity in 5-numbered and 6-membered ring containing one heteroatom; Synthesis, reactions and mechanism of substitution reactions of Furan, Pyrrole (Paal-Knorr synthesis, Knorr pyrrole synthesis, Hantzsch synthesis),Thiophene,
Derivatives of furan: Furfural and furoic acid. Pyridine (Hantzsch synthesis), Pyrimidine, Indole (Fischer indole synthesis and Madelung synthesis), Quinoline and isoquinoline (Skraup synthesis, Friedlander's synthesis).

Unit IV: Polymers **13 Lectures, Marks - 12**

Introduction and classification of polymers.

Polymerisation reactions -Addition and condensation -Mechanism of cationic, anionic and free radical addition polymerization; Ziegler-Natta polymerisation of alkenes; Preparation and applications of plastics – thermosetting (phenol-formaldehyde, Polyurethanes) and thermos softening (PVC, polythene); Fabrics – natural and synthetic (acrylic, polyamido, polyester); Rubbers – natural and synthetic: Buna-S, Chloroprene and Neoprene; Vulcanization; Polymer additives; Biodegradable polymers with examples.

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. Finar, I. L. *Organic Chemistry* (*Volume 2: Stereochemistry and the Chemistry ofNatural Products*), Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).

4. Acheson, R.M. *Introduction to the Chemistry of Heterocyclic compounds,* JohnWiley & Sons (1976).

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

6. Kalsi, P. S. *Textbook of Organic Chemistry 1st Ed.*, New Age International (P)Ltd. Pub.

7. Clayden, J.; Greeves, N.; Warren, S.; Wothers, P.; *Organic Chemistry*, OxfordUniversity Press.

SEMESTER-V
CHEMISTRY
(Major)DSC-X
Course Title: (Physical Chemistry)
Course Code: MJ-T4-CHE-503
Credit: 4, Contact Hours: 60
[L=3, T=1, P=0]
Full Marks =80 IA=24 End Semester=56

Objective of the Course: To develop the basic knowledge of electrochemistry, various laws governing electro chemical process and their application.

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

i. Quantitative aspects of Faraday's laws of electrolysis
ii. Application of conductance measurement
iii. Concept of phases, phase diagrams for systems of solid- liquid equilibria involving eutectic, congruent, and incongruent melting point, solid solution etc

Unit I: Conductance **20 Lectures, Marks - 20**

Conductivity, equivalent and molar conductivity, and their variation with dilution for weak and strong electrolytes. Molar conductivity at infinite dilution. Kohlrausch law of independent migration of ions. Debye-Hückel-Onsager equation, Wien effect, Debye-Falkenhagen effect, Walden's rules.

Ionic velocities, mobilities and their determinations, transference numbers and their relation to ionic mobilities, determination of transference numbers using Hittorf and Moving Boundary methods. Applications of conductance measurement: (i) degree of dissociation of weak electrolytes, (ii) ionic product of water (iii) solubility and solubility product of sparingly soluble salts, (iv) conductometric titrations, and (v) hydrolysis constants of salts.

Unit II: Electrochemistry **20 Lectures, Marks - 20**

Quantitative aspects of Faraday's laws of electrolysis, rules of oxidation/reduction of ions based on half-cell potentials. Reversible and irreversible cells with examples. Electromotive force of a cell and its measurement, Nernst equation; Standard electrode (reduction) potential and its application to different kinds of half-cells. Application of EMF measurements in determining (i) free energy, enthalpy and entropy of a cell reaction, (ii) equilibrium constants, and (iii) PH values, using hydrogen, quinone-hydroquinone. Concentration cells with and without transference, liquid junction potential; determination of activity coefficients and transference numbers. Qualitative discussion of potentiometric titrations (acid-base, redox, precipitation).

Unit I: Phase Equilibria **20 Lectures, Marks - 16**

Concept of phases, components and degrees of freedom, derivation of Gibbs Phase Rule for nonreactive and reactive systems; Clausius-Clapeyron equation and its applications to solid liquid, liquid-vapour and solid-vapour equilibria, phase diagram for one component systems, with applications. Phase diagrams for systems of solid-liquid equilibria involving eutectic, congruent and incongruent melting points, solid solutions. Three component systems, water-chloroform-acetic acid system, triangular plots. *Binary solutions:* Gibbs-Duhem-Margules equation, its derivation, and applications to fractional distillation of binary miscible liquids (ideal and nonideal), azeotropes, lever rule, Steam distillation. Nernst distribution law: its derivation and applications, partial miscibility of liquids, CST.

Recommended Textbooks:

1. Atkins, P.W & Paula, J.D. Physical Chemistry, 9th Ed., Oxford University Press (2011).
2. Castellan, G. W. Physical Chemistry 4th Ed., Narosa (2004).
3. Mortimer, R. G. Physical Chemistry 3rd Ed., Elsevier: NOIDA, UP (2009).
4. Barrow, G. M., Physical Chemistry 5th Ed., Tata McGraw Hill: New Delhi (2006).
5. Engel, T. & Reid, P. Physical Chemistry 3rd Ed., Prentice-Hall (2012).
6. Rogers, D. W. Concise Physical Chemistry Wiley (2010).
7. Silbey, R. J.; Alberty, R. A. & Bawendi, M. G. Physical Chemistry 4th Ed., John Wiley & Sons, Inc. (2005).
8. Negi,A.S; Anand,S.C. A Textbook of Physical Chemistry New Age International Publishers
9. Puri,Sharma,Pathiana Principles of Physical Chemistry Vishal Publishing Co

SEMESTER-V
CHEMISTRY
(Major) DSE VI
Option I
Course Title: Chemistry Practical
(General Chemistry)
Course Code: DS-P3-CHE-501A
Credit: 3, Contact Hours: 90
[L=0, T=0, P=3]
Full Marks =60 IA=0 End Semester=60

Group A: Physical Chemistry (Marks 18)

Conductometry

- Perform the following conductometric titrations:
  i. Strong acid vs. strong base
  ii. Weak acid vs. strong base
  iii. Mixture of strong acid and weak acid vs. strong base
  iv. Strong acid vs. weak base

Potentiometry

- Perform the following potentiometric titrations:
  i. Strong acid vs. strong base
  ii. Weak acid vs. strong base
  iii. Dibasic acid vs. strong base
  iv. Potassium dichromate vs. Mohr's salt

Phase Equilibrium

- Determination of critical solution temperature and composition of the phenol-water system and to study the effect of impurities on it.
- Distribution of acetic/ benzoic acid between water and cyclohexane.

Group B: Inorganic Chemistry (Marks 18)

- **Qualitative Inorganic Analysis:**

Qualitative analysis of mixtures containing 2 anions and 3 cations. Emphasis should be given to the understanding of the chemistry of different reactions. The following radicals are suggested: NO2-, S2-, SO32-, S2O32-, CH3COO-, F-, Cl-, Br-, I-, NO3-, BO33-, C_2O4_2-,PO_43-, NH4+, K+, Pb2+, Cu2+, Cd2+, Bi3+, Sn2+, Sb3+, Fe3+, Al3+, Cr3+, Zn2+, Mn2+,Co2+, Ni2+, Ba2+, Sr2+, Ca2+, Mg2+Mixtures should preferably contain one interfering anion, or insoluble component e.g., BaSO4, SrSO4, PbSO4, CaF2 or Al2O3 or combination of anions e.g. CO32- and SO32- ,NO2- and NO3
-, Cl- and Br-, Cl- and I-, B- rand I-, NO3- and Br-, NO3- and I-.

Group C: Organic Chemistry (Marks 18)

1. Estimation of glycine by Sorenson's formalin method.
2. Study of the titration curve of glycine.
3. Estimation of proteins by Lowry's method.
4. Study of the action of salivary amylase on starch at optimum conditions.
5. Effect of temperature on the action of salivary amylase.
6. Saponification value of an oil or a fat.
7. Determination of Iodine number of an oil/ fat.
8. Isolation and characterization of DNA from onion/ cauliflower/peas.

Viva **Marks 6**

Recommended Textbooks:

1. Khosla, B. D.; Garg, V. C. & Gulati, A. Senior Practical Physical Chemistry,

R. Chand & Co.: New Delhi (2011).

2. Garland, C. W.; Nibler, J. W. & Shoemaker, D. P. Experiments in Physical Chemistry, 8th Ed.; McGraw-Hill: New York (2003).

3. Halpern, A. M. & McBane, G. C. Experimental Physical Chemistry 3rd Ed.; W.H.

Freeman & Co.: New York (2003).

4. Yadav, J.B., Advanced Practical Physical Chemistry 32nd Ed; Goel Publishing Hours

SEMESTER-V
CHEMISTRY
(Major) DSE VI
Option II
Course Title: Computational Chemistry Practical II
Course Code: DS-P3-CHE-501B
Credit: 3, Contact Hours: 90
[L=0, T=0, P=3]
Full Marks =60 IA=0 End Semester=60

A. Tools and techniques for data analysis and visualization in computational chemistry. Visualization of molecular structures, orbitals, and electron densities using software like VMD, Gauss view, Avogadro.
B. Mapping PES and transition state search for simple reactions
C. Solvent effect on molecular properties using implicit solvation models (PCM, COSMO)
D. Computational prediction of IR, UV-Vis, NMR spectra and comparison with experimental data.
E. Basics of molecular docking, scoring functions, and applications in drug design. Performing docking studies using AutoDock or similar software.
F. Applications of computational chemistry in materials science and nanotechnology. Simulating properties of materials and nanostructures.
G. Independent project involving computational study of a chosen chemical problem.

Recommended Books:

1. Introduction to Computational Chemistry by Frank Jensen, WILEY.
2. Practical Aspects of Computational Chemistry: Methods, Concepts and Applications edited by Jerzy Leszczynski and Manoj K. Shukla, SPRINGER
3. Essentials of Computational Chemistry: Theories and Models, 2nd Edition, By Christopher J. Cramer, WILEY.

SEMESTER-V
CHEMISTRY
(Major) INTERNSHIP
Course Title: INTERNSHIP
Course Code: MJ-P4-CHE-501
Credit: 4, Contact Hours: 120
[L=0, T=0, P=4]
Full Marks =80 IA=0 End Semester=80

Objective of the Course:

4. To give the students an insight into the chemical industry, learning safety practices and industry trends.
5. To give the students an opportunity to collaborate on research projects.
6. To develop the sense of increased self-esteem, self-efficacy, and confidence in their skills and knowledge.

Expected Learning Outcomes:

1. Students will gain insights into the chemical industry, learning safety practices and industry trends.
2. Students will get opportunities to collaborate on research projects. Developing strong collaboration skills enhances teamwork and ensures the efficient completion of scientific investigations.
3. Internships contribute to personal development. Students will experience increased self-esteem, self-efficacy, and confidence in their skills and knowledge.

Completion of Internship Project	**Marks 10**
[Internship Completion Certificate to be provided]	
Submission of Report of the internship project work	**Marks 50**
Distribution of Marks in the Report:	
[Objective of the Internship Project	Marks 10
About the Works/Responsibilities/Tasks/Experiments done	Marks 10
Challenges and Problem-Solving	Marks 10
Skills Developed	Marks 10
Conclusion	Marks 10]
Oral Presentation/Viva	**Marks 20**

[Students will go for internships immediately after their Semester Examinations including Semester brakes.]

SEMESTER-VI
CHEMISTRY
(Major)DSC-XI
Course Title: (Inorganic Chemistry)
Course Code: MJ-T5-CHE-601
Credit: 5, Contact Hours: 75
[L=4, T=1, P=0]
Full Marks =100 IA=30 End Semester=70

Objective of the Course:
To give the students an idea about different kinds of organometallic compounds, the 18-electron rule, bonding and structure of key organometallic complexes, common reactions of organometallic compounds, mechanisms of catalytic processes and the role of organometallic intermediates.

Expected Learning Outcome:
The chapter will enable students to

1. Comprehend the definition and classification of organometallic compounds, including the nature of metal-carbon bonds.
2. Understand the 18-electron rule and its application to organometallic compounds.
3. Learn about the bonding and structure of key organometallic complexes.
4. Understand the common reactions of organometallic compounds, including oxidative addition, reductive elimination, migratory insertion, and β-hydride elimination.
5. Understand the mechanisms of these catalytic processes and the role of organometallic intermediates.

Unit I: Reaction Kinetics and Mechanism I **25 Lectures, Marks 20**
Introduction to inorganic reaction mechanisms. Substitution reactions in square planar complexes, Trans-effect, theories of trans-effect, mechanism of nucleophilic substitution in square planar complexes, Thermodynamic and kinetic stability, kinetics of octahedral substitution, ligand field effects and reaction rates, Mechanism of substitution in octahedral complexes.

Unit II: Organometallic compounds **25 Lectures, Marks 25**
Definition and classification of organometallic compounds based on bond type. Concept of hapticity of organic ligands.

Metal carbonyls: 18 electron rules, electron count of mononuclear, polynuclear and substituted metal carbonyls of 3d series. General methods of preparation (direct combination, reductive carbonylation, thermal and photochemical decomposition) of mono and binuclear carbonyls of 3d series. Structures of mononuclear and binuclear carbonyls of Cr, Mn, Fe,Co and Ni using VBT.

π-acceptor behavior of CO (MO diagram of CO to be discussed), synergic effect and use of IR data to eplain extent of back bonding.

Zeise's salt: preparation and structure, evidence of synergic effect and comparison of synergic effect with that in carbonyls.

Metal Alkyls: Important structural features of methyl lithium (tetramer) and trialkyl aluminium (dimer), concept of multicentre bonding in these compounds. Role of triethylaluminium in polymerization of ethane (Ziegler-Natta Catalyst). Species present in ether solution of Grignard reagent and their structures, Schlenk equilibrium.

Ferrocene: Preparation and reactions (acetylation, alkylation, metallation, Mannich condensation). Structure and aromaticity. Comparison of aromaticity and reactivity with that of benzene.

Unit III: Catalysis by Organometallic Compounds 10 Lectures, Marks 10

Study of the following industrial processes and their mechanism

1. Alkene hydrogenation (Wilkinson's Catalyst)
2. Hydroformylation (Co salts)
3. Wacker Process
4. Synthetic Gasoline (Fisher Tropsch reaction)
5. Synthesis gas by metal carbonyl complexes

Unit IV: Clusters Lecture 15, Marks 15

Definition of clusters, Low and high nuclearity metal carbonyl and metal halide clusters, bimetallic clusters. Closed shell electronic requirements for cluster compounds, introduction to tensor surface harmonic theory of clusters. Organization of neutral boron hydrides, anionic borane, carboranes and metallocarboranes. Synthesis and properties of C60.

Textbooks Recommended:

1. Vogel, A. I. Qualitative Inorganic Analysis, Longman, 1972.
2. Svehla, G. Vogel's Qualitative Inorganic Analysis, 7th Ed., Prentice Hall.
3. Cotton, F. A. G.; Wilkinson & Gaus, P. L. Basic Inorganic Chemistry 3rd Ed.; Wiley India,
4. Huheey, J. E.; Keiter, E. A. & Keiter, R. L. Inorganic Chemistry, Principles of Structure and Reactivity 4th Ed., Harper Collins 1993, Pearson, 2006.
5. Sharpe, A. G. Inorganic Chemistry, 4th Indian Reprint (Pearson Education) 2005
6. Douglas, B. E.; McDaniel, D. H. & Alexander, J. J. Concepts and Models in Inorganic Chemistry 3rd Ed., John Wiley and Sons, NY, 1994.
7. Greenwood, N. N. & Earnshaw, A. Chemistry of the Elements, Elsevier 2nd Ed, 1997 (Ziegler Natta Catalyst and Equilibria in Grignard Solution).
4. Lee, J. D. Concise Inorganic Chemistry 5th Ed., John Wiley and sons 2008.

5. Powell, P. Principles of Organometallic Chemistry, Chapman and Hall, 1988.
6. Shriver, D. D. & P. Atkins, Inorganic Chemistry 2nd Ed., Oxford University Press, 1994.
7. Basolo, F. & Person, R. Mechanisms of Inorganic Reactions: Study of Metal Complexes in Solution 2nd Ed., John Wiley & Sons Inc; NY.
8. Purcell, K. F. & Kotz, J. C., Inorganic Chemistry, W. B. Saunders Co. 1977
9. Miessler, G. L. & Donald, A. Tarr, Inorganic Chemistry 4th Ed., Pearson, 2010.
10. Collman, James P. et al. Principles and Applications of Organotransition Metal Chemistry. Mill Valley, CA: University Science Books, 1987.
11. Crabtree, Robert H. The Organometallic Chemistry of Transition Metals. New York, NY: John Wiley, 2000.
12. B.K. Sharma: Industrial Chemistry, Goel Publishing House, Meerut.

SEMESTER-VI
CHEMISTRY
(Major)DSC-XII
Course Title: (Organic Chemistry)
Course Code: MJ-T4-CHE-602
Credit: 4, Contact Hours: 60
[L=3, T=1, P=0]
Full Marks =80 IA=24 End Semester=56

Objective of the Course: To acquire knowledge in organic synthesis, retro synthesis, and to understand biochemistry.

Expected Learner Outcome: Students will gain an understanding of ---
i. i. Application of UV, IR, NMR spectroscopy, mass spectra in organic molecules
ii. Biological importance of carbohydrates
iii. Colour and constitution of dyes and applications of different dyes.
ii. The chemical properties of amino acids and peptides.
iii. Enzyme kinetics, chemical logic of metabolism

Unit I: Organic Spectroscopy **12 Lectures, Marks - 12**
General principles Introduction to absorption and emission spectroscopy.
UV Spectroscopy: Types of electronic transitions, λmax, Chromophores and Auxochromes, Bathochromic and Hypsochromic shifts, Intensity of absorption; distinction between cis and trans isomers.
IR Spectroscopy: IR absorption positions of O, and N containing functional groups; Effect of H-bonding, conjugation, resonance, and ring size on IR absorptions; Fingerprint region and its significance.
NMR Spectroscopy: Basic principles of Proton Magnetic Resonance, chemical shift and Interpretation of NMR spectra of simple compounds.

Applications of IR, UV, and NMR for identification of simple organic molecules.

Unit II: Dyes **8 Lectures, Marks - 8**
Classification, Colour and constitution; **Mordant and Vat Dyes**; Chemistry of dyeing; Synthesis and applications of: **Azo dyes** – Methyl Orange and Congo Red; **Triphenyl Methane Dyes** - Malachite Green, and Crystal Violet; **Phthalein Dyes** – Phenolphthalein and Fluorescein; **Natural dyes** –synthesis of Alizarin and Indigotin; Edible Dyes with examples.

Unit III: Amino Acids, Peptides, Proteins and Nucleic Acids 8 Lectures, Marks - 8

Amino acids, Peptides and their classification. α-Amino Acids - Synthesis, ionic properties and reactions. Zwitterions, p*K*a values, isoelectric point, and Study of peptides: methods of peptide synthesis. Structure of DNA (Watson &Model) and RNA, Genetic Code, Replication, Transcription and Translation (elementary idea only

Unit IV: Enzymes 8 Lectures, Marks -8

Introduction, classification, and characteristics of enzymes. Mechanism of enzyme action (taking trypsin as example), factors affecting enzyme action, coenzymes and cofactors, specificity of enzyme action (including stereo specificity), enzyme inhibitors and their importance.

Unit V: Lipids 8 Lectures, Marks - 8

Introduction to oils and fats; common fatty acids present in oils and fats, Hydrogenation of fats and oils, Saponification value, acid value, iodine number. Reversion and rancidity.

Unit VI: Carbohydrates 16 Lectures, Marks - 10

Occurrence, classification and their biological importance.

Monosaccharides: Constitution and absolute configuration of glucose and fructose, epimersand anomers, mutarotation, Ring structure of glucose and fructose, Haworth projections and conformational structures; Ascending and descending in monosaccharide; Interconversions of aldoses and ketoses; Killiani- Fischer synthesis and Ruff degradation

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. Finar, I. L. *Organic Chemistry* (*Volume 2: Stereochemistry and the Chemistry ofNatural Products*), Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).

4. Acheson, R.M. *Introduction to the Chemistry of Heterocyclic compounds,* JohnWiley & Sons (1976).

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

6. Kalsi, P. S. *Textbook of Organic Chemistry 1st Ed.*, New Age International (P)Ltd. Pub.

7. Clayden, J.; Greeves, N.; Warren, S.; Wothers, P.; *Organic Chemistry*, OxfordUniversity Press.

8. Singh, J.; Ali, S.M. & Singh, J. *Natural Product Chemistry*, PrajatiParakashan(2010).

SEMESTER-VI
CHEMISTRY
(Major)DSC-XIII
Course Title: (Physical Chemistry)
Course Code: MJ-T4-CHE-603
Credit: 4, Contact Hours: 60
[L=3, T=1, P=0]
Full Marks =80 IA=24 End Semester=56

Objective of the Course: To make the students familiar with the various aspects of photo chemistry and quantum chemistry.

Expected Learner Outcome: Students will gain an understanding of

i. The difference between classical and quantum mechanics
ii. Qualitative treatment of hydrogen atom and hydrogen like ions.
iii. Interpretation of Spectra

Unit I: Quantum Chemistry-I **30 Lectures, Marks-28**

Background of quantum mechanics, Postulates of quantum mechanics, quantum mechanical operators, Angular momentum: Commutation rules.

Schrödinger equation and its application to free particle and "particle-in-a-box" (rigorous treatment), quantization of energy levels, zero-point energy and Heisenberg Uncertainty principle; wavefunctions, probability distribution functions, nodal properties, Extension to two- and three-dimensional boxes, separation of variables, degeneracy.

Qualitative treatment of simple harmonic oscillator model of vibrational motion: Setting up of Schrödinger equation and discussion of solution and wavefunctions. Vibrational energy of diatomic molecules and zero-point energy.

Rigid rotator model of rotation of diatomic molecule. Schrödinger equation, transformation to spherical polar coordinates.

Qualitative treatment of hydrogen atom and hydrogen-like ions: setting up of Schrödinger equation in spherical polar coordinates, radial part, quantization of energy (only final energy expression).

Unit II: Molecular Spectroscopy-I **30 Lectures, Marks-28**

Interaction of electromagnetic radiation with molecules and various types of spectra.
Rotation spectroscopy: Selection rules, intensities of spectral lines, determination of bond lengths of diatomic and linear triatomic molecules, isotopic substitution.

Vibrational spectroscopy: Classical equation of vibration, computation of force constant, amplitude of diatomic molecular vibrations, anharmonicity, Morse potential, dissociation energies, fundamental frequencies, overtones, hot bands, degrees of freedom for polyatomic molecules, modes of vibration, concept of group frequencies.

Electronic spectroscopy: Franck-Condon principle, electronic transitions, singlet and triplet states, fluorescence and phosphorescence, dissociation and predissociation, calculation of electronic transitions of polyenes using free electron model.

Nuclear Magnetic Resonance (NMR) spectroscopy: Principles of NMR spectroscopy, Larmor precession, chemical shift and low-resolution spectra, different scales, spin-spin coupling and high-resolution spectra, interpretation of PMR spectra of organic molecules.

Recommended Textbooks:

1. Banwell, C. N. & McCash, E. M. Fundamentals of Molecular Spectroscopy 4th Ed.

   Tata McGraw-Hill: New Delhi (2006).

2. Chandra, A. K. Introductory Quantum Chemistry Tata McGraw-Hill (2001).

3. House, J. E. Fundamentals of Quantum Chemistry 2nd Ed. Elsevier: USA (2004).

4. Lowe, J. P. & Peterson, K. Quantum Chemistry, Academic Press (2005).

5. Kakkar, R. Atomic & Molecular Spectroscopy, Cambridge University Press (2015).

6. Sen,B.K. Quantum Chemistry including Spectroscopy Kalyani Publishers.

SEMESTER-VI
CHEMISTRY
(Major) DSC XIV
Course Title: Chemistry Practical
(General Chemistry)
Course Code: MJ-P4-CHE-601
Credit: 4, Contact Hours: 120
[L=0, T=0, P=4]
Full Marks =80 IA=0 End Semester=80

Group A: UV-Visible Spectroscopy and Colorimetry

UV/Visible spectroscopy **Marks 15**

I. Study the 200-500 nm absorbance spectra of $KMnO_4$ and $K_2Cr_2O_7$ (in 0.1 M H_2SO_4) and λ determine the max values. Calculate the energies of the two transitions in different units (J molecule-1, kJ mol-1, cm-1, eV).
II. Study the pH-dependence of the U V-Vis spectrum (200-500 nm) of $K_2Cr_2O_7$.
III. Record the 200-350 nm UV spectra of the given compounds (acetone, acetaldehyde, 2-propanol, acetic acid) in water. Comment on the effect of structure on the UV spectra of organic compounds.

Colorimetry **Marks 20**

- Verify Lambert-Beer's law and determine the concentration of $CuSO_4$/ $KMnO_4$/ $K_2Cr_2O_7$ in a solution of unknown concentration.
- Determine the concentrations of $KMnO_4$ and $K_2Cr_2O_7$ in a mixture.
- Study the kinetics of iodination of propanone in acidic medium.
- Determine the amount of iron present in a sample using 1,10-phenathroline.
- Determine the dissociation constant of an indicator (phenolphthalein/ methyl red).
- Determine phosphate concentration in a soft drink.
- Analysis of the given vibration-rotation spectrum of HCl(g)

Group B: Organic Chemistry **Marks 20**

1. Extraction of caffeine from tea leaves.
2. Analysis of Carbohydrate: aldoses and ketoses, reducing and non-reducing sugars.
3. Identification of simple organic compounds by IR spectroscopy and NMR Spectroscopy (Spectra to be provided).

Group C: Inorganic Chemistry **Marks 17**

1. Percentage of available chlorine in bleaching powder.

2. Estimation of total alkalinity of water samples (CO_3^{-2}, HCO_3^-) using double titration method.
3. Measurement of dissolved CO_2

Viva **Marks 8**

Reference Books:

1. K.De, *Environmental Chemistry*: New Age International Pvt. Ltd., New Delhi
2. S. M. Khopkar, *Environmental Pollution Analysis*: Wiley Eastern Ltd, New Delhi
3. Khosla, B. D.; Garg, V. C. & Gulati, A., *Senior Practical Physical Chemistry*, R. Chand & Co.: New Delhi (2011).
4. Garland, C. W.; Nibler, J. W. & Shoemaker, D. P. *Experiments in Physical Chemistry 8th Ed.;* McGraw-Hill: New York (2003).
5. Halpern, A. M. & McBane, G. C. *Experimental Physical Chemistry 3rd Ed.;* W.H. Freeman & Co.: New York (2003).
6. Yadav, J.B., *Advanced Practical Physical Chemistry 32nd Ed*; Goel Publishing Hour.

SEMESTER-VI
CHEMISTRY
(Major) DSE VII
Option I
Course Title: Chemistry and Environment
Course Code: DS-T3-CHE-601A
Credit: 3, Contact Hours: 45
[L=2, T=1, P=0]
Full Marks =60 IA=18 End Semester=42

Objective of the Course: To impart knowledge about nuclear pollution, the ecosystem, handling of industrial gases, etc.

Expected Learner Outcome: Students will gain an understanding of
i. Stored and handled different types of industrial gases and chemicals.
ii. The effect of hazardous chemicals, purification method of water and industrial waste management.

Unit I: Environment and its segments **25 Lectures, Marks - 30**
Ecosystem, Biogeochemical cycles of carbon, nitrogen and sulphur.

Air Pollution: Major regions of atmosphere. Chemical and photochemical reactions in the atmosphere. Air pollutants: types, sources, particle size and chemical nature. Photochemical smog: its constituents and photochemistry. Environmental effects of ozone, major sources of air pollution. Pollution by SO_2, CO_2, CO, NOx, H_2S and other foul smeling gases, Methods of estimation of CO, NOx, SOx and control procedures. Effects of air pollution on living organisms and vegetation. Greenhouse effect and Global warming, Ozone Letion by oxides of nitrogen, chlorofluorocarbons and halogens, removal of sulphur from coal. Control of particulates.

Water pollution: Hydrological cycle, water resources, aquatic ecosystems, Sources and nature of water pollutants, Techniques for measuring water pollution, Impacts of water pollution on hydrological and ecosystems. Water purification methods. Effluent treatment plants (primary, secondary and tertiary treatment). Industrial effluents from the following industries and their treatment: electroplating, textile. Tannery, diary, petroleum and petrochemicals, agro, fertilizers etc. Sludge disposal. Industrial waste management, incineration of waste. Water treatment and purification (Reverse osmosis, electro dialysis, ion-exchange). Water quality parameters for waste watter, industrial water and domestic water.

Unit II: Energy & Environment **Lecture 10, Marks - 8**

Sources of energy: Coal, petrol and natural gas. Nuclear Fusion/ Fission, Solar energy, Hydrogen, Geothermal, Tidal and Hydel etc.

Nuclear pollution: Disposal of nuclear waste, nuclear disaster, and its management.

Unit III: Biocatalysis: **Lecture 10, Marks - 4**

Introduction to biocatalysis: Importance in "Green Chemistry" and "Chemical Industry"

Reference Books:

1. S.S.Dara: *A Textbook of Engineering Chemistry*, S. Chand & Company Ltd, New Delhi
2. K.De, *Environmental Chemistry*: New Age International Pvt. Ltd., New Delhi
3. S. M. Khopkar, *Environmental Pollution Analysis*: Wiley Eastern Ltd, New Delhi
4. S.E. Manahan, *Environmental Chemistry*, CRC Press (2005)
5. G. T. Miller, *Environmental Science*, 11th Ed. Brooks/ Cole (2006)
6. A. Mishra, *Environmental Studies*. Selective and Scientific Books, New Delhi (2005)

SEMESTER-VI
CHEMISTRY
(Major) DSE VII
Option II
Course Title: CHEMISTRY IN ANCIENT INDIA
Course Code: DS-T3-CHE-601B
Credit: 3, Contact Hours: 45
[L=2, T=1, P=0]
Full Marks =60 IA=18 End Semester=42

Objective of the Course:
To give the students an idea about the diverse and rich heritage of India from the Chemistry point of view. To make students know about the historical contributions of ancient Indian scholars in the field of Chemistry, the rich tradition of iron and steel metallurgy in ancient India. Also, how Ayurveda contributed in herbal medicines, mineral-based treatments, and hygiene practices.

Expected Course outcome:
1. Students will gain knowledge about the diverse and rich heritage of India.
2. They will learn about the historical contributions of ancient Indian scholars in the field of Chemistry.
3. Students will learn how ancient India had a rich tradition of iron and steel metallurgy, with indigenous techniques.
4. Students will learn how Ancient Indian chemists and artisans developed practical skills related to chemical processes.
5. IKS fosters holistic development by connecting traditional wisdom with modern education.
6. Students will learn how Ayurveda, the ancient Indian system of medicine, incorporated principles of chemistry. Herbal medicines, mineral-based treatments, and hygiene practices were integral to Ayurvedic health care.

Unit-I: **8 Lectures Marks: 5**

HISTORY OF CHEMISTRY IN ANCIENT INDIA

Chemistry in early literature, Knowledge of Fundamental Concepts of Chemistry in Ancient India, Early Chemical Techniques, Technology and Arts, Concept of Atom, Nano particles, Chemistry in India, Vatsyayana, Nagarjuna, Khanda, Al-Biruni, Vagbhaṭa –building of the Rasa-shala (laboratory), working arrangements of Rasa -shala, material and equipment, Yaśodhara Bhaṭṭa-process of distillation, apparatus, saranasamskara, saranataila

Unit-II: **10 Lectures, Marks: 15**

METALLURGY IN ANCIENT INDIA

Chemistry and Metallurgy in India: Disappearance of Metallurgical Skills, Metals and their making: Suvarna(gold) and its different types, prosperities, Rajata(silver), Tamra(copper), Loha(iron), Vanga(tin), Naga / sisa (lead), Pittala(brass), gold-silver alloy, metallurgical processes and minerals. Glass Making.

Unit-III: **5 Lectures, Marks 5**

CHEMICALS IN ANCIENT INDIA

Paper and ink making, Paints and Dyes, Perfumes and Cosmetics, Paper and Ink Making, Alcoholic Liquors.

Unit-IV: **12 Lectures, Marks 10**

ĀYURVEDIC MEDICAL SYSTEM

Ayurveda for Life, Health, and Well-being**:** Introduction to Ayurveda: From Alchemy to Chemistry. Rasayana in Ayurvedic texts, Preparation of different types of Bhasmas (Gold Bhasma, Silver Bhasma, Copper Bhasma and Lead Bhasma) and their medicinal values.

Unit-V: **10 Lectures, Marks 7**

TEXTILE TECHNOLOGY IN INDIA: Cotton (natural cellulose fiber), silk, wool (natural protein fibers), bast and leaf fibers, mridhu dhauta dhupitambaram (meaning a practice of fumigating the fabric with incense smoke before use as a part of the finishing process), sitadhautavasanayugala (bleached white–a finishing process); suchhastah, sutradharah (needle and thread – tools for stitching). dyeing, washing spinning and weaving technology.

Textbooks Recommended

1. P.C. Ray, History of Chemistry in ancient and medieval India, Chowkhambha Krishnadas Academy, Reprint Edition, 1 January 2004.
2. Textbook on IKS by Prof. B Mahadevan, IIM Bengaluru
3. Kapur K and Singh A.K (Eds) 2005). Indian Knowledge Systems, Vol. 1. Indian Institute of Advanced Study, Shimla. Tatvabodh of Sankaracharya, Central Chinmay Mission Trust, Bombay, 1995.
4. The Cultural Heritage of India. Vol.I. Kolkata:Ramakrishna Mission Publication, 1972.
5. Nair, Shantha N. Echoes of Ancient Indian Wisdom. New Delhi: Hindology Books, 2008.
6. Dr. R. C. Majumdar, H. C. Raychaudhuri and Kalikinkar Datta: An Advanced History of India (Second Edition) published by Macmillan & Co., Limited, London, 1953.
7. Rao, N. 1970. The Four Values in Indian Philosophy and Culture. Mysore: University of Mysore.
8. Avari, B. 2016. India: The Ancient Past: A History of the Indian Subcontinent from *7000* BCE to CE 1200. London: Routledge.

SEMESTER-VII

CHEMISTRY

(Major)DSC-XV

Course Title: (Inorganic Chemistry)

Course Code: MJ-T5-CHE-701

Credit: 5, Contact Hours: 75

[L=4, T=1, P=0]

Full Marks =100 IA=30 End Semester=70

Objective of the Course:

To make students understand about the principles of oxidation-reduction (redox) reactions, including the concepts of oxidation states and electron transfer, VBT and MOT, the bonding in coordination compounds, the application of crystal field theory (CFT) and ligand field theory (LFT). Also to discuss the structure and function of key Metallo biomolecules such as hemoglobin, myoglobin, and cytochromes, the role of metal ions in electron transfer, oxygen transport, and catalysis.

Expected Learning Outcome:

The study of the chapter will enable student to

1. Understand the principles of oxidation-reduction (redox) reactions, including the concepts of oxidation states and electron transfer.
2. Understand the various theories of chemical bonding, including valence bond theory (VBT) and molecular orbital theory (MOT).
3. Explore the bonding in coordination compounds, including the role of ligands and the application of crystal field theory (CFT) and ligand field theory (LFT).
4. Study the structure and function of key metallo-biomolecules such as hemoglobin, myoglobin, and cytochromes.
5. Understand the role of metal ions in electron transfer, oxygen transport, and catalysis.
6. Understand the basics of supramolecular chemistry.

Unit 1: Supramolecular Chemistry: 10 Lectures, Marks 10

Concepts of host guest chemistry, classification, non-covalent interactions, Molecular recognition, Supramolecular reactivity and catalysis, Effects of medium, Chiral recognition.

Unit II: Chemical Bonding II Lecture 30, Marks 28

Recapitulation of VSEPR Theory: Structure of molecules containing lone pair(s) of electrons, structure, and hybridization.

Bent's rule, Bent bond, non-bonded repulsion, and structure. LCAO-MO methods in homo and heteronuclear diatomic molecules (O2, N2, CO, NO). MO description of tri and tetra atomic molecules (CO_2, NO_2, NO_2^+, CO_3^{2-}, O_3 and NO_3^-). Bonding in electron deficient compounds.

Structure and bonding in boranes, carboranes, metallocarboranes, S-N and Se-N and P-N compounds.

Metallic and Metal ligand bonding: Spinel and Perovskite structures. Ionic surrounding: Crystal Field Theory; Covalent surrounding: Transition metal MO and ligand field Theory, Transition metal complexes with σ and π bonding ligands. Molecular orbital model, General view of ML6 and ML_4 structures: $ML_6(Oh)$, $ML_4(D_{4h})$ and $ML_4(Td)$. Chemical periodicity, Chemical hardness, Application of electronegativity.

Unit III: Acid Base and Redox Chemistry II **Lecture 15, Marks14**

Acid-Base in water. Non-aqueous solvent, aprotic solvent and superacid. Half-cell reaction, reduction potential, application of reduction potential data, electrochemical series; brief idea of corrosion and its prevention; Nernst equation. Latimer and Frost diagram (V, Mn Fe, Cu etc.), disproportionation reaction; cyclic voltametry.

Unit IV: Bioinorganic Chemistry II **Lecture 20, Marks 18**

Hemerythrin, hemocyanin, Electron transfer protein: Cytochromes, Iron-Sulphur, Nitrogen fixation. Metalloenzymes, corrinoids (vitamin B12 and co-enzyme), carboxy-peptidases, chlorophyll and photosynthesis, futuristic aspects of organo-transition metal complexes in bioinorganic chemistry.

Reference Books:

1. Vogel, A. I. Qualitative Inorganic Analysis, Longman, 1972.
2. Svehla, G. Vogel's Qualitative Inorganic Analysis, 7th Ed., Prentice Hall.
3. Cotton, F. A. G.; Wilkinson & Gaus, P. L. Basic Inorganic Chemistry 3rd Ed.; Wiley India,
4. Huheey, J. E.; Keiter, E. A. & Keiter, R. L. Inorganic Chemistry, Principles of Structure and Reactivity 4th Ed., Harper Collins 1993, Pearson, 2006.
5. Sharpe, A. G. Inorganic Chemistry, 4th Indian Reprint (Pearson Education) 2005
6. Douglas, B. E.; McDaniel, D. H. & Alexander, J. J. Concepts and Models in Inorganic Chemistry 3rd Ed., John Wiley and Sons, NY, 1994.
7. Greenwood, N. N. & Earnshaw, A. Chemistry of the Elements, Elsevier 2nd Ed, 1997 (Ziegler Natta Catalyst and Equilibria in Grignard Solution).
8. Lee, J. D. Concise Inorganic Chemistry 5th Ed., John Wiley and sons 2008.
9. Powell, P. Principles of Organometallic Chemistry, Chapman and Hall, 1988.
10. Jonathan W. Steed and Jerry L Atwood, Supramolecular Chemistry, 3rd Edition.
11. Shriver, D. D. & P. Atkins, Inorganic Chemistry 2nd Ed., Oxford University Press, 1994.

SEMESTER-VII
CHEMISTRY
(Major)DSC-XVI
Course Title: (Organic Chemistry)
Course Code: MJ-T5-CHE-702
Credit: 5, Contact Hours: 75
[L=4, T=1, P=0]
Full Marks =100 IA=30 End Semester=70

Objectives:

1. To provide students with the fundamental knowledge of the structure, reactivity, and reaction mechanism of organic compounds.
2. To design organic transformations through disconnection approach.
3. Application of NMR for compound characterization

Expected Learner Outcome:

1. Students will gain an insight into the various types of bonding and their implications in reactivity and properties of organic compound.
2. Students will acquire expertise in designing newer synthetic methodologies through disconnection approach and characterization of the products using spectroscopic techniques.

Unit I: Disconnection approach in Organic Synthesis Lectures 15, Marks 15

Disconnection approach in organic synthesis: Acceptor and donor synthons, Use of umpolung, Retrosynthesis of Alcohols (Grignard approaches and hydride transfer approaches) and Carbonyl compounds. One group and two group C-X disconnections. One group and two group C-C disconnections. Retrosynthesis of 1,2-, 1,3-, 1,4-, 1,5- and 1,6-difunctional (O, O and N, O in a difunctional relation) compounds. Use of protecting groups in organic synthesis: protection and deprotection of hydroxyl, dihydroxy, carbonyl, carboxyl, and amino groups.

Unit II Lecture 20, Marks 20

Structure, bonding and reactivity of organic compounds: Delocalised Chemical Bonding, Aromaticity, antiaromacity and homoaromaticity, metallocenes, tropolones and azulenes. Hyper conjugation, supramolecular chemistry: Bonds weaker than covalent bond (Hydrogen Bond, Addition Compounds), charge transfer complexes, inclusion complexes and crown ethers. Cryptand, rotaxanes, Fullerenes, Graphenes. Phase transfer catalyst. Hammet equation, Taft equation. Influence of reaction medium on rates.

Unit III **Lecture 20, Marks 20**

Organic reaction mechanism – Transition state vs. Reaction intermediate, Organic reactive intermediates: Generation, stability and reactivity of carbocations, carbanions, free radicals, carbenes, benzynes and nitrenes, Energy profile of multistep reaction, Significance of rate limiting step in multistep reactions, Catalysed and uncatalysed reactions, Kinetic vs. Thermodynamic control, Kinetic and non-kinetic methods of studying organic reaction mechanism; Isotope labeling studies and kinetic isotope effects, Cross-over experiment. Reactivity - selectivity principle: Chemoselectivity, regioselectivity, stereoselectivity and stereospecificity in substitution, elimination, and addition reactions.

Unit IV **Lecture 20, Marks 15**

NMR spectroscopy: Chemical shift, factors affecting chemical shift, spin- spin interaction, coupling constant and Factors affecting, relaxation processes, NOE, Nuclear magnetic double resonance, shift resonance, spin tickling; Proton and 13C NMR spectroscopy of simple organic molecules, living systems – MRI, Two-dimensional NMR, NOESY, DEPT, INEPT terminology, Instrumentation, FT NMR. IR: Application of IR in organic spectroscopy

Recommended Books:

1. Organic Chemistry, Vols I– I. L. Finar, ELBS.
2. Introduction to Spectroscopy – by Donald L. Pavia, Cengage Learning India Private Limited
3. A Guidebook to Mechanism in Organic Chemistry– Peter Sykes, Longman, New York.
4. Organic Chemistry – R. T. Morrison, R. N. Boyd and S. K. Bhattacharjee, Prentice Hall India Limited
5. Organic Chemistry – Paula Yurkanis Bruice, Pearson
6. Advanced Organic Chemistry: Reaction Mechanism and Structure – Jerry March, Wiley Eastern.
7. Disconnection Approach in Organic Synthesis – S. Warren, Wiley
8. Organic Reaction Mechanism, Christine Willis and martin Willis, Oxford chemistry Primers (No. 74)
9. Disconnection Approach in Organic Synthesis – S. Warren, Wiley
10. Designing Organic Synthesis – S. Warren, Wiley, Chichester
11. The Logic of Organic Synthesis – E.J. Corey and Xue Min Chen, Wiley, New York

SEMESTER-VII
CHEMISTRY
(Major)DSC-XVII
Course Title: (Physical Chemistry)
Course Code: MJ-T4-CHE-703
Credit: 4, Contact Hours: 60
[L=3, T=1, P=0]
Full Marks =80 IA=24 End Semester=56

Objectives:
1. To impart knowledge on the concept's fugacity, activity, partial molar quantities and third law of thermodynamics.
2. To understand the fundamental ideas and basic principles of quantum mechanics and its applications to simple model systems.
3. To impart the foundations of rotational, vibrational, and electronic spectroscopies with the help of Quantum Chemical model systems.

Expected Learner Outcome:
1. Students will understand the fundamentals and develop skills to solve problems related to fugacity, activity, partial molar quantities and third law of thermodynamics.
2. Students will be motivated to develop perception of matter from a Quantum Mechanical viewpoint.
3. Students will know and understand the basic principles of Quantum Chemistry.
4. Students will gain a knowledge of the fundamentals of spectroscopy and its analysis. They will also develop skills to apply this knowledge to solve problems in spectroscopy.

Unit 1: Equilibrium and Thermodynamics: Lecture 20, Marks 20

Concept of fugacity and its determination. Ideal solution and non-ideal solutions, Activity and activity coefficient, Determination of activity coefficient, Partial molar quantities: chemical potential, Determination of Partial molar volume, Thermodynamics of mixing. Excess thermodynamic functions, Nernst's Heat Theorem, Third law of thermodynamics, its experimental verification, determination of absolute entropy, Residual entropy.

Unit 2: Statistical thermodynamics: Lecture 20, Marks 20

Maxwell-Boltzmann distribution law, Bose-Einstein, and Fermi-Dirac distribution law. Boltzmann relation between entropy and probability. Partition functions and thermodynamic functions. Thermodynamic functions of a monatomic gas, Sackur – Tetrode equation. Evaluation of translational Partition function using Particle in a box model for ideal monatomic gas.

i) Rotational and vibrational entropy of gases, Free energy, and Partition functions. General expression for Partition function and equilibrium constant. Energy and heat capacity of gases. Einstein and Debye's theory of heat capacity of solids. Numerical calculations of thermodynamic quantities for monoatomic, diatomic, and polyatomic molecules.

Unit 3: Photochemistry **Lecture 20, Marks 16**

Light absorption: Jablonski Diagram, mechanism of absorption and emission of photochemical radiation: electric dipole transition, Einstein treatment of absorption and emission phenomena, concept of quantum yield and its determination; Fluorescence emission and structure; Triplet state and phosphorescence emission; delayed fluorescence; Study of kinetics of H_2-Cl_2 reaction, H_2-Br_2 reaction, photo dimerisation of anthracene, Photosensitisation and quenching, Stern Volmer equation.

Recommended Books:

1. Physical Chemistry by P.W. Atkins, Oxford University Press
2. Quantum Chemistry, by Ira N. Levine, Pentice Hall
3. Fundamentals of Molecular Spectroscopy by C.N. Banwell and E.M. McCash, Tata McGraw Hill.
4. Physical Chemistry by I. N. Levine
5. Thermodynamics for Chemist by S. Glasstone

SEMESTER-VII
Discipline Specific Elective
CHEMISTRY
(Major)DSE-VIII
Course Title: (Research Methodology)
Course Code: DS-T3-CHE-701A
Credit: 3, Contact Hours: 45
[L=2, T=1, P=0]
Full Marks =60 IA=18 End Semester=42

Objective of the Course:
To give students an idea about the importance of research methodology, the skill of writing an evidence-based research paper, literature review skills, the importance of citation and referencing.

Expected Learner Outcome:
1. Students will learn the importance of research methodology.
2. Students will learn the skill of writing an evidence-based research paper.
3. Students will learn literature review skills.
4.Students will learn the importance of citation and referencing
5. Students will learn the importance of research design and proper problem identification.

Unit I: Research Methodology: Lecture 15, Marks 12

Meaning of Research (Objectives and motivation of research). Research problems and research design. Research techniques, Sampling, and data analysis. Literature survey (different sources of literature survey including online databases), defining hypothesis, Research design, Sampling Design, Data collection, Data analysis: measures of central tendency, measures of dispersion, measures of asymmetry, measures of relationship. Preparation of research manuscript. Writing a research grant proposal (research funding)

Unit III: Methods of Data Collection and Analysis of Data Lecture 15, Marks 15

Types of Information, Collection of Primary, secondary, and tertiary Data, Observation Method, Interview Method, Collection of Data through Questionnaires, Collection of Data through Schedules, Difference between Questionnaires and Schedules, Some Other Methods of Data Collection, Collection of Secondary Data Selection of Appropriate Method for Data Collection,

Case Study Method, Processing Operations, Some Problems in Processing, Elements/Types of Analysis, Statistics in Research.

Unit IV: Testing of Hypotheses, Interpretation and Report Writing Lecture 15, Marks 15

What is a Hypothesis? Basic Concepts Concerning Testing of Hypotheses, Procedure for Hypothesis Testing, Flow Diagram for Hypothesis Testing, Measuring the Power of a Hypothesis Test, Tests of Hypotheses.

Meaning of Interpretation, Why Interpretation? Technique of Interpretation: Precaution in Interpretation, Significance of Report Writing, Different Steps in Writing Report, Layout of the Research Report, Types of Reports (Research Project and Research article), Oral Presentation, Mechanics of Writing a Research Report, Precautions for Writing Research Reports, Conclusions, writing ethics, avoiding plagiarism, use of computers and Computer Technology in research.

Textbooks:

1. C. R. Kothari and Gaurav Garg, Research Methodology Methods, and techniques, New Age International
2. Ghosh, B.N., *Scientific Methods and Social Research*, New Delhi: Sterling Publishers Pvt. Ltd.,
3. Gopal, M.H., *Research Reporting in Social Sciences*, Dharwar: Karnatak University
4. Hillway, T., *Introduction to Research,* 2nd ed., Boston: Houghton Mifflin
5. Kothari, C.R., *Quantitative Techniques,* 2nd ed., New Delhi: Vikas Publishing House Pvt. Ltd.
6. Lastrucci, Carles L., *The Scientific Approach: Basic Principles of the Scientific Method,* Cambridge, Mass.: Schenkman Publishing Co., Inc., 1967.

SEMESTER-VII
Discipline Specific Elective
CHEMISTRY
(Major)DSE-VIII
Course Title:
(Tools and Techniques in Research Methodology)
Course Code: DS-T3-CHE-701B
Credit: 3, Contact Hours: 45
[L=2, T=1, P=0]
Full Marks =60 IA=18 End Semester=42

Objective of the Course:
The objective of the course is to provide students with a comprehensive understanding of the principles and practices of research. The course aims to equip students with the skills necessary to design, conduct, analyze, and present research in a methodologically sound and ethically responsible manner. It focuses on various research methods, both qualitative and quantitative, and introduces students to the tools and techniques essential for conducting high-quality research in various fields.

Expected Course Outcome:

1. The course will help the students to understand Research Fundamentals.
2. The course will enable students to formulate Research Problems.
3. The course will enable the students to use quantitative methods (e.g., surveys, experiments, statistical analysis) in practical applications.
4. Students will learn the techniques of Interpreting Research Findings.
5. The course will help the students to develop critical thinking skills to evaluate research designs and methodologies.

Unit-I: Introduction to Research Methodology **Lecture 10, Marks 10**

Meaning of Research, Definitions of Research, Purpose of Research, Characteristics of Research, Types of Research.

Research process, (i) Formulating the Research Problem (ii) Extensive Literature Survey (iii) Developing the Research Hypothesis (iv) Preparing the Research Design (v) Determining the Research Design (vi) Collecting the Research Data (vii) Execution of the Project (viii) Analysis of Data (ix) Hypothesis Testing (x) Generalization and Interpretation (xi) Preparing of the Report or Presentation of the Result.

Unit-II: Research Design and Problem Identification **Lecture 10, Marks 10**

Research design, Purpose of a Research Design, Characteristics of Good Research Design

Research Problem, Definitions of the Problem, Identification of a Research Problem, The Sources of the Problem, Statement of Problem, Objectives of Assumptions about the Problem, Aspects of Delimiting a Problem, Evaluation of the Problem.

Unit-III: Sampling Techniques and Tools for Data Collection in Research Methodology:

Lecture 15, Marks 12

Sampling, Census Method or Parametric method and Sampling method or Non-parametric method, Assumptions of Sampling, Need of Sampling, Advantages of Sampling, Disadvantages or Limitation of Sampling, Essentials of an Ideal Sample, Characteristics of a Good Sample, Types of Sampling Designs/Methods of Sampling, Difference between Probability and Non-Probability Sampling, Simple Random Sampling, Systematic Sampling, Stratified Sampling, Multiple or Double Repetitive Sampling, Multi Stage Sampling, Cluster Sampling, Non-Probability Sampling Method, incidental or Accidental Sampling, Judgment Sampling, Purposive Sampling, Quota Sampling, Snowball Sampling, Purposive or Expert Choice Sampling, Tools of Data Collection, Questionnaires, Interviews, Schedules, Observation Techniques, Rating Scales.

Unit-IV: Data Processing and Statistical Analysis in Research: **Lecture 10, Marks 10**

Processing and Analysis of Data, Processing Operations, Some Problems in Processing, Elements/Types of Analysis, Statistics in Research, Measures of Central Tendency, Measures of Dispersion, Measures of Asymmetry (Skewness), Measures of Relationship, Simple Regression Analysis, Multiple Correlation and Regression, Partial Correlation, Association in Case of Attributes, Other Measures.

Reference:

1. Ackoff, Russell L. (1961). *The Design of Social Research*, University of Chicago Press: Chicago.
2. Allen, T. Harrell, (1978). *New Methods in Social Research*, Praeger Publication: New York.
3. Baker, R.P. & Howell, A.C. (1958). *The Preparation of Reports*, Ronald Press: New York.
4. Barzun, Jacques & Graff. F. (1990). *The Modern Researcher*, Harcourt, Brace Publication: New York.
5. Berelson Conard & Colton, Raymond. (1978). *Research and Report Writing for Business and Economics*, Random House: New York.
6. Best, John, W.& Kahn, James. (1986). *Research in Education*, 5th ed., Prentice–Hall of India Pvt Ltd: New Delhi.

SEMESTER-VII
Discipline Specific Elective Practical
Option I
CHEMISTRY
(Major)DSE-IX
Course Title: (General Chemistry Practical)
Course Code: DS-P3-CHE-702A
Credit: 3, Contact Hours: 90
[L=0, T=0, P=3]
Full Marks =60 IA=0 End Semester=60

Inorganic Lab 2 **Marks 18**

1. Estimation of Mg^{2+} and Ca^{2+} by complexometric method in different ores and from given solution with one / two components.
2. Estimation of alloys – Brass, Cu-Ni, etc.
3. Synthesis and characterization of nanoparticles by sol-gel and co-precipitation methods.

Organic Lab 2 **Marks 18**

1. Separation and identification of amino acids present in a mixture by paper chromatography.
2. Organic Preparation -
   One –step preparation
   a. Cannizaro reaction of benzaldehyde (separation of benzyl alcohol and benzoic acid by solvent extraction)
   b. Oxidation of p-nitrotoluene to p-nitrobenzoic acid
   c. Reduction of benzophenone to benzhydrol
   d. Phthalic anhydride to phthalimide

Physical Lab 2 **Marks 18**

1. To study hydrolysis of methyl acetate in presence of HCl and H_2SO_4 and hence determine the relative strength of the acids (use Guggenheim method)
   i) analytically.
   ii) polarimetrically.
2. Determine the equivalent conductivity of acetic acid at infinite dilution by Kohlrausch's method.
3. Determine the relative strength of acetic acid and mono chloro acetic acid by conductance measurement.
4. Determine the specific rotation of sucrose and hence determine the unknown

concentration of supplied solution by polarimetric measurements.

5. Determination of pH of a mixture of CH_3COOH and CH_3COONa, and hence determine the dissociation constant of the acid.
6. Preparation of conducting polymers and study of their electrical conductivity.

Viva Marks 6

Reference Books:

1. Vogel, Arthur I: A Test book of Quantitative Inorganic Analysis (Rev. by G. H. Jeffery and others) 5th Ed., The English Language Book Society of Longman.
2. Willard, Hobert H. et al.: Instrumental Methods of Analysis, 7th Ed., Wardsworth Publishing Company, Belmont, California, USA, 1988.
3. Khopkar, S.M. Basic Concepts of Analytical Chemistry. New Age, International Publisher, 2009.
4. Mendham, J., A. I. Vogel's *Quantitative Chemical Analysis 6th Ed.*, Pearson, 2009.
5. Das, Subhas C, Advanced Practical Chemistry for 3-Year Honours Course.
6. Mann, F.G. & Saunders, B.C. *Practical Organic Chemistry*, Pearson Education (2009)
7. Yadav, J.B., *Advanced Practical Physical Chemistry 32nd Ed*; Goel Publishing Ho

SEMESTER-VII
Discipline Specific Elective Practical
Option II
CHEMISTRY
(Major)DSE-IX
Course Title: (General Chemistry Practical)
Course Code: DS-P3-CHE-702B
Credit: 3, Contact Hours: 90
[L=0, T=0, P=3]
Full Marks =60 IA=0 End Semester=60

Inorganic Lab 2 **Marks 18**

1. Estimation of Zn^{2+} and Cu^{2+} by complexometric method in different ores and from given solution with one / two components.
2. Estimation of alloys – Bronze, Cu-Ni, etc.
3. Synthesis and characterization of nanoparticles by biogenic methods.

Organic Lab 2 **Marks 18**

1. Two –step preparation
   i. p-nitrobenzene azo 2-naphthol (Para Red) from p-nitroaniline
   ii. Benzanilide from benzophenone
   iii. Dibenzyl from benzoin
2. Preparation of Green reagent: TetrabutylammoniumTribromide (TBATB) and its use

Physical Lab 2 **Marks 18**

1. Determine the specific rotation of sucrose and hence determine the unknown concentration of supplied solution by polarimetric measurements.
2. Determine the amount of each component of the following ternary mixture by
3. Conductometric titration.
   i) HCl, CH_3COOH, $CuSO_4$
   ii) HCl, NaCl, NH_4Cl
7. Determine the ionization constant of acetic acid by conductivity method.
8. Determination of Critical Micelle Concentration (CMC) of Sodium dodecyl sulphate (SDS) by surface tension measurement.
9. To find the stability constant of the co-ordination compound formed between Cu^{2+} and 5-Sulphosalicylic acid.
10. Establish the order reaction for $K_2C_2O_4 + 2HgCl_2 \rightarrow Hg_2Cl_2 + 2KCl + 2CO_2$ by the method of ratio variation.

Viva Marks 6

Reference Books:

8. Vogel, Arthur I: A Test book of Quantitative Inorganic Analysis (Rev. by G. H. Jeffery and others) 5th Ed., The English Language Book Society of Longman.
9. Willard, Hobert H. et al.: Instrumental Methods of Analysis, 7th Ed., Wardsworth Publishing Company, Belmont, California, USA, 1988.
10. Khopkar, S.M. Basic Concepts of Analytical Chemistry. New Age, International Publisher, 2009.
11. Mendham, J., A. I. Vogel's *Quantitative Chemical Analysis 6th Ed.*, Pearson, 2009.
12. Das, Subhas C, Advanced Practical Chemistry for 3-Year Honours Course.
13. Mann, F.G. & Saunders, B.C. *Practical Organic Chemistry*, Pearson Education (2009)
14. Yadav, J.B., *Advanced Practical Physical Chemistry 32nd Ed*; Goel Publishing Ho

SEMESTER-VIII
CHEMISTRY
(Major)DSC-XVIII
Course Title: (Inorganic Chemistry)
Course Code: MJ-T3-CHE-801
Credit: 3, Contact Hours: 45
[L=4, T=1, P=0]
Full Marks =60 IA=18 End Semester=42

Objectives of the course:

1. To get a brief overview about inorganic reaction mechanism
2. To understand the application of group theory in Chemical Science.

Expected Learner Outcome:

1. Student will gather a thorough concept about the kinetics of inorganic reactions.
2. Student will understand the importance of group theory and applications in chemical science.

Unit I: Inorganic reaction mechanism II **Lecture 18, Marks 17**

Stability constant- formation constant of complexes, chelate effect, Thermodynamic and Kinetic stability; inert and labile complexes; Factor affecting stability, Correlation of stability constant with thermodynamic factors –G, H and S. Determination of stability constant –Jobs and Bjerrum's methods. Mechanism of ligand replacement reactions: Substitution reactions in octahedral [Cr(III), Co(III)] and square planar [Rh(I), Pt(II) and Pd(II)] complexes, Rate of water replacement reaction; Solvolysis and hydrolysis reaction; acid hydrolysis and base hydrolysis reaction; Factors affecting the rate of substitution reaction, trans effect and its importance, theories of trans effect, idea concerning electron transfer reactions, inner and outer sphere reactions.

Unit II: Symmetry operation, elements of symmetry **Lecture 17, Marks 15**

Matrices and matrix representation of symmetry operations, Definition of Group, finite and infinite group. Examples of groups using geometrical object and symmetry operations. Symmetry elements as elements of group. Point groups. Orthogonality theorem: reducible and irreducible representation, use of vectors and mathematical functions in group representation, Character table for molecular point group, construction of C_{2v} and C_{3v} Character table. Direct product representation. Projection operator, symmetry adapted linear combination (SALC) for C_{2v}, C_{3v}, D_{4h} and T_d point group molecules.

Chemical Applications of Group Theory: Qualitative Aspects Only.

Unit III: Statistical Methods of Analysis **Lecture 10, Marks 10**

Accuracy, precession, deviation, standard deviation, classification of errors, minimization of errors, significant figures.

Indicators: Choice of indicators in neutralization, redox, adsorption and complexometric reactions

Textbooks:

1. Inorganic Chemistry: Principles of structure and reactivity, 4thEdition; J.E. Huheey, E.A. Keiter, R.L. Keiter, O.K. Medhi.

Recommended Books:

1. Advanced Inorganic Chemistry, 6thEdition, F.A. Cotton, G. Wilkinson, C.A. Murillo and M. Bochmann.
2. Inorganic Chemistry, K.F. Purcell and J.C. Kotz.

SEMESTER-VIII
CHEMISTRY
(Major)DSC-XIX
Course Title: (Organic Chemistry)
Course Code: MJ-T3-CHE-802
Credit: 3, Contact Hours: 45
[L=2, T=1, P=0]
Full Marks =60 IA=18 End Semester=42

Objectives: To provide knowledge on
1. Pericyclic reactions.
2. heterocyclic compounds of biological and pharmaceutical importance.
3. Stereochemistry of organic compounds.

Expected Learner Outcome:
1. Students will gain insight on isolation, characterization, and synthesis of various natural compounds of biological importance.
2. Students will acquire knowledge on different heterocyclic compounds.
3. They will also be familiarized with mass spectrometric technique.

Unit I **Lecture 15, Marks 15**

Pericyclic reactions – Classification of pericyclic reactions, FMO method, PMO method for the explanation of pericyclic reactions under thermal and photochemical conditions; Cycloaddition reactions: [2+2], [4+2], [6+4] cycloadditions, 1,3-dipolar cycloadditions; the ene reaction, cheletropic reactions, Sigmatropic rearrangement – [m+n] sigmatropic shifts of hydrogen and carbon, Cope and Claisen rearrangement. Electrocyclic reactions, Stereoselectivity and regioselectivity of pericyclic reactions.

Unit II **Lecture 15, Marks 12**

Heterocyclic Chemistry: Principles of heterocyclic synthesis involving cyclization and cycloaddition reaction. Synthesis and properties heterocycles containing one and two heteroatoms viz., N, O and S (aziridine, oxirane, pyrazole, isoxazole, imidazole, oxazole and thiazole).

Unit III **Lecture 15, Marks 15**

Stereochemistry: Concept of prostereoisomerism and prochirality – Homotopic and heterotopic ligands and faces; Optical purity and enantiomeric excess; Chirality in molecules devoid of chiral centers - allenes, spirans and biphenyls. Classification of stereoselective synthesis: diastereoselective and enantioselective reactions; Nucleophilic addition to aldehydes and acyclic ketones: Cram and Felkin – Ahn model. Enantioselective synthesis.

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Textbooks:

1. Organic Chemistry of Natural Products, Vol I and II, Gurdeep Chatwal, Himalaya Publishing House, Bombay.
2. Heterocyclic Chemistry: Synthesis, Reactions and Mechanisms – Raj K. Bansal, Wiley Eastern.

Recommended Books:

1. Chemistry of Organic Natural Products, Vol I and II, O.P. Agarwal, Goel Publishing House, Meerut.
2. The Alkaloids: K. W. Bentley.
3. Organic Chemistry, Vol- I, II, I.L. Finar
4. Heterocyclic Chemistry – T.L. Gilchrist, Longman Scientific and Technical/Pitman Publ. Ltd.
5. Singh, J.; Ali, S.M. & Singh, J. *Natural Product Chemistry*, Pragati Parakashan (2010).
6. A Guidebook to Mechanism in Organic Chemistry– Peter Sykes, Longman, New York.

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SEMESTER-VIII
CHEMISTRY
(Major)DSE-X
OPTION1
Course Title: (Spectroscopy II)
Course Code: DS-T2-CHE-801A
Credit: 2, Contact Hours: 30
[L=1, T=1, P=0]
Full Marks =40 IA=12 End Semester=28

Objective of the Course:

To impart the foundations of Raman Spectroscopy, electronic spectroscopy, Mass Spectroscopy and Photoelectron Spectroscopy with the help of Quantum Chemical model systems including applications.

Expected Learning Outcome:

The study of the course will enable student to

1. Understand the basic principles of Raman spectroscopy, including the Raman effect and the difference between Stokes and anti-Stokes scattering.
2. Understand the principles of UV-Visible spectroscopy, including electronic transitions and the Beer-Lambert law.
3. Gain knowledge of the components of UV-Visible spectrophotometers, including light sources, monochromators, sample holders, and detectors.
4. Understand the basic principles of mass spectrometry, including ionization methods, mass analyzers, and detectors.
5. Explore the applications of mass spectrometry in fields such as organic chemistry, biochemistry, environmental science, and pharmaceuticals.
6. Understand the basic principles of photoelectron spectroscopy, including the photoelectric effect and the relationship between binding energy and kinetic energy of electrons.
7. Learn about the types of photoelectron spectroscopy, such as X-ray Photoelectron Spectroscopy (XPS) and Ultraviolet Photoelectron Spectroscopy (UPS).

Unit 1: Raman Spectroscopy: **Lecture 6, Marks 5**

Quantum theory of Raman Effect, Selection rules, mutual exclusion principle, vibration rotation Raman spectra. Intensity of Raman lines.

Unit 2: UV-Visible spectroscopy: **Lecture 10, Marks 10**

Electronic transitions and selection rules, Frank Condon principle and electronic spectra of polyatomic molecules, Fluorescence and phosphorescence, solvent effects, absorption and intensity shifts, Calculation of absorption maxima by Woodward-Fieser Rules.

Unit 3: Mass spectrometry: **Lecture 10, Marks 8**

Ion fragmentation mechanism, Base peak and molecular ion peak, metastable peak, instrumentation and techniques, ionization methods, isotopic distribution, Application in determining the structure of organic and inorganic compounds.

Unit 4: Introduction to Photoelectron Spectroscopy: Auger electron spectroscopy. Chemical information from ESCA **Lecture 4, Marks 5**

Textbooks Recommended:

1. Banwell, C. N. & McCash, E. M. Fundamentals of Molecular Spectroscopy 4th Ed. Tata McGraw-Hill: New Delhi (2006).

5. Kakkar, R. Atomic & Molecular Spectroscopy, Cambridge University Press (2015).

6. Sen, B. K., Quantum Chemistry including Spectroscopy Kalyani Publishers

SEMESTER-VIII
CHEMISTRY
(Major)DSE-X
OPTION2
Course Title:
(Spectroscopic Techniques in Forensic Science)
Course Code: DS-T2-CHE-801B
Credit: 2, Contact Hours: 30
[L=1, T=1, P=0]
Full Marks =40 IA=12 End Semester=28

Objective of the Course:
By the end of this course, students will be able to:

1. Understand the fundamental principles of various spectroscopic techniques.
2. Understand the basis of applications of spectroscopic methods to solve forensic problems.
3. Critically evaluate the strengths and limitations of different spectroscopic techniques in forensic analysis.

Course Outcome:

1. To know about the concept of Spectroscopy, electromagnetic spectrum, sources of radiation, their utility and limitations.
2. This paper tends to describe the different Physical instrumentation techniques.
3. To understand basic principles and theory of radiochemical techniques.

Unit I: Introduction to Spectroscopy in Forensic Science: **Lecture 10, Marks 10**

Atomic & Molecular Spectroscopy, electromagnetic spectrum, sources of radiation. Conventional sources for UV, visible and infrared rays, sources for shorter wavelength radiations (X-ray tubes), interaction of radiation with matter: - reflection, absorption, transmission, fluorescence, phosphorescence and their forensic applications, radiation filters. Detection of radiation; photographic detectors, thermal detectors, photoelectric detectors etc.

Atomic spectra, energy levels, quantum numbers and designation of states, selection rules, qualitative discussions of atomic spectra. Elements of X-ray spectrometry, fluorescence, energy dispersive X-ray analysis (EDX), wavelength dispersive X-ray analysis (WDX), X-ray diffraction, augur effect. Application of these techniques in forensic science.

Unit II: Advanced Spectroscopic Techniques in Forensic Science: **Lecture 10, Marks 10**

Physical instrumentation techniques IR spectroscopy- correlation of infrared spectra with molecular structure, Fourier Transform, infrared (FTIR) and Raman spectroscopy, Forensic Applications of IR Spectroscopy.

Atomic absorption spectrometry: Instrumentation and techniques, interference in AAS, background correction methods, quantitative analysis. Atomic emission spectrometry: Instrumentation and techniques, arc/spark emission, ICP-AES, comparison ICP vs AAS methods, quantitative analysis, applications. Techniques - RBS (Rutherford Back Scattering spectrometry), Application of these techniques in forensic science.

Unit III: Analytical Techniques in Forensic Science: **Lecture 10, Marks 8**

Radiochemical and Nuclear techniques Radiochemical techniques: Basic principles and theory, introduction about nuclear reactions and radiations, neutron sources, neutron activation analysis (NAA), Thermal analysis methods: Basic principles and theory, differential scanning colorimetry and differential analysis, thermogravimetry.

Nuclear Magnetic Resonance spectroscopy: Basic principles, theory and instrumentation, **Mass Spectrometry**, GCMS, LCMS, Secondary Mass Spectrometry, Laser Mass spectrometry, Application of these techniques in forensic science.

Suggested Readings

6. Robinson, J.W; Atomic Spectroscopy, 2nd Ed. Revised & Expanded, Marcel Dekker, Inc., New York, 1996.
7. Workman, J; Art Springsteen; Applied Spectroscopy- A compact reference for Practitioners, Academic Press, London, 1997.
8. Subrahmanyam, N. &Lal B; A textbook of Optics, S. Chand & Company, New Delhi, 2004.
9. Willard, H.H. Lynne L. Merrett, J. Dean, A. Frank, A. Settle. J; Instrumental Methods of Analysis, 7th Edition CBS pub.& Distributors, New Delhi, 1986.
10. Khandpur, R. S; Handbook of Analytical Instruments, Tata McGraw Hill Pub. Co. New Delhi, 2004.
11. Thomson, K.C. &Renolds, R.J; Atomic Absorption Fluorescence & Flame Emission Spectroscopy, A Practical Approach, 2nd Edition Charles Griffith & Company, New South Wales, 1978.

12. Dudley, H. Williams & Fleming, I; Spectroscopic Methods in Organic Chemistry, 4thEdn, Tata McGraw- Hill Publishing Company, New Delhi, 1994.

OPTIONAL PAPER
SEMESTER-VIII
CHEMISTRY
(Major)DSC-XX
Course Title: (*Analytical Methods in Chemistry*)
Course Code: MJ-T4-CHE-803
Credit: 4, Contact Hours: 60
[L=3, T=1, P=0]
Full Marks =80 IA=24 End Semester=56

Objective of the Course: To develop a strong knowledge on spectroscopy, qualitative and quantitative aspects of analysis and thermal analysis.

Expected Learner Outcome: Students will gain an understanding of

i. The principles and applications of modern chemical instrumentation, experimental design, and data analysis.

ii. The composition of written laboratory reports that summarize experimental procedures and accurately present and interpret data.

iii. Qualitative and quantitative aspect of solvent extraction, chromatographic method of analysis -TLC & HPLC

Unit I: Qualitative and quantitative aspects of analysis

Sampling, evaluation of analytical data, errors, accuracy and precision, methods of their expression, normal law of distribution if indeterminate errors, statistical test of data; F, Q and t test, rejection of data, and confidence intervals**.**

10 Lectures, Marks - 6

Unit II: UV-Visible and IR Spectrometry

Origin of spectra, interaction of radiation with matter, fundamental laws of spectroscopy and selection rules, validity of Beer-Lambert's law.

UV-Visible Spectrometry: Basic principles of instrumentation (choice of source, monochromator, and detector) for single and double beam instrument; Basic principles of quantitative analysis: estimation of metal ions from aqueous solution, geometrical isomers, keto-enol tautomers. Determination of composition of metal complexes using Job's method of continuous variation and mole ratio method.

Infrared Spectrometry: Basic principles of instrumentation (choice of source, monochromator & detector) for single and double beam instruments; sampling techniques. Structural illustration through interpretation of data, effect, and importance of isotope substitution.

Flame Atomic Absorption and Emission Spectrometry: Basic principles of instrumentation (choice of source, monochromator, detector, choice of flame and Burner designs. Techniques of atomization and sample introduction; Method of background correction, sources of chemical interferences and their method of removal. Techniques for the quantitative estimation of trace level of metal ions from water samples.

30 Lectures, Marks - 25

Unit III: Thermal Methods of analysis:

Theory of thermo-gravimetry (TG), basic principle of instrumentation. Techniques for quantitative estimation of Ca and Mg from their mixture.

5 Lectures, Marks - 10

Unit IV: Separation techniques

Solvent extraction: Classification, principle, and efficiency of the technique. Mechanism of extraction: extraction by solvation and chelation. Technique of extraction: batch, continuous and counter current extractions. Qualitative and quantitative aspects of solvent extraction: extraction of metal ions from aqueous solution, extraction of organic species from the aqueous and non-aqueous media.

Chromatography: Classification, principle, and efficiency of the technique. Mechanism of separation: adsorption, partition & ion exchange. Development of chromatograms: frontal, elution, and displacement methods. Qualitative and quantitative aspects of chromatographic methods of analysis: TLC and HPLC.

15 Lectures, Marks - 15

Textbooks Recommended:

1. Vogel, Arthur I: A Test book of Quantitative Inorganic Analysis (Rev. by G.H. Jeffery and others) 5th Ed., The English Language Book Society of Longman.
2. Willard, Hobert H. et al.: Instrumental Methods of Analysis, 7th Ed., Wardsworth Publishing Company, Belmont, California, USA, 1988.
3. Christian, Gary D; Analytical Chemistry, 6th Ed., John Wiley & Sons, New York, 2004.
4. Harris, Daniel C: Exploring Chemical Analysis, Ed. New York, W. H. Freeman, 2001.
5. Khopkar, S. M. Basic Concepts of Analytical Chemistry. New Age, International Publisher, 2009.
6. Skoog, D. A. Holler F.J. and Nieman, T.A. Principles of Instrumental Analysis, Thomson Asia Pvt. Ltd. Singapore.
7. Mikes, O. & Chalmes, R.A. Laboratory Handbook of Chromatographic & Allied Methods, Elles Harwood Ltd. London.
8. Ditts, R.V. Analytical Chemistry - Methods of separation.
9. Skoog, Douglas A., West, Donald M., Holler, F. James and Crouch, Stanley R., Fundamentals of Analytical Chemistry, 9th Edition.

OPTIONAL PAPER
SEMESTER-VIII
CHEMISTRY
(Major)DSC-XXI
Course Title: (Physical Chemistry)
Course Code: MJ-T4-CHE-804
Credit: 4, Contact Hours: 60
[L=3, T=1, P=0]
Full Marks =80 IA=24 End Semester=56

Objectives:

1. To provide knowledge on
a. The three components of surface chemistry viz. adsorption, catalysis, and colloids.
b. Polymers, their preparation, properties, and applications.
c. Kinetics of polymerization reactions.

Expected Learner Outcome:
1. Students will achieve insight on different adsorption isotherms and their applications in Chemical analysis and industry
2. Students will acquire knowledge on different mechanisms of polymerization processes.
3. They will also be familiarized with the electrical aspects of surface chemistry.

Unit1: Surface Chemistry **Lecture 30, Marks 36**

i) Adsorption isotherms, Langmuir and BET isotherms-postulates and derivation, determination of surface area of an adsorbent using Langmuir or BET isotherms. Capillary condensation – adsorption in micropores, hysteresis loop. Application of adsorption in chemical analysis and industry. **10**

ii) **Kinetics of heterogeneous catalysis:** Langmuir-Hinselwood mechanism, Kinetics of unimolecular and bimolecular surface reactions, Effect of temperature on the rate of surface reactions. Volcano curves.
D**ifferent categories of heterogeneous catalysts and their development**: Metals, semiconductors and insulators, Photo and Electrocatalysts.
Zeolites and Clays: Zeolites (natural and synthetic) - shape selectivity properties- solid acids, acidity of zeolites and clays, Applications of zeolites and clays as heterogeneous catalysts in cracking, reforming, and olefin reactions. Catalysis in Hydrogenation,

oxidation, polymerization, in petrochemical industry, Catalysis for Environmental pollution control: control of pollution from automobile exhaust, catalytic converters, cleaning of industrial effluents **15**

iii) **Electrical aspects of surface chemistry**: **Lecture 10, Marks 11**

The structure of electrical double layer, Zeta potential and colloidal stability, Measurement of zeta potential. Surfactants – definition and classification, micelle formation and determination of critical micelle concentration. Reverse micelle and its application, solubilization, microemulsion.

Unit 2: Polymers and their Characterization: Lecture 20, Marks 20

i) Classification of polymers and polymerization reactions. Number and mass average molar masses of polymers, determination molar masses by methods of osmometry, viscometry, light scattering and ultra centrifugation. . Gel permeation chromatography and fractional precipitation techniques for polymer fractionation.

ii) Kinetics and mechanism of addition, condensation polymerization, determination of degree of polymerization, carothers equation, kinetic chain length, Different factors affecting chain polymerization: monomer structure, inhibitors, chain transfer. Inhibition and retardation, Gel effect

Textbooks Recommended:

13. Physical Chemistry – P.W. Atkins, Oxford University Press.
14. Physical Chemistry of Surfaces – A. W. Adamson, Wiley India Pvt. Ltd.
15. Billmeyer, F. W. Textbook of Polymer Science, John Wiley & Sons, Inc.
16. Gowariker, V. R Viswanathan, N. V. & Sreedhar, J. Polymer Science, New Age International (P) Ltd. Pub.

OPTIONAL PAPER

SEMESTER-VIII

CHEMISTRY

(Major)DSC-XXII

Course Title: (*Advanced Analytical Practicals*)

Course Code: MJ-P4-CHE-801

Credit: 4, Contact Hours: 120

[L=0, T=0, P=4]

Full Marks =80 IA=0 End Semester=80

A. *Any 2 (two) experiments to be set in examination* **Marks - 18×2=36**

i) Paper chromatographic separation of Fe3+, Al3+, Cr3+, Ag+, Hg22+, and Pb2+

ii) Separation and identification of the monosaccharides present in the given mixture (glucose & fructose) by paper chromatography. Reporting the Rf values.

iii) Separate a mixture of Sudan yellow and Sudan Red by TLC technique and identify them on the basis of their Rf values.

iv) Chromatographic separation of the active ingredients of plants, flowers and juices by TLC

v) Determine the pH of the given aerated drinks fruit juices, shampoos and soaps.

vi) Determination of Na, Ca, Li in cola drinks and fruit juices using flame photometric techniques.

vii) Analysis of soil: determination of pH of soil, total soluble salt, estimation of calcium, magnesium, phosphate, nitrate

viii) Separation of metal ions from their binary mixture.

ix) Separation of amino acids from organic acids by ion exchange chromatography.

x) Determination of dissolved oxygen in water.

xi) Determination of chemical oxygen demand (COD).

xii) Determination of Biological oxygen demand (BOD).

B. **A.** ***Any 2 (two) experiment to be set in examination*** **Marks - 18x2=36**

a. Determination of free acidity in ammonium sulphate fertilizer.
b. Estimation of Calcium in Calcium ammonium nitrate fertilizer.
c. Estimation of phosphoric acid in superphosphate fertilizer.
d. Electroless metallic coatings on ceramic and plastic material.
e. Determination of composition of dolomite (by complexometric titration).
f. Analysis of (Cu, Ni); (Cu, Zn) in alloy or synthetic samples.
g. Analysis of Cement.
h. Preparation of pigment (zinc oxide).

B. Viva - voce **Marks - 8**

Reference Books:

1. Vogel, Arthur I: A Test book of Quantitative Inorganic Analysis (Rev. by G. H. Jeffery and others) 5th Ed., The English Language Book Society of Longman.
2. Willard, Hobert H. et al.: Instrumental Methods of Analysis, 7th Ed., Wardsworth Publishing Company, Belmont, California, USA, 1988.
3. Khopkar, S.M. Basic Concepts of Analytical Chemistry. New Age, International Publisher, 2009.

OPTIONAL PAPER

SEMESTER-VIII

CHEMISTRY

(Major)

Course Title: (*Research Project*)

Course Code: MJ-P12-CHE-802

Credit: 12, Contact Hours: 360

[L=0, T=0, P=12]

Full Marks =100 IA=30 End Semester=70

[The project being of 12 credits, a student will have to devote 360 hours for the project work, which will be 45 working days if the students give 8 hours per day for the work. Students will begin the project work immediately after the 7th semester examination, will continue to work for maximum of 50 days including 5 days required for all sorts of communications with the host institution. During the tenure the student will have to attend online classes/interactions being taken by the faculties of the Department of the parent institution in free hours]

Objective and Expected Course outcome:

1. Students would learn how to correctly conduct scientific research.
2. They would acquire knowledge regarding how to assess and use sources of information.
3. They would understand scientific methods of data collection and analysis.
4. There would be development of specific laboratory skills, research methodology, and critical thinking abilities.

In this paper students will have to carry out project work (Laboratory experiments) either at their respective colleges or any other R&D laboratory and UGC recognized University under guidance of a faculty member.

The area of work is to be decided by the advisor. On completion of the project work students will have to submit the work in the form of a dissertation followed by oral presentation in the presence of faculty members and an external expert.

[Mark Distribution for evaluation of the Project Work

Laboratory Experiment

1. Literature Review	5 Marks
2. Objectives	5 Marks
3. Experimental work	25 Marks
4. Results & Discussions	25 Marks
5. Presentation and Viva	20 Marks
6. IA	20 Marks

Note: Students are encouraged to carry out laboratory experiments individually (However in case of infrastructural issues a maximum of 4 students can perform experiments together). The format of the report to be submitted is attached as **Annexure 1** below:

Annexure 1:

Guidelines for preparation of Dissertation / Project Report

1. Organization of the Dissertation/ Project Report:

The Dissertation/Project Report shall be presented in a number of chapters, starting with 'Introduction' and ending with 'Conclusion'. The chapters will have a precise title reflecting the contents of the chapter. A chapter can be subdivided into sections, sub-sections to present the content discretely. Total numbers of chapters may be ranged from1- 5(minimum) and 1-8(maximum).

1.1 Introduction:

The title of Chapter-I shall be 'Introduction'. It shall justify the research problem, define the topic and explain the aim and scope of the proposed research. The significant contribution from the investigation to civil society may also be focused in this chapter.

1.2 Review of Literature:

The title of Chapter-II shall be "Review of Literature". This chapter shall present a critical appraisal of the previous works published in the literature pertaining to the topic of the investigation.

1.3 Report on the Present Investigation:

The reporting on the investigation shall be presented in one or more chapters with appropriate title.

- Due importance shall be given to procedures and methodologies adopted.
- Figures and tables should be presented immediately following their first mention in the text. Short tables and figures (say, less than half the writing area of the page) should be presented within the text, while large tables and figures may be presented on separate pages.

1.4 Results and Discussions:

This is the penultimate chapter of the report and shall include a thorough evaluation of the research problem carried out and bring out the contributions from the study. The discussion shall logically

lead to meaningful conclusions.

1.5 Conclusions:

This is the last chapter of the report. A brief report of the work carried out shall form the first part of the chapter. Conclusions derived from the logical analysis presented in the "Results and Discussions" chapter shall be presented and clearly enumerated. This chapter should indicate the possibilities/ scope for future work in the concerned field.

NB: In non-empirical research, particularly in the discipline of Humanities and Social Sciences, textual/content analysis may be conceived in several chapters with appropriate title instead of present investigation, results and discussion.

1.6 Appendix:

Detailed information, lengthy derivations, observations etc. are to be presented in the separate appendices, which shall be numbered in Roman Capitals (e.g. "Appendix-I")

1.7 Bibliography:

This should follow the appendices, (if any), otherwise the Conclusion chapter. The researchers shall follow either the MLA (latest edition), or APA (latest edition) referencing style, or any other style whichever is accepted by the concerned department.

2. Dissertations/ Project Reports Format:

2.1 Paper:

The report shall be in printed form and the size of the paper shall be standard A4; height 297mm, width 210mm.

2.2 Type – Setting, Text Processing and Printing:

The text shall be printed on single side of a page employing laser jet or inkjet printer. The text having been processed using a standard text processor. The standard font should be **Time New Roman** of **12**pts with **1.5** line spacing for **English** text while **Geetanjali** of **12**pts with **1.5** line spacing and **Mangal / Unicode** of 12pts with 1.5 spacing for **Assamese** and **Hindi** texts respectively**.**

2.2.1 Page Format:

The Printed sheets shall have the following written area and margins: Top margin: 15mm

Head height	: 3mm
Head separation	: 12mm
Bottom margin	: 22mm
Footer	: 3mm
Foot separation	: 10mm
Left margin	: 30mm
Right margin	: 20mm
Text height	: 245mm
Text width	: 160mm

When header is not used, the top margin shall be 30mm.

2.2.2 Pagination:

Page numbering in the text of the Dissertation/Report shall be Hindu- Arabic numerals at the right corner of the Page. Page number "1" for the first page of the Introduction chapter should not appear in print; only the second page will bear the number "2". The subsequent chapters shall begin on a fresh page. Pagination for pages before the Introduction chapter shall be in lower case Roman numerals, e.g., "i", " ii" etc.

2.2.3 Header:

When the header style is chosen, the header can have the Chapter number and Section number (e.g., Chapter-II, Section-iii) on even numbered page headers and Chapter title or Section title on the numbered page header.

2.2.4 Paragraph format:

Vertical space between paragraphs shall be about 2.5 line spacing. A paragraph should normally comprise more than one line. A single line of a paragraph shall not be left at the top or bottom of a page.

2.3 Chapter and Section Format:

2.3.1 Chapter:

Each chapter shall begin on a fresh page with an additional

top margin of about 75mm. Chapter number (Roman Numerical) and title shall be printed at the centre of the line in 6mm font size (18pt) in bold face using both upper and lower case. (See the specimen: 'E')

2.3.2 Section and Sub-sections:

A chapter can be divided into Section and Sub-Sections so as to present different concepts separately. Sections and sub-sections can be numbered using decimal points, e.g. II. ii for the second section in Chapter-II and II. iii. 4 for the fourth Sub-section in third section of Chapter-II.

2.3.3 Table/ Figure Format:

Tables and figures should be presented in portrait style. Small size table and figures (less than half of writing area of a page) should be incorporated within the text, while larger ones may be presented on separate pages. Tables and figures shall be numbered chapter-wise. For example, the second figure in Chapter-IV will bear the number Figure IV.2 or Fig. IV.2.

3.0 Auxiliary Format:

3.1 Binding:

The final hard bound copies to be submitted after the viva-voce examination will be accepted during the submission of Dissertation/ Project Report with **black colour** for **P.G** and **brown colour** for **U.G** course respectively.

3.2 Front Covers:

The front covers shall contain the following details:

- Full title of Dissertation/ Project Report in 6mm 22point's size font properly centered and positioned at the top.
- Full name of the candidate in 4.5mm 15 point's size font properly centered at the middle of the page.
- A 50mm die replica of the institute emblem followed by the name of the supervisor, name of the department, name of the institute and the year of submission, each in a separate line and properly centered and located at the bottom of page.

3.2.1 Lettering:

All lettering shall be embossed in gold.

3.2.2 Bound back:

The degree, the name of the candidate and the year of submission shall also be embossed on the bound (side) in gold.

3.3 Blank Sheets:

In addition to the white sheets (binding requirement) two white sheets shall be put at the beginning and the end of the Dissertation/ Project Report.

3.4 Title Sheet:

This shall be the first printed page of the report and shall contain the submission statement: the Dissertation/ Project Report submitted in partial fulfilment of requirements of the------ Degree, the name and Roll No. of the candidate, name(s) of the Supervisor and Co- supervisor(s) (if any), Department, Institute and year of submission.

- Sample copy of the 'Title Sheet' is appended (Specimen 'A')

3.5 Approval Sheet:

This will form the first page of the Dissertation/ Project Report. Sample copy of the 'Internal Approval Sheet' is appended (Specimen 'B')

3.6 Internal Approval Sheet:

This will form the second page. A sample copy of the Approval Sheet is appended (Specimen 'C')

3.7 A Declaration of Academic Honesty and Integrity:

A declaration of academic honesty and integrity is required to be included along with every Dissertation/ Project Report after the internal approval sheet. The format of this declaration is given in Specimen 'D' attached.

3.8 Acknowledgements:

A list of acknowledgements is required to be included along with every Dissertation/ Project Report after the Declaration

sheet.

3.9 Contents:

NB: From 3.5 to 3.8, the pagination should be in Roman number with lower case.

Specimen 'A': Title Sheet

Title

(A Dissertation/Project Report submitted in partial fulfilment of the requirements of BA/BSc/MA/MSc degree in (subject))

by

(Name of the Student)
(Roll No. _____)
Registration No. ……

Supervisor(s):
(Name of Supervisor)

(Name of the Department)
North Lakhimpur College (Autonomous)

(Year)

Specimen 'B': Approval Sheet

Dissertation Approval for ……

This Dissertation/ Project Report entitled (**Title**) by (**Author Name**) is approved for the degree of _____(**Degree details**).

Examiners

1. ……

2. ……

Date:

Place:

Specimen 'C': Internal Approval Sheet

CERTIFICATE

This is to certify that the Dissertation/Project Report entitled "**Title of Dissertation/ Project**" is a bona-fide work of "**Name of student" (Roll No**…., **Regd. No……..**) submitted to the North Lakhimpur College (Autonomous) in partial fulfilment of the requirements for the award of "B.A./B. Sc./M.A/M. Sc. degree in..... (subject)"

(Name and Sign)
Supervisor

(Name and Sign)
Co-Supervisor

(Name and Sign)
Head of Department

Specimen 'D': Declaration

DECLARATION

I, (name), do hereby declare that the dissertation/ Project Report entitled "Title" represents my idea in my own words and where others' ideas or words have been included, I have adequately cited and referenced the original sources. I also declare that I have adhered to all principles of academic honesty and integrity and have not misinterpreted or fabricated or falsified any idea/ data/ fact/ source in my submission. I understand that any violation of the above will invite disciplinary action by the institute.

…….

(Signature)

……

(Name of student and Roll No)

Date :

Place:

Specimen 'E': Starting Chapter page Formatting.

Chapter – I

Introduction

1.1 (Specimen 'E')

1.2 Formatting Guidelines

Works cited

.....

Chapter – II

Title

2.1 .....

2.2 .....

Works cited

.....

Specimen 'F': Standards Style references

References

MLA 9th Edition

Refer to Appendix- I (for

quick guide) APA 7th Edition

Refer to Appendix- II (for quick guide)