B.Sc. (Life Science) with Chemistry as one of the core discipline

(Semester-I)
Based on
Undergraduate Curriculum Framework 2022 (UGCF)
(Effective from Academic Year 2022-23)

University of Delhi

Course Title	Nature of the Course	Total Credits	Components			Eligibility Criteria/ Prerequisite
			Lecture	Tutorial	Practical	
Basic Concepts of Organic Chemistry	DSC-Chemistry	04	02	-	02	Chemistry+Physics+Biology/ Biological studies/Biotechnology

Course Code : CHEM-DSC-01
Course Title: Basic Concepts of Organic Chemistry
Total Credits: 04 (Credits: Theory-02, Practical-02)
Total Lectures: Theory- 30, Practical- 15 classes of 4 hours each

Objectives: The course is infused with the recapitulation of fundamentals of organic chemistry and the introduction of the concept of visualizing the organic molecules in a three-dimensional space. To establish the applications of these concepts, a study of diverse reactions through mechanisms is included. The constitution of the course strongly aids in the paramount learning of the basic concepts and their applications.

Learning Outcomes:
By the end of the course, the students will be able to:

- Understand and explain the differential behavior of organic compounds based on fundamental concepts learnt.
- Understand the fundamental concepts of stereochemistry.
- Formulate the mechanism of organic reactions by recalling and correlating the fundamental properties of the reactants involved.
- Learn and identify many organic reactions and their mechanisms including electrophilic addition, nucleophilic addition, nucleophilic substitution, electrophilic substitution and rearrangement reactions.

Unit 1: Fundamentals of organic chemistry — Lectures: 05

Types of Electronic displacements: Inductive effect, Resonance effect, Hyperconjugation, Electromeric Effect. Reactive intermediates and their stability: carbocations, free radicals, carbanions, benzyne, carbenes.
Acidity and basicity in organic compounds (comparison of carboxylic acids, alcohols, phenols, primary, secondary and tertiary aliphatic amines, aniline and its derivatives)

UNIT 2: Stereochemistry — Lectures: 07

Types of projection formulae: Flying Wedge Formula, Newmann, Sawhorse and Fischer representations and their interconversion.
Stereoisomerism: Concept of chirality (upto two carbon atoms). Configurational isomerism: geometrical and optical isomerism; enantiomerism, diastereomerism and meso compounds). Threo and erythro; D and L; *Cis-trans* nomenclature; CIP Rules: R/ S (for upto 2 chiral carbon atoms) and *E*/*Z* nomenclature (for upto two C=C systems).
Conformational isomerism with respect to ethane, butane and cyclohexane.

UNIT 3: Types of Organic Reactions (Including reactions of alkenes, alkyl and aryl halides, alcohols, aldehydes, ketones)

Lectures: 18

Electrophilic addition reactions

Electrophilic addition reaction (with respect to propene, propyne, 3,3-dimethyl-1-butene): Hydration, Addition of HX in the absence and presence of peroxide, Hydroboration oxidation, Addition of bromine (with stereochemistry).

Nucleophilic addition reactions

Nucleophilic addition reaction of carbonyl compounds: Addition of HCN, ammonia derivatives (Hydroxylamine, Hydrazine, Semicarbazide and 2,4-DNP), the addition of carbanion (Aldol condensation, Claisen Schmidt, Benzoin condensation, Perkin reaction, reactions involving Grignard reagent).

Elimination and Nucleophilic substitution reactions

Nucleophilic substitution reaction (S_N1 and S_N2) in alkyl halides (mechanisms with stereochemical aspect), alcohols (with nucleophiles like ammonia, halides, thiols, ambident nucleophiles (cyanide and nitrite ion)), ethers (Williamson ether synthesis), Elimination reaction (E1 & E2), elimination *vs* substitution (*w.r.t.* potassium t-butoxide and KOH); Nucleophilic aromatic substitution in aryl halides-elimination addition reaction *w.r.t.* chlorobenzene, including the effect of nitro group (on the ring) on the reaction. relative reactivity and strength of C-X bond in alkyl, allyl, benzyl, vinyl and aryl halides towards substitution reactions

Electrophilic substitution reactions

Electrophilic Aromatic substitution with mechanism (benzene)- sulphonation, nitration, halogenation, Friedel craft acylation :*o*-, *m*- and *p*- directive influence giving examples of toluene/nitrobenzene/ phenol/ aniline/ chlorobenzene.

Reactive intermediates and Rearrangement Reactions

Free radicals (Birch Reduction); *Carbocations* (Pinacol-Pinacolone, Wagner-Meerwein, Rearrangement, and Beckmann rearrangement); *Carbanions (*Michael Addition); *Carbenes* (Reimer-Tiemann).

PRACTICALS: 60 hours

(Laboratory periods: 15 classes of 4 hours each)

1. Purification of an organic compound by crystallization (from water and alcohol) and distillation, Criteria of purity: Determination of M.P.
2. Determination of boiling point of liquid compounds. (Boiling point lower than and more than 100 °C by distillation and capillary method)
3. Detection of extra element
4. Preparations: (Mechanism of various reactions involved to be discussed).

a. Bromination of phenol/aniline.
b. 2,4-Dinitrophenylhydrazone of aldehydes and ketones
c. Semicarbazone of aldehydes/ ketones
d. Aldol condensation reaction using green method.
e. Bromination of Stilbene.
f. Acetanilide to p-Bromoacetanilide.

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

References:

Theory:

1. Sykes, P.(2003), **A Guide Book to Mechanism in Organic Chemistry,** 6th Edition Pearson Education.
2. Eliel, E. L. (2001), **Stereochemistry of Carbon Compounds**, Tata McGraw Hill.
3. Morrison, R. N.; Boyd, R. N., Bhattacharjee, S.K. (2010), **Organic Chemistry**, 7th Edition, Pearson Education.
4. Bahl, A; Bahl, B. S. (2019), **Advanced Organic Chemistry**, 22nd Edition, S. Chand.

Practical:

1. Furniss, B.S.; Hannaford, A.J.; Smith, P.W.G.; Tatchell, A.R. (2012), **Vogel's Textbook of Practical Organic Chemistry**, Pearson.
2. Mann, F.G.; Saunders, B.C. (2009), **Practical Organic Chemistry**, Pearson Education.
3. Dhingra, S; Ahluwalia V.K., (2017), **Advanced Experimental Organic Chemistry**, Manakin Press.
4. Pasricha, S., Chaudhary, A. (2021), **Practical Organic Chemistry: Volume I**, I K International Publishing House Pvt. Ltd., New Delhi.

Teaching Learning Process:

- Blend of conventional blackboard teaching, modern teaching learning tools and
- Computational infrastructure- based instructions and Practical training.
- Problem solving and quizzes for enhanced understanding of the concepts.
- Explaining the handling and usage of the hardware and softwares required for solution to the given set of problems.

Assessment Methods:

- Presentations by individual student/ group of students
- Class Tests at periodic intervals.
- Written assignment(s)
- End semester University theory examination presentations by individual student/ group of students

Keywords: Chirality, Electrophilic addition, Nucleophilic addition, Nucleophilic substitution, Electrophilic substitution

BSc. Life Science with Chemistry as one of the Core Discipline

DISCIPLINE SPECIFIC CORE COURSE

SEMESTER-II

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Chemical Bonding and Elements in Biological System CHEM-DSC-02	4	2	0	2	Class XII Pass	----

Learning Objectives

The Learning Objectives of this course are as follows:

- Students gain basic knowledge of chemical bonding in compounds which is a necessary pre-requisite in understanding the general properties of the compound.
- Unit 2 reviews the importance of inorganic chemical species, especially metals in biological systems, their classification and detailed discussion of toxic metals.
- The discussions also provide them the details of sodium-potassium pump, role of some metal ions such as calcium, magnesium and the role of iron in transport and storage system

Learning outcomes

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

- Understand the concept of lattice energy using Born-Landé and Born Haber Cycle and their applications
- Rationalize the conductivity of metals, semiconductors and insulators based on the Band theory.
- Understand the importance and application of chemical bonds, inter-molecular and intramolecular weak chemical forces and their effect on melting points, boiling points, solubility and energetics of dissolution.
- Know about the essential, non-essential, trace and toxic metal ions and their role in biological system and effects of their deficiency. They will also learn their dose response relationship curves.
- Understand active and Passive transport and diagrammatically explain the working of

the sodium-potassium pump in organisms and the factors affecting it

- Explain the sources and consequences of excess and deficiency of trace metals and learn about the toxicity of certain metal ions, the reasons for toxicity
- Storage and transport of iron in bio-systems

SYLLABUS OF DSC-4

Unit I: Chemical Bonding (18 Hours)

Ionic Bonding: General characteristics of ionic bonding, Lattice Enthalpy and Solvation Enthalpy and their relation to stability and solubility of ionic compounds, Born-Lande equation for calculation of Lattice Enthalpy (no derivation), 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: Valence Bond Approach, Hybridization and VSEPR Theory with suitable examples, Concept of resonance and resonating structures in various inorganic and organic compounds, Molecular Orbital Approach: Rules for the LCAO method, bonding, nonbonding and antibonding MOs and their characteristics for s-s, s-p and p-p combinations of atomic orbitals, MO treatment of homonuclear diatomic molecules of 1^{st} and 2^{nd} periods (including idea of s-p mixing) and heteronuclear diatomic molecules such as CO, NO and NO^+.

Brief introduction to Metallic Bonding, Hydrogen Bonding, van der Waals forces

Unit II: Elements in Biological System (12 Hours)

Classification of elements in biological system, Geochemical effect on the distribution of metals, Metal ions present in biological systems with special reference to Na^+, K^+, Ca^{2+}, Mg^{2+}, Fe^{2+}, Cu^{2+} and Zn^{2+}, Sodium / K-pump, Role of Ca^{2+} (blood clotting and structural), Role of Mg^{2+} in chlorophyll and energy production, Excess and deficiency of some trace metals, Toxicity of metal ions (Hg, Pb, Cd and As), reasons for toxicity, Dose response relationship curves of metal ions, Iron and its application in bio-systems, Storage and transport of iron.

PRACTICALS: 60 Hours

1. Preparation of standard solutions.
2. Estimation of Sodium carbonate using HCl by acid base titration.
3. Estimation of carbonate and hydroxide present together in a mixture.
4. Estimation of carbonate and bicarbonate present together in a mixture.
5. Estimation of free alkali present in different soaps/detergents
6. Estimation of oxalic acid using $KMnO_4$ by redox titration.
7. Estimation of Mohr's salt using $KMnO_4$ by redox titration.
8. Determination of dissolved oxygen in water.
9. Estimation of Fe (II) ions by titrating it with $K_2Cr_2O_7$ using internal and external indicators.
10. Estimation of Cu (II) ions iodometrically using $Na_2S_2O_3$
11. Paper Chromatographic separation of mixture of metal ions

a. Cu^{2+}, Cd^{2+}
b. Ni^{2+}, Co^{2+}.

12. Any suitable experiment (other than the listed ones) based upon neutralisation/redox reactions.

References:

Theory:

1. Lee, J.D.; (2010), **Concise Inorganic Chemistry**, Wiley India.
2. Huheey, J.E.; Keiter, E.A.; Keiter; R. L.; Medhi, O.K. (2009), **Inorganic Chemistry-Principles of Structure and Reactivity**, Pearson Education.
3. Douglas, B.E.; McDaniel, D.H.; Alexander, J.J. (1994), **Concepts and Models of Inorganic Chemistry**, John Wiley & Sons.
4. Atkins, P.W.; Overton, T.L.; Rourke, J.P.; Weller, M.T.; Armstrong, F.A. (2010), Shriver and Atkins **Inorganic Chemistry**, 5th Edition, Oxford University Press.
5. Crichton, R.; (2019), **Biological inorganic chemistry**: **a new introduction to molecular structure and function**, third edition, Elsevier, Academic Press.
6. Kaim, W; Schwederski, B.; Klein, A. (2013), **Bioinorganic Chemistry - Inorganic Elements in the Chemistry of Life: An Introduction and Guide**, 2nd Edition, Wiley.

Practical:

1. Jeffery, G.H.; Bassett, J.; Mendham, J.; Denney, R.C. (1989), **Vogel's Textbook of Quantitative Chemical Analysis**, John Wiley and Sons.

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Bachelor of Sciences (Life Sciences)

BSc (Life Sciences) with Chemistry as one of the Core Discipline

SEMESTER-III

DISCIPLINE SPECIFIC CORE COURSE Chemistry -III Chemical Energetics and Equilibria

Credit distribution, Eligibility and Pre-requisites of the Course

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Chemical Energetics and Equilibria (DSC Chemistry 03:	04	02	00	02	Passed Class 12th with Physics, Chemistry, Mathematics	NIL

Learning objectives

The objectives of this course are as follows:

- To develop basic understanding of the chemical energetics, laws of thermodynamics and ionic equilibrium.
- to provides basic understanding of the behaviour of electrolytes and their solutions.
- To make students learn about the properties of ideal and real gases and deviation from ideal behavior

Learning outcomes

By studying this course, students will be able to:

- Explain the laws of thermodynamics, thermochemistry and equilibria.
- Use the concept of pH and its effect on the various physical and chemical properties of the compounds.
- Use the concepts learnt to predict feasibility of chemical reactions and to study the behaviour of reactions in equilibrium

SYLLABUS

UNIT-1: Chemical Energetics **(16 Hours)**

Recapitulation of Intensive and extensive variables; state and path functions; Isolated, closed and open systems

First law

Concept of heat (Q), work (W), internal energy (U), and statement of first law; enthalpy (H), relation between heat capacities for ideal gas, Joule's experiment, calculations of Q, W, ΔU and ΔH for reversible expansion of ideal gases under isothermal conditions.

Thermochemistry

Enthalpy of reactions: standard states; enthalpy of neutralization, enthalpy of ionization enthalpy of hydration, enthalpy of formation and enthalpy of combustion, Integral enthalpy of solution, bond dissociation energy and bond enthalpy; Hess's law, Born Haber's cycle (NaCl/ KCl).

Second Law

Concept of entropy; statements of the second law of thermodynamics (Kelvin and Clausius). Calculation of entropy change for reversible processes (for ideal gases). Free Energy Functions: Gibbs and Helmholtz energy (Non-PV work and the work function); Free energy change and concept of spontaneity (for ideal gases).

Third Law

Statement of third law, qualitative treatment of absolute entropy of molecules (examples of NO, CO), concept of residual entropy

UNIT-2: Chemical Equilibrium (4 Hours)

Criteria of thermodynamic equilibrium. Free energy change in a chemical reaction and equilibrium constant, exergenic and endergenic reactions with examples such conversion of ATP to ADP or vice verca,, Le Chatelier's principle, relationship between Kp, Kc and Kx for reactions involving ideal gases.

UNIT-3: Ionic Equilibria (10 Hours)

Strong, moderate and weak electrolytes, degree of ionization, factors affecting degree of ionization, Ostwald's dilution law, ionization constant and ionic product of water, ionization of weak acids and bases, Degree of ionization, pH scale, common ion effect, Buffer solutions, Henderson-Hasselbach equation. Solubility and solubility product of sparingly soluble salts – applications of solubility product principle

Practical Component: 60 Hours

(Laboratory periods: 15 classes of 4 hours each)

Chemical Energetics:

1. Determination of heat capacity of calorimeter.
2. Determination of enthalpy of neutralization of hydrochloric acid with sodiumhydroxide.
3. Determination of the enthalpy of ionization of acetic acid.
4. Determination of enthalpy of neutralization of acetic acid and ammonium hydroxide using Hess's law.

5. Determination of integral enthalpy of solution (both endothermic and exothermic) of salts.
6. Determination of enthalpy of hydration of Copper sulphate.

Ionic equilibria:

7. Preparation of buffer solutions: (i) Sodium acetate-acetic acid or (ii) Ammonium chloride-ammonium acetate. Measurement of the pH of buffer solutions and comparison of the values with theoretical values.
8. Study the effect of addition of HCl/NaOH on pH of the buffer solutions (acetic acid, and sodium acetate).
9. pH metric titration of strong acid with strong base,
10. pH metric titration of weak acid with strong base

References:

Theory:

1. Castellan, G. W. (2004),**Physical Chemistry**,Narosa.
2. Kapoor, K. L. (2015),**A Textbook of Physical Chemistry**,Vol 1, 6th Edition, McGraw Hill Education.
3. Kapoor, K. L. (2015), **A Textbook of Physical Chemistry**, Vol 2, 6thEdition, McGraw Hill Education.
4. Puri, B. R., Sharma, L. R. and Pathania M. S. (2020), **Principles of Physical Chemistry**, Vishal PublishingCo.

Practical:

1. Khosla,B. D.;Garg,V. C.; Gulati,A.(2015), **SeniorPracticalPhysicalChemistry**,R.Chand&Co.
2. Kapoor, K. L. (2019), **A Textbook of Physical Chemistry**, Vol 7, 1st Edition, McGraw Hill Education.
3. Batra, S. K., Kapoor, V and Gulati, S. (2017) 1st Edition, **Experiments in Physical Chemistry,** Book Age series.

Additional Resources:

1. Mahan, B. H.(2013), **University Chemistry**,Narosa.
2. Barrow, G. M. (2006), **Physical Chemistry**, 5thEdition, McGrawHill.

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

BSC. (LIFE SCIENCE)- CHEMISTRY COMPONENT

SEMESTER-IV

DISCIPLINE SPECIFIC CORE COURSE CHEM-DSC - 04 Chemistry- IV: Chemistry of Carboxylic Acids & their Derivatives, Amines and Heterocycles

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Chemistry of Carboxylic Acids & their Derivatives, Amines and Heterocycles DSC-Chemistry- 04	**04**	**02**	**-**	**02**	**Class 12th with Physics, Chemistry, Mathematics**	

Learning Objectives

The Learning Objectives of this course are as follows:

- To introduce the basics of coordination chemistry and which are of immense importance to biological systems, qualitative and quantitative analysis, catalysis, medicines, paints and pigments etc.
- Nomenclature, isomerism, bonding in coordination compounds has been dealt with in sufficient detail along with special emphasis on important coordination compounds in the biological system.

Learning outcomes

By studying this course, students will be able to:

- Understand terms: ligand, denticity of ligands, chelate, coordination number.
- Systematically name coordination compounds.
- Discuss the various types of isomerism possible in Octahedral and Tetrahedral coordination compounds.
- Use Valence Bond Theory to predict the structure and magnetic behaviour of metal complexes and understand the terms inner and outer orbital complexes.
- Explain the meaning of the terms $\Delta o.$, Δt, pairing energy, CFSE, high spin and low spin and how CFSE affects thermodynamic properties like lattice enthalpy and hydration enthalpy.
- Explain magnetic properties and colour of complexes on basis of Crystal Field Theory
- Understand reaction mechanisms of coordination compounds and differentiate between kinetic and thermodynamic stability.
- Discuss the application of coordination compounds in the biological systems such as Heamoglobin, myoglobin and some enzymes

Syllabus

Unit 1: Carboxylic acids and their Derivatives (aliphatic and aromatic) (Hours:13)

Preparation: Oxidation reactions of alcohols, aldehydes and ketones, Acidic and alkaline hydrolysis of esters; Reactions: Hell-Volhard Zelinsky reaction,

Carboxylic acid derivatives (aliphatic): Preparation: Acid chlorides, anhydrides, esters and amides from acids and their interconversion, Claisen condensation. Reactions: Relative reactivities of acid derivatives towards nucleophiles, Reformatsky reaction, Perkin condensation.

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

Unit 2: Amines (aliphatic & aromatic) and Diazonium Salts (Hours:10)

Amines

Preparation: from alkyl halides, Gabriel's Phthalimide synthesis, Hofmann Bromamide reaction. Reactions: Hofmann *vs* Saytzeff elimination, carbylamine test, Hinsberg test, reaction with HNO_2, Schotten-Baumann reaction. Electrophilic substitution (case aniline): nitration, bromination, sulphonation; basicity of amines.

Diazonium salt

Preparation: from aromatic amines; Reactions: conversion to benzene, phenol and dyes.

Unit 3: Heterocyclic Compounds (Hours:07)

Introduction, classification, structure, nomenclature and uses. Preparation and properties of the following heterocyclic compounds with reference to electrophilic and nucleophilic substitution: furan, pyrrole, thiophene, and pyridine.

PRACTICALS: Credits: 02

(Laboratory periods: 60)

1. Systematic qualitative analysis and preparation of suitable crystalline derivative (carboxylic acids, carbonyl, alcohols, phenols, amines (1°, 2°,3°) and amides).
2. Preparation:

    a. Acetylation of Aniline and Phenols.
    b. Benzoylation of Aniline and phenols.

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

References:

Theory:

1. Morrison, R. N.; 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. Ahluwalia, V.K.; Bhagat, P.; Aggarwal, R.; Chandra, R. (2005), **Intermediate for Organic Synthesis**, I.K. International.

4. Solomons, T. W. G.; Fryhle, C. B.; Snyder, S. A. (2016), **Organic Chemistry**, 12th Ed., Wiley.

5. Parashar, R.K., Negi, B. (2016) **Chemistry of Heterocyclic Compounds**, Ane Books Pvt Ltd.

Practical:

1. Ahluwalia, V.K.; Dhingra, S.; Gulati, A. (2005), **College Practical Chemistry**, University Press (India) Ltd.

2. Ahluwalia, V.K.; Dhingra, S. (2004), **Comprehensive Practical Organic Chemistry: Qualitative Analysis**, University Press.

3. Pasricha, S., Chaudhary, A. (2021), **Practical Organic Chemistry: Volume I**, I K International Publishing House Pvt. Ltd., New Delhi.

4. Pasricha, S., Chaudhary, A. (2021), **Practical Organic Chemistry: Volume II**, I K International Publishing House Pvt. Ltd., New Delhi.

5. Vogel, A.I. (1972), **Textbook of Practical Organic Chemistry**, Prentice-Hall.

6. Jeffery, G.H.; Bassett, J.; Mendham, J.; Denney, R.C. (1989), **Vogel's Textbook of Quantitative Chemical Analysis**, John Wiley and Sons.

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BSC. (LIFE SCIENCE)- CHEMISTRY COMPONENT

SEMESTER-V

DISCIPLINE SPECIFIC CORE COURSE CHEM-DSC Chemistry- V: Coordination Chemistry and its Application in Biological Systems

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Coordination Chemistry and its Application in Biological Systems DSC Chemistry- 5	**04**	**02**	**-**	**02**	**Class 12th with Physics, Chemistry, Mathematics**	

Learning Objectives

The Learning Objectives of this course are as follows:

- To introduce the basics of coordination chemistry and which are of immense importance to biological systems, qualitative and quantitative analysis, catalysis, medicines, paints and pigments etc.
- Nomenclature, isomerism, bonding in coordination compounds has been dealt with in sufficient detail along with special emphasis on important coordination compounds in the biological system.

Learning outcomes

By studying this course, students will be able to:

- Understand terms: ligand, denticity of ligands, chelate, coordination number.
- Systematically name coordination compounds.
- Discuss the various types of isomerism possible in Octahedral and Tetrahedral coordination compounds.
- Use Valence Bond Theory to predict the structure and magnetic behaviour of metal complexes and understand the terms inner and outer orbital complexes.
- Explain the meaning of the terms $\Delta o.$, Δt, pairing energy, CFSE, high spin and low spin and how CFSE affects thermodynamic properties like lattice enthalpy and hydration enthalpy.
- Explain magnetic properties and colour of complexes on basis of Crystal Field Theory

- Understand reaction mechanisms of coordination compounds and differentiate between kinetic and thermodynamic stability.
- Discuss the application of coordination compounds in the biological systems such as Heamoglobin, myoglobin and some enzymes

Syllabus

Unit 1: Introduction to Coordination Compounds (Hours: 6)

Brief discussion with examples of types of ligands, denticity and concept of chelate. IUPAC system of nomenclature of coordination compounds (mononuclear and binuclear) involving simple monodentate and bidentate ligands. Structural and stereoisomerism in complexes with coordination numbers 4 and 6.

Unit 2: Bonding in Coordination Compounds (Hours: 14)

Valence Bond Theory (VBT): Salient features of theory, concept of inner and outer orbital complexes, Drawbacks of VBT.

Crystal Field Theory: Splitting of d orbitals in octahedral symmetry. Crystal field effects for weak and strong fields, Crystal field stabilization energy (CFSE), concept of pairing energy, Factors affecting the magnitude of Δ, Spectrochemical series, Splitting of d orbitals in tetrahedral symmetry, Comparison of CFSE for octahedral and tetrahedral fields, tetragonal distortion of octahedral geometry, Jahn-Teller distortion.

Unit 3: Thermodynamic and Kinetic aspects of Metal Complexes (Hours: 6)

A brief outline of thermodynamic and kinetic stabilities of metal complexes and factors affecting the stability. Substitution reactions of square-planar complexes – Trans effect: cisplatin and transplatin.

Unit 4: Application of coordination compounds in biological systems (Hours: 4)

Haemoglobin, Myoglobin, carboxypeptidase, carbonic anhydrase

Practicals Component **Credits: 02**
(Laboratory periods: 60)

1. Estimation of Mg^{2+} by direct complexometric titrations using EDTA.
2. Estimation of Zn^{2+} by direct complexometric titrations using EDTA.
3. Estimation of Ca^{2+} by direct complexometric titrations using EDTA.
4. Estimation of Zn^{2+} in zinc tablet.
5. Estimation of Ca^{2+} in milk sample.
6. Estimation of total hardness of a given sample of water by complexometric titration.
7. Determination of the composition of the Fe^{3+} - salicylic acid complex / Fe^{2+} -1,10-phenanthroline complex in solution by Job's method
8. Determination of the composition of the Fe^{3+} - salicylic acid complex / Fe^{2+}-1,10-phenanthroline complex in solution by mole ratio method

9. Preparation of the following inorganic compounds:
   a). Tetraamminecopper(II) sulphate
   b). Potassium trioxalatoferrate(III) trihydrate
   c). Chrome alum
10. Any suitable experiment (other than the listed ones) based upon complexation reactions.

References:

Theory:

9. Huheey, J.E.; Keiter, E.A., Keiter; R. L.; Medhi, O.K. (2009), **Inorganic Chemistry- Principles of Structure and Reactivity**, Pearson Education.
10. Shriver, D.D.; Atkins, P.; Langford, C.H. (1994), **Inorganic Chemistry** 2nd Ed., Oxford University Press.
11. Atkins, P.W.; Overton, T.L.; Rourke, J.P.; Weller, M.T.; Armstrong, F.A. (2010), **Inorganic *Chemistry***, 5th Edition, W. H. Freeman and Company.
12. Cotton, F.A.; Wilkinson, G.; Gaus, P.L. **Basic Inorganic Chemistry**, 3rd Edition, Wiley India.
13. Douglas, B.E.; McDaniel, D.H.; Alexander, J.J. (1994), **Concepts and Models of Inorganic Chemistry**, John Wiley & Sons.
14. Greenwood, N.N.; Earnshaw, A. (1997), **Chemistry of the Elements**, 2nd Edition, Elsevier.
15. Lee, J.D.; (2010), **Concise Inorganic Chemistry**, Wiley India.
16. Sodhi G.S., Principles of Inorganic Chemistry, Third Edition, Viva Books, India.

Practicals:

1. Jeffery, G.H.; Bassett, J.; Mendham, J.; Denney, R.C. (1989), **Vogel's Textbook of Quantitative Chemical Analysis**, John Wiley and Sons.
2. Marr, G.; Rockett, B.W. (1972), **Practical Inorganic Chemistry**, Van Nostrand Reinhold.
3. Dua A, Manav N, **Practical Inorganic Chemistry,** (2017), Manakin Press.

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BSC. (LIFE SCIENCE)- CHEMISTRY COMPONENT

SEMESTER-VI

DISCIPLINE SPECIFIC ELECTIVE COURSE CHEM-DSC : Chemistry- VI: Conductance, Electrochemistry and Chemical Kinetics

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Conductance, Electrochemistry and Chemical Kinetics DSC-Chemistry- 6	**04**	**02**	**-**	**02**	**Class XII with Science**	

Learning Objectives

The Learning Objectives of this course are as follows:

- To develop basic understanding of electrolytic and galvanic cells.
- Measurementof conductance and its applications, measurement of emf and its applications.
- To understand reaction rate, order, activation energy and theories of reaction rates.

Learning outcomes

By studying this course, students will be able to:

- Explain the factors that affect conductance, migration of ions and application of conductance measurement.
- Understand the importance of Nernst equation, measurement of emf, calculations of thermodynamic properties and other parameters from the emf measurements.
- Understand rate law and rate of reaction, theories of reaction rates and catalysts; both chemical and enzymatic.

Syllabus

Unit 1: Conductance **(Hours: 8)**

Conductivity, equivalent and molar conductivity and their variation with dilution for weak and

strong electrolytes, Kohlrausch Law of independent migration of ions, Ionic velocity, mobility and their determination, transference number and its relation to ionic mobility, Conductometric titrations (only acid-base).

Unit 2: Electrochemistry **(Hours: 12)**

Concept of reversible and irreversible electrochemical cells, Standard hydrogen electrode, standard electrode potential, concept of EMF of a cell, measurement of EMF of a cell, Nernst equation and its importance, types of electrodes (Reference and inert electrodes), electrochemical series.

Thermodynamics of a reversible cell, calculation of thermodynamic properties: G, H and S from EMF data. Calculation of equilibrium constant from EMF data. pH determination using glass electrode, Potentiometric titrations-qualitative treatment (acid-base and oxidation-reduction only).

Unit 3: Chemical Kinetics and Catalysis **(Hours: 10)**

The concept of reaction rates, effect of temperature, pressure, catalyst and other factors on reaction rates. Order and molecularity of a reaction, integrated rate equations for zero, first and second order reactions (derivation not required), half–life of a reaction, Concept of activation energy and its calculation from Arrhenius equation.

Catalysis: Types of catalyst, specificity and selectivity, generalized treatment of catalyzed reactions at solid surfaces. Enzyme catalysis, Michaelis-Menten mechanism, acid-base catalysis.

Practical Component: **Credits:02**

Laboratory periods: 60

1. Determination of molar conductance, degree of dissociation and dissociation constant of a weak acid.
2. Perform the following conductometric titrations: Strong acid vs strong base.
3. Perform the following conductometric titrations: Weak acid vs strong base.
4. Determination of TDS of water from different sources.
5. Determination of Soil pH of soil collected from various locations.
6. Perform the potentiometric titrations of strong acid vs strong base
7. Perform the potentiometric titrations of Weak acid vs strong base.
8. Perform the potentiometric titrations of Potassium dichromate vs. Mohr's salt.
9. Perform the potentiometric titrations of $KMnO_4$ vs. Mohr's salt.
10. Study the kinetics of acid hydrolysis of methyl acetate with hydrochloric acid.

References:

Theory:

1. Castellan, G. W .(2004), **Physical Chemistry**, Narosa Publications.
2. Kapoor, K.L. (2015),**A Textbook of Physical Chemistry**, Vol.1, 6th Edition, McGraw Hill Education.
3. Kapoor, K.L. (2015),**A Textbook of Physical Chemistry**, Vol.5, 3rd Edition, McGraw Hill Education.
4. Puri, B.R., Sharma, L.R. and Pathania M.S. (2020), **Principles of Physical Chemistry,** Vishal Publishing Co.

Practical:

1. Khosla, B.D.; Garg, V.C.; Gulati, A.(2015), **Senior Practical Physical Chemistry**, R. Chand & Co.
2. Kapoor, K.L. (2019), **A Textbook of Physical Chemistry**, Vol 7, 1st Edition, McGraw Hill Education.
3. Batra, S.K., Kapoor, V and Gulati, S. (2017) 1st Edition, **Experiments in Physical Chemistry,** Book Age series.

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

POOL OF DISCIPLINE SPECIFIC ELECTIVES FOR SEMESTER -III/IV/V/VI

SEMESTER III

DISCIPLINE SPECIFIC ELECTIVE COURSE CHEM-DSE -1: Main Group Chemistry

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical / Practice		
Chem-DSE 1: Main Group Chemistry	**04**	**02**	**-**	**02**	**Class XII with Science**	

Learning Objectives

The Learning Objectives of this course are as follows:

- To provide basic understanding of the fundamental principles of metallurgy through study of the different methods of extraction and refining of metals.
- To illustrate the diversity and fascinating aspects of inorganic chemistry through the study of structure, properties and utilities of s- and p-block elements and their compounds.

Learning outcomes

By studying this course, students will be able to:

- Understand the basis of occurrence of metals in nature and the methods that can be applied on minerals to extract the metals from them.
- Explain the importance of free energy of formation of oxides with the choice of reducing agents for extracting the metals.
- Understand and explain the importance of refining of metals and the choice of a refining procedure.
- Explain the group trends observed for different properties of s and p block elements.
- Explain the structures and the bonding of compounds of s- and p- block elements
- Explain the unique properties of alkali metals and some other main group elements
- Understand and explain the polymerization mechanism of inorganic ions to generate inorganic polymers and the difference between organic and inorganic polymers.

Syllabus

Unit 1: General Principles of Metallurgy **(Hours: 6)**

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 with reference to cyanide process for silver and gold. Methods of purification of metals: Electrolytic process, Van Arkel-De Boer process, Zone refining.

Unit 2: General Properties **(4 Hours)**

General group trends of s- and p-block elements with special reference to melting and boiling points, flame colour, metallic character and complex formation tendency, diagonal relationship and anomalous behaviour of first member of each group, Alkali metal solutions in liquid ammonia

Unit 3: Structure, Bonding, Properties and Applications **(Hours: 16)**

Structure, bonding, properties (Acidic/Basic nature, stability, ionic/covalent nature, oxidation/reduction, hydrolysis, thermal stability) and applications of the following:

Crown Ethers and cryptates of Alkali metals
Hydrides: hydrides of Group 13 (only diborane), Group 14, Group 15 (EH_3 where E = N, P, As, Sb, Bi), Group 16 and Group 17.
Oxides: Oxides of nitrogen, phosphorus and sulphur.
Oxoacids: oxoacids of phosphorus, sulphur and chlorine
Halides of phosphorus

Unit 4: Inorganic Polymers **(4 Hours)**

Preparation, properties, structure and uses of the following:
Borazine, Silicates and Silicones.

Practicals **Credits:02**

(Laboratory periods:60)

Qualitative semi-micro analysis of mixtures containing 2 anions and 2 cations (preferably 7-8 mixtures). Emphasis should be given to the understanding of the chemistry of different reactions. The following radicals are suggested:

CO_3^{2-}, NO_2^- , S^{2-}, SO_3^{2-}, SO_4^{2-} , $S_2O_3^{2-}$, CH_3COO^-, F^-, Cl^-, Br^-, I^- , NO_3^- , BO_3^{3-}, $C_2O_4^{2-}$, PO_4^{3-}, NH_4^+, K^+, Pb^{2+} , Cu^{2+}, Cd^{2+}, Bi^{3+}, Sn^{2+}, Sb^{3+}, Fe^{3+}, Al^{3+}, Cr^{3+}, Zn^{2+}, Mn^{2+}, Co^{2+}, Ni^{2+}, Ba^{2+}, Sr^{2+}, Ca^{2+}, Mg^{2+}.
The mixtures may contain combination of anions/one interfering anion.
Spot tests should be preferred wherever applicable.

References:

Theory:

1. Lee, J.D.; (2010), **Concise Inorganic Chemistry**, Wiley India.
2. Huheey, J.E.; Keiter, E.A.; Keiter; R. L.; Medhi, O.K. (2009), **Inorganic Chemistry- Principles of Structure and Reactivity**, Pearson Education.
3. Douglas, B.E.; McDaniel, D.H.; Alexander, J.J. (1994), **Concepts and Models of Inorganic Chemistry**, John Wiley & Sons.
4. Atkins, P.W.; Overton, T.L.; Rourke, J.P.; Weller, M.T.; Armstrong, F.A. (2010), Shriver and **Atkins Inorganic Chemistry**, 5th Edition, Oxford University Press.
5. Housecraft, E. H.; Sharpe, A.G. (2018), **Inorganic Chemistry**, 5th Edition, Pearson.
6. F.A. Cotton & G. Wilkinson (1999), **Advanced Inorganic Chemistry**, 6th Edition, John Wiley & Sons.

Practicals:

1. Vogel, A.I. (1972), **Qualitative Inorganic Analysis**, Longman.
2. Svehla, G. (1996), **Vogel's Qualitative Inorganic Analysis**, Prentice Hall.
3. Dua A, Manav N, **Practical Inorganic Chemistry,** (2017), Manakin Press.

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

DISCIPLINE SPECIFIC ELECTIVE COURSE CHEM-DSE -2: Green Chemistry

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Chem-DSE-2: Green Chemistry	**04**	**02**	**-**	**02**	**Class XII with Science**	

Learning Objectives

The Learning Objectives of this course are as follows:

- To learn about the environmental status, public awareness in evolution, principles involved in green chemistry, bio-catalytic reactions, global warming and its control measures, availability of green analytical methods.
- To practice chemistry in the safest way possible
- To imbibe safeworking conditions in the laboratories as well as the chemical industry extending to society in a sustainable future for the planet.

Learning outcomes

By studying this course, students will be able to:

- Understand the twelve principles of green chemistry and also build the basic understanding of toxicity, hazard and risk related to chemical substances.
- Calculate atom economy, E-factor and relate them in all organic synthesis
- Appreciate the use of catalyst over stoichiometric reagents
- Learn to use green solvents, renewable feedstock and renewable energy sources for carrying out safer chemistry
- Appreciate the use of green chemistry in problem solving skills and critical thinking to innovate and find solutions to environmental problems.
- Learn to design safer processes, chemicals and products through understanding of inherently safer design (ISD)
- Appreciate the success stories and real-world cases as motivation for them topractice green chemistry

Syllabus

Unit 1: Introduction **(Hours: 8)**

Definition of green chemistry and how it is different from conventional chemistry and environmental chemistry.

Need of green chemistry.

Importance of green chemistry in- daily life, Industries and solving human health problems (four examples each).

A brief study of Green Chemistry Challenge Awards (Introduction, award categories and study about five last recent awards).

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Unit 2: Twelve Principles of Green Chemistry **(Hours: 12)**

The twelve principles of the Green Chemistry with their explanations Special emphasis on the following:

- Prevention of waste / by products, pollution prevention hierarchy.
- Green metrics to assess greenness of a reaction: environmental impact factor, atom economy and calculation of atom economy.
- Green solvents-supercritical fluids, water as a solvent for organic reactions, ionic liquids, solvent less reactions, solvents obtained from renewable sources.
- Catalysis and green chemistry- comparison of heterogeneous and homogeneous catalysis, biocatalysis, asymmetric catalysis and photocatalysis.
- Green energy and sustainability.
- Real-time analysis for pollution prevention.

Prevention of chemical accidents, designing greener processes, principles of inherent safer design (ISD). Bhopal Gas Tragedy (safer route to carbaryl) and Flixborough accident (safer route to cyclohexanol), subdivision of ISD, minimization, simplification, substitution, moderation and limitation.

Unit 3: Real-world Cases in Green Chemistry **(Hours: 10)**

Discussion of the following Real-world Cases in green chemistry: Surfactants for carbon dioxide – replacing smog producing and ozone depleting solvents with CO_2 for precision cleaning and dry cleaning of garments. Designing of environmentally safe marine antifoulant. Right fit pigment: Synthetic azo pigments to replace toxic organic and inorganic pigments. An efficient, green synthesis of a compostable and widely applicable plastic (polylactic acid) made from corn.

Practical Component **Credits:02**

(Laboratory periods:60)

Characterization by melting point, UV-Visible spectroscopy, IR spectroscopy and any other specific method should be done (wherever applicable).

1. Preparation and characterization of nanoparticles of gold using tea leaves/silver nanoparticles using plant extracts.

2. Preparation of biodiesel from waste cooking oil and characterization (TLC, pH, solubility, combustion test, density, viscosity, gel formation at low temperature and IR can be provided).

3. Benzoin condensation using thiamine hydrochloride as a catalyst instead of cyanide.

4. Extraction of D-limonene from orange peel using liquid CO_2 prepared from dry ice.

5. Mechanochemical solvent free, solid-solid synthesis of azomethine using p-toluidine and o-vanillin/p-vanillin.

6 Microwave-assisted Knoevenagel reaction using anisaldehyde, ethyl cyanoacetate and ammonium formate.

7. Photoreduction of benzophenone to benzopinacol in the presence of sunlight.

8. Photochemical conversion of dimethyl maleate to dimethyl fumarate (cis-trans isomerisation)

9. Benzil- Benzilic acid rearrangement: Preparation of benzilic acid in solid state under solvent-free condition.

References:

Theory:

1. Anastas, P.T., Warner, J.C. (2014), **Green Chemistry**, **Theory and Practice**, Oxford University Press.
2. Lancaster, M. (2016), **Green Chemistry: An Introductory Text**, 3rd Edition, RSC Publishing.
3. Cann, M. C., Connely, M.E. (2000), **Real-World cases in Green Chemistry**, American Chemical Society, Washington.
4. Matlack, A.S. (2010), **Introduction to Green Chemistry**, 2nd Edition, Boca Raton: CRC Press/Taylor & Francis Group publisher.
5. Alhuwalia, V.K., Kidwai, M.R. (2005), **New Trends in Green chemistry**, Anamalaya Publishers.
6. Sidhwani, I.T, Sharma, R.K. (2020), **An Introductory Text on Green Chemistry**, Wiley India Pvt Ltd.

Practicals:

7. Kirchoff, M.; Ryan, M.A. (2002), **Greener approaches to undergraduate chemistry experiment**, American Chemical Society, Washington DC.

8. Sharma, R.K.; Sidhwani, I.T.; Chaudhari, M.K. (2013), **Green Chemistry Experiments: A monograph**, I.K. International Publishing House Pvt Ltd. New Delhi.
9. Pavia, D.L.; Lamponam, G.H.; Kriz, G.S.W. B. (2012), **Introduction to organic Laboratory Technique- A Microscale approach**, 4th Edition, Brooks-Cole Laboratory Series -for Organic chemistry.
10. Sindhwani I.T. (2015), **Wealth from Waste: A green method to produce biodiesel from waste cooking oil and generation of useful products from waste further generated**. DU Journal of Undergraduate Research and Innovation, 1(1),131-151. ISSN: 2395- 2334.
11. Sidhwani, I.T; Sharma, R.K. (2020), **An Introductory Text on Green Chemistry**, Wiley India Pvt Ltd.
12. **Monograph on Green Chemistry Laboratory Experiments**, Green Chemistry Task Force Committee, Department of Science and Technology, Government of India.

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

DISCIPLINE SPECIFIC ELECTIVE COURSE CHEM-DSE 3: Chemistry of Colloids and Adsorption

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Chem-DSE 3: Chemistry of Colloids and Adsorption	**04**	**02**	**-**	**02**	**Class XII with Science**	

Learning Objectives

The Learning Objectives of this course are as follows:

- To develop basic concepts of colloids and colloidal phenomenon.
- Preparation and characterization of sols, understanding about applications of colloid in food, petroleum and cosmetic industry.
- Basic understanding of adsorption, types of adsorption, chemistry of adsorption and its applications.

Learning outcomes

By studying this course, students will be able to:

- Understand colloid solutions, preparation of sols.
- Understand the concept of Electrical double layer, charge on colloidal particles.
- Characterize the colloids sols, learn colloid phenomenon like Tyndall effect, Brownian movement, electrophoresis, dialysis, coagulation and flocculation.
- Understand adsorption, types of adsorption. Characteristics, factors affecting adsorption and its applications

Syllabus

Unit 1: Colloidal State **(Hours: 8)**

Distinction among true solutions, colloids and suspensions, components of Colloids, classification of colloids - lyophilic, lyophobic; Preparation methods and properties of lyophobic solutions, Hydrophile-lyophile balance (HLB), multi molecular, macromolecular and associated colloids (micelles formation), Schulze -Hardy law.

Unit 2: Preparation and Properties of Colloids **(Hours: 14)**

Methods of preparation of colloids, Tyndall effect, Brownian movement, coagulation and flocculation; electrophoresis, dialysis.

Emulsification by surfactants, selection of surfactants as emulsifying agent, colloidal phenomenonin food chemistry, Protein based functional colloids.

Unit 3: Surface Chemistry **(Hours: 8)**

Adsorption, Distinction between adsorption and absorption, Types of Adsorption, Physisorption and chemisorption and their characteristics, factors affecting adsorption of gases on solids - Freundlich and Langmuir adsorption isotherms, Adsorption from solutions. Applications of Adsorption phenomenon in living systems.

Practical component **Credits: 02**

(Laboratory periods: 60)

1. Preparation of Colloidal Sols of following
   a. Egg Albumin
   b. Starch /Gum
   c. Ferric chloride
   d. Aluminum hydroxide
   e. Antimony Sulphide

2. To find out the precipitation values of Antimony Sulphide sol by using monovalent, bivalentand trivalent cations.
3. To verify the Schulze -Hardy law.
4. To verify the Freundlich's Adsorption isotherms.
5. Study of adsorption of HAc on charcoal and prove the validity of Langmuir's adsorption isotherms
6. Study of adsorption of Oxalic acid on charcoal and prove the validity of Langmuir's adsorption isotherms.

References:

Theory:

1. Puri B. R., Sharma L. R. and Pathania M.S., (2020) Principles of Physical Chemistry, Vishal Publishing Co.Jalandhar, Punjab, India.
2. Kapoor K L, **Text Book of Physical Chemistry, Vol. 4,** McGraw Hill Education (India) Private Limited, Chennai, India.
3. Evans D F and Wennerström's, **The Colloidal Domain**, Second Edition, John Wiley & Sons Inc.
4. Adamson A. W. and Gast A., **Physical Chemistry of Surfaces** (Main text) Sixth Edition, John Wiley & Sons Inc.
5. Berg J. C., **An Introduction to Interfaces and Colloids,** World Scientific Publishing Co., Inc. New Jersey.
6. Israelachvili J. N., **Intermolecular and Surface Forces,** Elsevier Inc.

Practical:

1. Giri, S; Bajpai, D.N.; Pandey, O.P. **Practical Chemistry**, S. Chand Limited.
2. Khosla, B.D.; Garg, V.C.; Gulati, A.(2015), **Senior Practical Physical Chemistry**, R. Chand & Co.

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

SEMESTER IV

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

DISCIPLINE SPECIFIC ELECTIVE COURSE CHEM-DSE -4: Nanoscale Materials and their Applications

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Chem-DSE-4: Nanoscale Materials and their Applications	**04**	**02**	**-**	**02**	**Class XII with Science**	

Learning Objectives

The Learning Objectives of this course are as follows:

- To introduce nanoscale materials and their applications.
- To provide an insight into bottom-up and top-down-approach, the methods of synthesis of nanoparticles, simple characterization techniques and applications of nanomaterials.

Learning outcomes

By studying this course, students will be able to:

- Understand the concept of nano dimensions.
- Know the various methods of preparation of nanomaterials.
- Understand the principles of optical and electron microscopy techniques of characterizing nanomaterials.
- Understand and appreciate the real life applications of nanomaterials.

Syllabus

Unit 1: Introduction to Nanodimensions **(Hours: 12)**

0D, 1D, 2D nanomaterials, Quantum Dots, Nanoparticles, Nanostructures (nanowires, thin films, nanorods), carbon nanostructures (carbon nanotubes, carbon nanofibers, fullerenes), Size Effects in nano systems, Quantum confinement and its consequences, Semiconductors. Band structure and band gap. Optical Properties Surface plasmon resonance

.

Unit 2: Preparation of Nanomaterials **(Hours: 10)**

Top down and Bottom up approach, Photolithography. Ball milling. Vacuum deposition. Physical vapor deposition (PVD), Chemical vapor deposition (CVD), Thermal decomposition, Chemical reduction, Sol-Gel synthesis, Hydrothermal synthesis, Spray pyrolysis, Electrochemical deposition, Pulsed Laser deposition. Characterization of nanomaterials: Basic principle of optical methods and electron microscopy.

Unit 3: Applications of Nanomaterials (Hours: 8)

Nanomaterials as Catalysts, semiconductor nanomaterials as photocatalysts, Nanocomposites as catalysts. Carbon nanostructures as catalytic nanoreactors, metal and metal oxides confined inside carbon nanostructures, Nanowires and thin films for photonic devices (LEDs, solar cells, transistors).

Practical Component Credits:02

(Laboratory periods:60)

1. Synthesis of silver nanoparticles by chemical methods and characterization using UV-visible spectrophotometer.
   a. Turkevich Method
   b. Burst Method
2. Synthesis of silver nanoparticles by green approach methods (using soluble starch, glucose or cinnamon bark) and characterization using UV-visible spectrophotometer.
3. Synthesis of metal sulphide nanoparticles and characterization using UV-visible spectrophotometer.
   a. MnS
   b. ZnS
   c. CuS
4. Intercalation of hydrogen in tungsten trioxide and its conductivity measurement using conductometer.
5. Synthesis of pure ZnO and Cu doped ZnO nanoparticles.
6. Phytochemicals mediated synthesis of gold nanoparticles (AuNPs) using tea leaves and to study the effect of size on color of gold/silver nanoparticles.
7. Preparation of magnetic nanoparticles (MNPs) of Fe_3O_4 using green tea leaf extract.
8. Any suitable experiment (other than the listed ones) based upon complexation reactions.

References:

Theory:

1. West, A. R. (2014), **Solid State Chemistry and Its Application**, John Wiley and Sons Inc.
2. Smart, L. E.; Moore, E. A., (2012), **Solid State Chemistry: An Introduction**, CRC Press Taylor & Francis.
3. Rao, C. N. R.; Gopalakrishnan, J. (1997), **New Direction in Solid State Chemistry**, Cambridge University Press.

4. Poole Jr.; Charles P.; Owens, Frank J. (2003), **Introduction to Nanotechnology**, John Wiley and Sons. Inc. Harris, D. C. (2007), **Quantitative Chemical Analysis**, 6th Edition, Freeman.
5. Chattopadhyay, K.K.; Banerjee, A. N. (2009), **Introduction to Nanoscience and Technology**, Prentice Hall India.

Practicals:

1. Orbaek, W.; McHale, M.M.; Barron, A. R.; **Synthesis and Characterization of Silver Nanoparticles for An Undergraduate Laboratory**, J. Chem. Educ. 2015, 92, 339−344.
2. MacDiarmid, G.; Chiang, J.C.; Richter, A.F.; Somasiri, N.L.D.(1987), **Polyaniline: Synthesis and Characterization of the Emeraldine Oxidation State by Elemental Analysis**, L. Alcaeer (ed.), Conducting Polymers, 105-120, D. Reidel Publishing.

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

DISCIPLINE SPECIFIC ELECTIVE COURSE CHEM-DSE -5: Molecules of Life

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Chem-DSE-5: Molecules of Life	**04**	**02**	**-**	**02**	**Class XII with Science**	

Learning Objectives

The Learning Objectives of this course are as follows:

- To deliver information about the chemistry of carbohydrates, proteins & enzymes and its relevance in the biological system using suitable examples.
- To provide an insight into the structural principles that govern reactivity/physical /biological properties of biomolecules as opposed to learning structural details.

Learning outcomes

By studying this course, students will be able to:

- Learn and demonstrate how the structure of biomolecules determines their chemical properties, reactivity and biological uses.
- Gain an insight into the mechanism of enzyme action and inhibition.
- Understand the basic principles of drug-receptor interaction and SAR.

Syllabus

Unit 1: Carbohydrates **(Hours: 12)**

Classification of carbohydrates, reducing and non-reducing sugars, biological functions, general properties and reactions of glucose and fructose, their open chain structure, epimers, mutarotation and anomers, reactions of monosaccharides, determination of configuration of glucose (Fischer proof), cyclic structure of glucose. Haworth projections. Cyclic structure of fructose. Linkage between monosaccharides: structure of disaccharides (sucrose, maltose, lactose) and polysaccharides (starch and cellulose) excluding their structure elucidation.

.

Unit 2: Amino acids, Peptides and Proteins **(Hours: 10)**

Classification of amino acids and biological uses of amino Acids, peptides and proteins. Zwitterion structure, isoelectric point and correlation to acidity and basicity of amino acids. Determination of primary structure of peptides, determination of N-terminal amino acid (by Edman method) and C–

terminal amino acid (with carboxypeptidase enzyme). Synthesis of simple peptides (up to dipeptides) by N-protection (t-butyloxycarbonyl) & C-activating groups (only DCC) and Merrifield solid phase synthesis, Overview of primary, secondary, tertiary and quaternary structure of proteins, denaturation of proteins.

Unit 3: Enzymes **(Hours: 4)**

Classification of enzymes and their uses (mention Ribozymes). Mechanism of enzyme action, factors affecting enzyme action, Coenzymes and cofactors and their role in enzyme action, specificity of enzyme action (including stereospecificity).

-

Unit 4: Nucleosides, Nucleotides and Nucleic Acids **(Hours: 4)**

Components of Nucleic acids: Adenine, guanine, thymine, cytosine and uracil (structure only), other components of nucleic acids, nucleosides and nucleotides (nomenclature), structure of polynucleotides; structure of DNA (Watson-Crick model) and RNA (types of RNA), difference between DNA and RNA.

Practical Component **Credits:02**

(Laboratory periods:60)

1. Estimation of glucose by Fehling's solution.
2. Determination of total sugar content by ferricyanide method (volumetric/colorimetric method).
3. Study of the titration curve of glycine and determine the isoelectic point of glycine.
4. Estimation of proteins by Lowry's method.
5. Qualitative tests for amino acids, proteins and carbohydrates.
6. Separation and identification of mixture of sugars by paper chromatography.
7. Separation and identification of mixture of Amino acids by paper chromatography.
8. Study of the action of salivary amylase on starch under optimum conditions and find the enzyme activity.
9. Study the effect of temperature on activity of salivary amylase.
10. Extraction of DNA from onion/cauliflower.

References:

Theory:

1. Finar, I. L. **Organic Chemistry (Volume 1 & 2)**, Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
2. Morrison, R. N.; Boyd, R. N., Bhattacharjee, S.K. (2010), **Organic Chemistry, 7th Edition**, Dorling Kindersley (India) Pvt. Ltd. (Pearson Education India).
3. Berg, J. M.; Tymoczko, J. L.; Stryer, L. (2019), **Biochemistry, 9th Ed**., W. H. Freeman Co Ltd.

Practicals:

1. Furniss, B.S.; Hannaford, A.J.; Smith, P.W.G.; Tatchell, A.R. (2012), Vogel's **Textbook of Practical Organic Chemistry**, Pearson Education India.
2. **Manual of Biochemistry Workshop, 2012**, Department of Chemistry, University of Delhi.

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

DISCIPLINE SPECIFIC ELECTIVE COURSE CHEM-DSE -6: Conductance, Electrochemistry and Chemical Kinetics

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Chem-DSE 6: Conductance, Electrochemistry and Chemical Kinetics	**04**	**02**	**-**	**02**	**Class XII with Science**	

Learning Objectives

The Learning Objectives of this course are as follows:

- To develop basic understanding of electrolytic and galvanic cells.
- Measurementof conductance and its applications, measurement of emf and its applications.
- To understand reaction rate, order, activation energy and theories of reaction rates.

Learning outcomes

By studying this course, students will be able to:

- Explain the factors that affect conductance, migration of ions and application of conductance measurement.
- Understand the importance of Nernst equation, measurement of emf, calculations of thermodynamic properties and other parameters from the emf measurements.
- Understand rate law and rate of reaction, theories of reaction rates and catalysts; both chemical and enzymatic.

Syllabus

Unit 1: Conductance **(Hours: 8)**

Conductivity, equivalent and molar conductivity and their variation with dilution for weak and strong electrolytes, Kohlrausch Law of independent migration of ions, Ionic velocity, mobility and their determination, transference number and its relation to ionic mobility, Conductometric titrations (only acid-base).

Unit 2: Electrochemistry **(Hours: 12)**

Concept of reversible and irreversible electrochemical cells, Standard hydrogen electrode, standard electrode potential, concept of EMF of a cell, measurement of EMF of a cell, Nernst equation and its importance, types of electrodes (Reference and inert electrodes), electrochemical series.

Thermodynamics of a reversible cell, calculation of thermodynamic properties: G, H and S from EMF data. Calculation of equilibrium constant from EMF data. pH determination using glass electrode, Potentiometric titrations-qualitative treatment (acid-base and oxidation-reduction only).

Unit 3: Chemical Kinetics and Catalysis **(Hours: 10)**

The concept of reaction rates, effect of temperature, pressure, catalyst and other factors on reaction rates. Order and molecularity of a reaction, integrated rate equations for zero, first and second order reactions (derivation not required), half–life of a reaction, Concept of activation energy and its calculation from Arrhenius equation.

Catalysis: Types of catalyst, specificity and selectivity, generalized treatment of catalyzed reactions at solid surfaces. Enzyme catalysis, Michaelis-Menten mechanism, acid-base catalysis.

Practical component **Credits:02**

Laboratory periods: 60

1. Determination of molar conductance, degree of dissociation and dissociation constant of aweak acid.
2. Perform the following conductometric titrations: Strong acid vs strong base.
3. Perform the following conductometric titrations: Weak acid vs strong base.
4. Determination of TDS of water from different sources.
5. Determination of Soil pH of soil collected from various locations.
6. Perform the potentiometric titrations of strong acid vs strong base
7. Perform the potentiometric titrations of Weak acid vs strong base.
8. Perform the potentiometric titrations of Potassium dichromate vs. Mohr's salt.
9. Perform the potentiometric titrations of $KMnO_4$ vs. Mohr's salt.
10. Study the kinetics of acid hydrolysis of methyl acetate with hydrochloric acid.

References:

Theory:

1. Castellan, G. W .(2004), **Physical Chemistry**, Narosa Publications.
2. Kapoor, K.L. (2015),**A Textbook of Physical Chemistry**, Vol.1, 6th Edition, McGraw Hill Education.
3. Kapoor, K.L. (2015),**A Textbook of Physical Chemistry**, Vol.5, 3rd Edition, McGraw Hill Education.
4. Puri, B.R., Sharma, L.R. and Pathania M.S. (2020),**Principles of Physical Chemistry,** Vishal Publishing Co.

*

Practicals:

1. Khosla, B.D.; Garg, V.C.; Gulati, A.(2015), **Senior Practical Physical Chemistry**, R. Chand & Co.Kapoor, K.L. (2019), **A Textbook of Physical Chemistry**, Vol 7, 1st Edition, McGrawHill Education.
2. Batra, S.K., Kapoor, V and Gulati, S. (2017) 1st Edition, **Experiments in Physical Chemistry,** Book Age series.

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

SEMESTER V

DISCIPLINE SPECIFIC ELECTIVE COURSE CHEM-DSE -7: Inorganic Materials of Industrial Importance

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Chem-DSE-7: Inorganic Materials of Industrial Importance	**04**	**02**	**-**	**02**	**Class XII with Science**	

Learning Objectives

The Learning Objectives of this course are as follows:

- The course introduces learners to the importance of Inorganic compounds in Industries.
- To provide an insight into how the inorganic materials form a basis of the products used in day-to-day life like silicates, fertilizers, surface coatings.

Learning outcomes

By studying this course, students will be able to:

- Learn the composition and applications of the different kinds of glass.
- Understand glazing of ceramics and the factors affecting their porosity.
- Give the composition of cement and discuss the mechanism of setting of cement.
- Explain the suitability of fertilizers for different kinds of crops and soil.
- Understand and explain the polymerization of inorganic ions to generate inorganic polymers and the difference between organic and inorganic polymers.

Syllabus

Unit 1: Silicate Industries **(Hours: 10)**

Glass: Glassy state and its properties, classification (silicate and non-silicate glasses). Manufacture and processing of glass. Composition and properties of the following types of glasses: Soda lime

glass, lead glass, armoured glass, different types of safety glass, borosilicate glass, fluorosilicate glass, coloured glass, photosensitive glass, photochromic glass, glass wool and optical fibre.

Ceramics: Brief introduction to types of ceramics. glazing of ceramics.

Cement: Manufacture of Portland cement and the setting process, Different types of cements: quick setting cements, eco-friendly cement (slag cement), pozzolana cement.

Unit 2: Fertilizers **(Hours: 8)**

Different types of fertilizers (N, P and K). Importance of fertilizers, chemistry involved in the manufacture of the following fertilizers: urea, ammonium nitrate, calcium ammonium nitrate, ammonium phosphates, superphosphate of lime, potassium chloride and potassium nitrate. Environmental impact of fertilizers.

Unit 3: Surface Coatings **(Hours: 12)**

Brief introduction to and classification of surface coatings, paints and pigments: formulation, composition and related properties, pigment volume concentration (PVC) and critical pigment volume concentration (CPVC), fillers, thinners, enamels and emulsifying agents. Special paints: heat retardant, fire retardant, eco-friendly paints, plastic paints, water and oil paints. Preliminary methods for surface preparation, metallic coatings (electrolytic and electroless with reference to chrome plating and nickel plating), metal spraying and anodizing. Contemporary surface coating methods like physical vapor deposition, chemical vapor deposition, galvanising, carburizing, sherardising, boriding, nitriding and cementation.

Practical Component
Credits:02

(Laboratory periods:60)

1. Detection of constituents of CAN fertilizer (Calcium, Ammonium and Nitrate ions) fertilizer and estimation of Calcium content.
2. Detection of constituents of Superphosphate fertilizer (Calcium and Phosphate ions) and estimation of phosphoric acid content.
3. Detection of constituents of Dolomite (Calcium, Magnesium and carbonate ions) and determination of composition of Dolomite (Complexometric titration).
4. Analysis of (Cu, Ni) in alloy or synthetic samples (Multiple methods involving Complexometry, Gravimetry and Spectrophotometry).
5. Analysis of (Cu, Zn) in alloy or synthetic samples (Multiple methods involving Iodometry, Complexometry and Potentiometry).
6. Preparation of following Inorganic Pigments:

a). Barium white
b). Chrome Yellow

c). Malachite
d).Chromium oxide
e). Prussian Blue
7. Any suitable experiment other than the listed ones.

References:

Theory:

1. West, A. R. (2014*),* **Solid State Chemistry and Its Application**, Wiley & sons.
2. Smart, L. E.; Moore, E. A. (2012), **Solid State Chemistry An Introduction**, CRC Press Taylor & Francis.
3. Atkins, P.W.; Overton, T.L.; Rourke, J.P.; Weller, M.T.; Armstrong, F.A.(2010), **Inorganic Chemistry**, W. H. Freeman and Company.
4. Kent, J. A. (ed**)** (1997), **Riegel's Handbook of Industrial Chemistry**, CBS Publishers, New Delhi.
5. Jain P.C., Jain M., **Engineering Chemistry**, Dhanpat Rai & Sons, Delhi.
6. Gopalan R., Venkappaya D.,Nagarajan S., **Engineering Chemistry***,* Vikas Publications, New Delhi.
7. Sharma, B.K., **Engineering Chemistry***,* Goel Publishing House, Meerut.
8. Kingery W.D., Bowen H. K., Uhlmann, D.R., (1976), **Introduction to Ceramics***,* Wiley & sons, Delhi.

Practicals:

1. Vogel A. I., Vogel'**s Quantitative Inorganic Analysis**, Pearson Education.
2. Banewicz, J. J.; Kenner, C.T. **Determination of Calcium and Magnesium in Limestones and Dolomites**, Anal. Chem., 1952, 24 (7), 1186–1187.

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

DISCIPLINE SPECIFIC ELECTIVE COURSE CHEM-DSE 8: Polynuclear Hydrocarbons, Pharmaceutical Compounds, UV- Visible & IR Spectroscopy

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Chem-DSE 8: Polynuclear Hydrocarbons, Pharmaceutical Compounds, UV-Visible & IR Spectroscopy	**04**	**02**	**-**	**02**	**Class XII with Science**	

Learning Objectives

The Learning Objectives of this course are as follows:

- To provide an insight to the fundamentals of polynuclear hydrocarbons and heterocyclic compounds
- The course introduces learners to IR and UV-Vis spectroscopic techniques and their importance in functional group identification.

Learning outcomes

By studying this course, students will be able to:

- Understand the fundamentals of polynuclear hydrocarbons and heterocyclic compounds through the study of methods of preparation, properties and chemical reactions with underlying mechanism.
- Gain insight into the basic fundamental principles of IR and UV-Vis spectroscopic techniques.
- Use basic theoretical principles underlying UV-visible and IR spectroscopy as a tool for functional group identification in organic molecules.

Syllabus

UNIT-1: Polynuclear Hydrocarbons **(Hours: 6)**

Introduction, classification, uses, aromaticity of polynuclear compounds, Structure elucidation of naphthalene, preparation and properties of naphthalene and anthracene.

UNIT-2: Pharmaceutical Compounds **(Hours: 12)**

Introduction, classification, general mode of action of antipyretics and analgesics, aspirin; Synthesis, uses and side effects of the following drugs:

Antipyretics - Paracetamol (with synthesis and mode of action); Analgesics- Ibuprofen (with synthesis and overview of the mode of action); Antimalarials - Chloroquine (synthesis and mode of action).

An elementary treatment of Antibiotics and detailed study of chloramphenicol including mode of action. Medicinal values of curcumin (haldi), azadirachtin (neem), vitamin C and antacid (ranitidine).

UNIT-3: UV-Vis and IR Spectroscopy **(Hours: 12)**

UV-Vis and IR Spectroscopy and their application to simple organic molecules. Electromagnetic radiations and their properties; double bond equivalence and hydrogen deficiency. UV-Vis spectroscopy (electronic spectroscopy): General electronic transitions, λ_{max} & ε_{max}, chromophores & auxochromes, bathochromic & hypsochromic shifts. Application of Woodward rules for the calculation of λ_{max} for the following systems: conjugated dienes - alicyclic, homoannular and heteroannular; α, β-unsaturated aldehydes and ketones, charge transfer complex.

Infrared (IR) Spectroscopy: Infrared radiation and types of molecular vibrations, the significance of functional group & fingerprint region. IR spectra of alkanes, alkenes, aromatic hydrocarbons (effect of conjugation and resonance on IR absorptions), simple alcohols (inter and intramolecular hydrogen bonding and IR absorptions), phenol, carbonyl compounds, carboxylic acids and their derivatives (effect of substitution on >C=O stretching absorptions).

Practical component **Credit:02**

(Laboratory periods: 15 classes of 4 hours each)

1. Isolation and estimation of the amount of aspirin in a commercial tablet.
2. Synthesis of ibuprofen.
3. Systematic qualitative identification and derivative preparation of organic compounds (Aromatic hydrocarbons, Aryl halides)
4. Detection of simple functional groups through examination of IR spectra (spectra to be provided). IR spectra of simple compounds like phenols, aldehydes, ketones, carboxylic acids may be given.
5. Differentiation between of o-/p-hydroxybenzaldehyde by IR spectroscopy (Spectra to be provided).
6. Differentiation between benzoic acid and cinnamic acid by UV spectroscopy.
7. Laboratory preparation of paracetamol.
8. Diel's Alder reaction using Anthracene and Maleic anhydride.

References:

Theory:

1. Finar, I. L. **Organic Chemistry** (Volume 1 & 2), Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
2. Morrison, R. N.; Boyd, R. N. **Organic Chemistry**, Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
3. Bahl, A; Bahl, B. S. (2012), **Advanced Organic Chemistry**, S. Chand.
4. Pavia, D.L. **Introduction to Spectroscopy**, Cengage learning (India) Pvt. Ltd.
5. Kemp, W. (1991), **Organic Spectroscopy**, Palgrave Macmillan.

Practicals

1. Ahluwalia, V.K.; Dhingra, S.; Gulati, A. (2005), **College Practical Chemistry**, University Press (India) Ltd.
2. Ahluwalia, V.K.; Dhingra, S. (2004), **Comprehensive Practical Organic Chemistry**: Qualitative Analysis, University Press.
3. Vogel, A.I. (1972), **Textbook of Practical Organic Chemistry**, Prentice-Hall.
4. Pasricha, S., Chaudhary, A. (2021), **Practical Organic Chemistry**: Volume I, I K International Publishing House Pvt. Ltd., New Delhi.
5. Pasricha, S., Chaudhary, A. (2021), **Practical Organic Chemistry**: Volume I, I K International Publishing House Pvt. Ltd., New Delhi.

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

DISCIPLINE SPECIFIC ELECTIVE COURSE CHEM-DSE 9: Computer Applications in Chemistry

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Chem-DSE 9: Computer Applications in Chemistry	**04**	**02**	**-**	**02**	**Class XII with Science**	

Learning Objectives

The Learning Objectives of this course are as follows:

- To introduce the students to basic computer skills that will help them in solving chemistry problems using spreadsheets and BASIC language.
- To acquaint the students with different software for data tabulation, calculation, graph plotting, data analysis and document preparation.
- To expose the students to the concept of molecular modelling, its applications to various molecular systems, energy minimization techniques, analysis of Mulliken Charge and ESP Plots.

Learning outcomes

By studying this course, students will be able to:

- Have knowledge of most commonly used commands and library functions used in programming in BASIC language.
- Develop algorithm to solve problems and write corresponding programs in BASIC language for performing calculations involved in laboratory experiments.
- Use various spreadsheet software to perform theoretical calculations and plot graphs

Syllabus

Unit 1: Programming using BASIC **(Hours: 20)**

Programming Language – Elements of BASIC language, Numeric and string Constants and Variables, arithmetic expressions, hierarchy of operations, inbuilt functions. Syntax and use of the various QBASIC commands: REM, CLS, INPUT, PRINT, GOTO, IF, IF…THEN, IF...THEN..ELSE, IF and END IF, FOR

and NEXT etc., DIM, READ, DATA, GOSUB, RETURN, RESTORE, DEF FNR and Library Functions, Simple programs based on usage of the commands mentioned above.

Statistical analysis using BASIC: Mean, Least square fit - Linear regression, variance, standard deviation.

Unit 2 : Handling of Numerical Data **(Hours: 4)**

Spreadsheet software: MS Excel. Creating a spreadsheet, entering and formatting information, applying basic functions and formulae to the data, drawing charts, tables and graphs, displaying the equation of graph along with the R^2 value, incorporating tables and graphs in Word files, graphical solution of equations, plotting pressure-volume curves of van der Waals gases, Maxwell-Boltzmann distribution, concentration versus time graphs, spectral data, titration curves, etc.

Unit 3: Molecular Modelling **(Hours: 6)**

Introduction to molecular modelling, overview of classical and quantum mechanical methods (molecular mechanics, semi empirical, ab initio and DFT), general considerations and comparison of these methods.

Practical component Credit:02

(Laboratory periods: 15 classes of 4 hours each)

Exercises of Programing

1. Calculate pressure of a real gas using Van der Waal's Equation.
2. Calculate the most probable speed, average speed and root men square velocity of an ideal gas.
3. Roots of quadratic equations
4. Binomial coefficient using GOSUB statement.
5. Mean, standard deviation
6. Least square curve fitting method for linear equation.

Plotting graphs using a spreadsheet

1. Van der Waals isotherms
2. Maxwell-Boltzmann distribution curves as function of temperature and molecular weight
3. Plot the conductometric titration curve for

   a) strong acid vs strong base and b) weak acid vs strong base
4. Plot the pH metric titration curve for

   a) strong acid vs strong base and b) weak acid vs strong base and determine the pK_a of the weak acid
5. Plot the graphs for the kinetics of first order reaction and determine the rate constant
6. Plot the UV-vis absorbance spectra and determine the molar absorption coefficient.

Molecular Modelling

1. Optimize and compare the geometry parameters of H_2O and H_2S using ArgusLab.
2. Compare the basicities of N atom in ammonia, methylamine, dimethylamine and trimethylamine using ArgusLab by comparing Mulliken charges and ESP map in ArgusLab.

3. Compare C-C bond lengths and bond order in ethane, ethene and ethyne using ArgusLab.
4. Determine enthalpy of isomerization of cis and trans-2-butene using ArgusLab.
5. Compare the HAH bond angles for the second row hydrides (BeH_2, CH_4, NH_3, H_2O) and compare with the results from qualitative MO theory.

References:

Theory:

1. Levie, R. de. (2001), **How to use Excel in analytical chemistry and in general scientific data analysis**, Cambridge Univ. Press.
2. Venit, S.M. (1996), **Programming in BASIC: Problem solving with structure and style**. Jaico Publishing House.
3. Lewars, E. (2003), **Computational Chemistry,** Kluwer academic Publisher.
4. Cramer, C.J.(2004), **Essentials of Computational Chemistry,** John Wiley & Sons.
5. Hinchcliffe, A. (1996), **Modelling Molecular Structures,** John Wiley & Sons.
6. Leach, A.R.(2001), **Molecular Modelling,** Prentice-Hall.

Practicals

1. Lewars, E. **(2003), Computational Chemistry,** Kluwer academic Publisher.
2. Cramer, C.J. **(2004), Essentials of Computational Chemistry,** John Wiley & Sons.
3. Hinchcliffe, A. **(1996), Modelling Molecular Structures,** John Wiley & Sons.

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

SEMESTER VI

DISCIPLINE SPECIFIC ELECTIVE COURSE CHEM-DSE -10: Analytical Methods in Chemistry

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Chem-DSE-10: Analytical Methods in Chemistry	**04**	**02**	**-**	**02**	**Class XII with Science**	

Learning Objectives

The Learning Objectives of this course are as follows:

- To familiarize students with the concepts of sampling, errors in analysis, accuracy, precision and introduce basics of statistical analysis.
- To introduces students to important instrumentation and separation techniques routinely used in the laboratory analysis of samples. The experiments expose students to instrumentation and they learn to detect and separate analytes in a mixture.

Learning outcomes

By studying this course, students will be able to:

- Understand various sources of errors in chemical analysis.
- Learn about methods to minimize error.
- Understand basic principle of instrumentation (Flame Photometer, UV-vis spectrophotometer, Atomic Absorption spectrophotometer).
- Apply the principles of analysis and instrumentation to analyse soil samples, soft drinks and synthetic mixtures provided in the laboratory.
- Learn basic principles of separation techniques (chromatography and solvent extraction) and apply them to separate mixtures.
- Understand principles of Gravimetric analysis and apply them in determination of Ni^{2+} and Al^{3+}
- Analyse samples independently in the laboratory.

Syllabus

Unit 1: Errors in Chemical Analysis **(Hours: 8)**

Types of errors, Accuracy and Precision, Absolute and relative uncertainty, propagation of uncertainty. The Gaussian distribution, mean and standard deviation, confidence intervals.

Unit 2: Optical Methods of Analysis **(Hours: 10)**

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

UV-Vis Spectrophotometry

Basic principles of instrumentation for single and double beam instruments. Determination of concentration of unknown compounds, composition of metal complexes using Job's method of continuous variation and mole ratio method.

Flame Atomic Absorption and Emission Spectroscopy

Basic principles of instrumentation. Techniques of atomization and sample introduction; Method of background correction, sources of chemical interferences and their method of removal.

Application of these techniques in analysis of samples.

Unit 3: Separation Techniques **(Hours: 12)**

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.

Chromatography

Principles of Chromatographic separations, Classification of Chromatographic techniques, Thin Layer Chromatography, Column Chromatography, efficiency of separation (Resolution, Efficiency of Resolution, Plate Height) Application of these techniques in analysis of samples.

Practical Component **Credits:02**

(Laboratory periods:60)

1. Analysis of soil**.**
   a. Determination of pH of soil, Total soluble salts, carbonate and bicarbonate, calcium and magnesium by titration.
   b. Estimation of Potassium, calcium and magnesium by flame photometry.
2. Separation of constituents of leaf pigments by thin layer chromatography.
3. Determination of the ion exchange capacity of an anion exchange resin.
4. Determination of the ion exchange capacity of a cation exchange resin.
5. Separation of amino acids by ion exchange chromatography.

6. Spectrophotometric analysis of Co^{2+} and Ni^{2+} ions in a mixture.
7. Spectrophotometric analysis of Caffeine and Benzoic acid in a soft drink.
8. Gravimetric estimation of Ni^{2+} using Dimethylglyoxime or Al^{3+} using oxine.

References:

Theory:

1. Willard, H.H. (1988), **Instrumental Methods of Analysis**, 7th Edition, Wardsworth Publishing Company.
2. Christian, G.D. (2004), **Analytical Chemistry**, 6th Edition, John Wiley & Sons, New York.
3. Harris, D. C. (2007), **Quantitative Chemical Analysis**,6th Edition, Freeman.
4. Skoog, D.A.; Holler F.J.; Nieman, T.A. (2005), **Principles of Instrumental Analysis**, Thomson Asia Pvt. Ltd.
5. Jeffery, G.H.; Bassett, J.; Mendham, J.; Denney, R.C. (1989), **Vogel's Textbook of Quantitative Chemical Analysis**, John Wiley and Sons.

Practicals:

1. Jeffery, G.H.; Bassett, J.; Mendham, J.; Denney, R.C. (1989), V**ogel's Textbook of Quantitative Chemical Analysis**, John Wiley and Sons.
2. Christian, G.D. (2004), **Analytical Chemistry**, 6th Edition, John Wiley & Sons, New York.
3. Harris, D. C. (2007), **Quantitative Chemical Analysis**, 6th Edition, Freeman.
4. Skoog, D.A.; Holler F.J.; Nieman, T.A. (2005), **Principles of Instrumental Analysis**, Thomson Asia Pvt. Ltd.

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

DISCIPLINE SPECIFIC ELECTIVE COURSE CHEM-DSE 11: Chemistry of Polymers, Dyes and Natural Products

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Chem-DSE 11: Chemistry of Polymers, Dyes and Natural Products	**04**	**02**	**-**	**02**	**Class XII with Science**	

Learning Objectives

The Learning Objectives of this course are as follows:

- To understand the process of converting knowledge of chemistry into marketable products for commercial gain.
- To familiarize the basic nomenclature of polymers, dyes and natural products, classification and important terms.

Learning outcomes

By studying this course, students will be able to:

- Learn about the chemistry of natural and synthetic polymers including fabrics and rubbers.
- Understand the chemistry of biodegradable and conducting polymers and appreciate the need of biodegradable polymers with emphasis on basic principles.
- Comprehend the theory of colour and constitution as well as the chemistry of dyeing.
- Know applications of various types of dyes including those in foods and textiles.
- Understand the chemistry and applications of natural products like terpenoids and alkaloids.

Syllabus

Unit 1: Polymers **(Hours: 12)**

Introduction and classification based on origin, monomer units, thermal response, mode of formation, structure, application and tacticity; di-block, tri-block and amphiphilic polymers;

Weight average molecular weight, number average molecular weight, glass transition temperature (T_g) 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 thermosoftening(PVC, polythene); Fabrics -natural (cellulose and synthetic derivatives of cellulose like rayon and viscose); synthetic (acrylic, polyamide, polyester); Rubbers-natural
and synthetic: Buna-N, Buna-S, Neoprene, silicon rubber; Vulcanization; Polymer additives; Introduction to Specialty Polymers: electroluminescent (Organic light emitting diodes), conducting, biodegradable polymers and liquid crystals.

Unit 2: Dyes **(Hours: 8)**

Classification, Colour and constitution; Mordant and Vat Dyes; Chemistry of dyeing. Synthesis and applications of Azo dyes – Methyl orange, Congo red; Triphenyl methane dyes- Crystal violet; Phthalein Dyes – Phenolphthalein; Natural dyes –Structure elucidation and synthesis of Alizarin and Indigotin; Edible Dyes with examples.

Unit 3: Natural Product Chemistry- An Introduction to Terpenoids and Alkaloids
(Hours: 10)

Terpenes: Introduction, occurrence, classification, uses, isoprene and special isoprene rule; structure elucidation, synthesis and industrial application of citral.

Alkaloids: Introduction, occurrence, classification, uses, general structural features, general methods for structure elucidation including Hoffmann's exhaustive methylation and Emde's method. Structure elucidation, synthesis and physiological action of Nicotine.

Practical component **Credits: 02**

(Laboratory periods: 60)

1. Preparation of Methyl Orange.
2. Preparation of Malachite Green.
3. Recycling of Plastic: Moulding of plastic or Cracking of plastic.
4. Preparation of Urea-formaldehyde resin.
5. Preparation of Methyl Orange.
6. (a) Dyeing of different fabrics (cotton, wool, silk) using Alizarin or any other dye.
7. (b) Preparation of azo dye on the surface of the fabric.
8. Qualitative test for identification of alkaloids (Dragendorff's reagent and Mayer's reagent test) and terpenoids (Salkowski test).
9. Preparation of perichromic dye using p-amino phenol and p-nitro benzaldehyde.

References:

Theory:

1. Finar, I.L. (2008), **Organic Chemistry**, Vol 2, 5th Edition, Pearson Education

2. Saunders, K. J. (1988), **Organic Polymer Chemistry**, 2nd Edition Chapman & Hall, London

3. Campbell, Ian M., (2000), **Introduction to Synthetic Polymers**, 2nd Edition Oxford University Press, USA.

4. Bahadur, P. and Sastry, N.V. (2002) **Principles of Polymer Science**, Narosa, New Delhi

5. Patrick, G. **An Introduction to Medicinal Chemistry** (2013), 4th Edition, Oxford University Press.

6. Priscilla Abarca, Patricia Silva, Iriux Almodovar and Marcos Caroli ezende*Quim. Nova, Vol. 37, No. 4, 745-747, 2014. http://dx.doi.org/10.5935/0100- 4042.20140120

Practical:

1. Furniss B S., Hannaford A. J., Smith Peter W. G. & Tatchell Austin R., **Vogel's Textbook of Practical Organic Chemistry** Fifth Edition, Longman Scientific & Technical.

2. Pasricha, S., Chaudhary, A. (2021), **Practical Organic Chemistry**: Volume I, I K International Publishing House Pvt. Ltd., New Delhi.

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

DISCIPLINE SPECIFIC ELECTIVE COURSE CHEM-DSE -12: Phase Equilibria and Photochemistry

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Chem-DSE 12: Phase Equilibria and Photochemistry	**04**	**02**	**-**	**02**	**Class XII with Science**	

Learning Objectives

The Learning Objectives of this course are as follows:

- To develop basic understanding of Phase, Component, Degree of freedom, basic principles of phase equilibria,
- To understand phase diagram of one and two component systems.
- The students will also gain an understanding of Binary solution, distillation of binary solution, CST and distribution law & its applications.

Learning outcomes

By studying this course, students will be able to:

- Understand phase equilibrium, criteria, CST, Gibbs-Duhem-Margules equation.
- Apply the concepts of phase, conductance and distribution law while studying otherchemistry courses and every-day life.
- Explain low and high quantum yield, photosensitized reactions

Syllabus

Unit 1: Phase Equilibria **(Hours: 22)**

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 (H_2O and S). Phase diagrams for systemsof solid-liquid equilibria involving eutectic, congruent and incongruent melting points.

Binary solutions: Gibbs-Duhem-Margules equation, its derivation and applications to fractional distillation of binary miscible liquids (ideal and non-ideal), azeotropes, lever rule, partial miscibility of liquids, CST, miscible pairs, steam distillation. Nernstdistribution law: its derivation and applications.

Unit 2: Photochemistry **(Hours: 8)**

Characteristics of electromagnetic radiation. Lambert-Beer's law and its limitations, physical significance of absorption coefficients. Laws of photochemistry, quantum yield, examples of low and high quantum yields

Photosensitized reactions, Jablonski's diagram. Role of photochemical reactions in biochemical processes, chemiluminescence.

Practical component **Credits: 02**

(Laboratory periods: 60)

Phase Equilibrium

1. Determination of critical solution temperature and composition at CST of the phenol water system.
2. Effect of impurity on CST of phenol-water system (NaCl and succinic acid).
3. Construction of the phase diagram using cooling curves :
   a. Simple eutectic.
   b. Congruent melting system(s).
4. Distribution of acetic/ benzoic acid between water and chloroform or cyclohexane.
5. Study of equilibrium of any one of the following reactions by distribution method:

   (i) I_2 (aq) + I^- (aq) $\rightleftharpoons$ I_3^-(aq)

   (ii) Cu^{2+} (aq) + $nNH_3 \rightleftharpoons [Cu(NH_3)n]^{2+}$

References:

Theory:

1. Atkins, P.W.; Paula, J.de. (2014), **Atkin's Physical Chemistry Ed**., 10th Edition, OxfordUniversity Press.
2. Ball, D. W. (2017), **Physical Chemistry**, 2nd Edition, Cengage Learning, India.
3. Castellan, G. W. (2004), **Physical Chemistry**, 4th Edition, Narosa.
4. Kapoor, K.L. (2015), **A Textbook of Physical Chemistry**, Vol 1, 6th Edition, McGrawHill Education.
5. Kapoor, K.L., **A Textbook of Physical Chemistry**, Vol 3, 5th Edition, McGraw HillEducation.

Practical:

1. Khosla, B.D.; Garg, V.C.; Gulati, A. (2015), **Senior Practical Physical Chemistry**, R.Chand & Co, New Delhi.
2. Kapoor, K.L. (2019), **A Textbook of Physical Chemistry**, Vol.7, 1st Edition, McGrawHill Education.
3. Garland, C. W.; Nibler, J. W.; Shoemaker, D. P. (2003), **Experiments in PhysicalChemistry**, 8th Edition, McGraw-Hill, New York

Additional Resources:

1. Moore, W.J. (1972), **Physical Chemistry**, 5th Edition, Longmans Green & Co. Ltd.
2. Glasstone, S. (1948), **Textbook of Physical Chemistry**, D. Van Nostrand company, NewYork.

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

DISCIPLINE SPECIFIC ELECTIVE COURSE – 13 (DSE-13): Research Methodology for Chemists

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Research Methodology for Chemists (DSE-13)	04	03	--	01	Class 12^{th} with Physics, Chemistry	

Learning objectives

The objectives of this course are as follows:

- To make the students aware of fundamental but mandatory ethical practices in chemistry.
- To introduce the concept of data analysis.
- To learn to perform literature survey in different modes.
- To make the students aware of safety handling and safe storage of chemicals.
- To make students aware about plagiarism and how to avoid it.
- To teach the use of different e-resources.

Learning outcomes

By studying this course, students will be able to:

- Follow ethical practices in chemistry
- Do Data analysis
- Literature survey in different modes
- Use e-resources.
- Avoid plagiarism, understand the consequences and how to avoid

SYLLABUS OF DSE-13

UNIT – 1: Scope of Research **(Hours: 3)**

Introduction, overview of research process: define research problem, review literature, formulate hypothesis, design research/experiment, collect and analyse data, interpret and report, scope and importance.

UNIT – 2: Literature Survey, Databases and Research metrics **(Hours: 15)**

Print: Sources of information: Primary, secondary, tertiary sources; Journals: Journal abbreviations, Digital: Databases and their responsible use: Google Scholar, Web of science, Scopus, UGC INFONET, SciFinder, PubMed, ResearchGate, E-consortium, e-books; Search techniques: Phrase, Field, Boolean, Proximity, Concept, Limiting/Refining Search Results. Research metrics: Impact factor of Journal, h-index, i10 index, Altmetrics, Citation index. Author identifiers/or profiles: ORCID, Publons, Google Scholar, ResearchGate, VIDWAN

UNIT – 3: Communication in Science (Hours: 12)

Types of technical documents: Full length research paper, book chapters, reviews, short communication, project proposal, Letters to editor, and thesis.
Thesis writing – different steps and software tools (Word processing, LaTeX, Chemdraw, Chemsketch etc) in the design and preparation of thesis, layout, structure (chapter plan) and language of typical reports, Illustrations and tables, bibliography, referencing: Styles (APA, Oxford etc), annotated bibliography, Citation management tools: Mendeley, Zotero and Endnote; footnotes. Oral presentation/posters – planning, software tools, creating and making effective presentation, use of visual aids, importance of effective communication, electronic manuscript submission, effective oral scientific communication and presentation skills.

UNIT – 4: Research and Publication ethics (Hours: 9)

Scientific Conduct: Ethics with respect to science and research, Scientific Misconducts: falsification, fabrication and plagiarism, similarity index, software tools for finding plagiarism (Turnitin, Urkund etc), redundant dublications

Publication Ethics: Introduction, COPE (Committee on Publication Ethics) guidelines; conflicts of interest, publication misconduct: problems that lead to unethical behaviour and vice versa, types, violation of publication ethics, authorship and contributorship, predatory publishers and journals

IPR - Intellectual property rights and patent law, commercialization, copy right, royalty, trade related aspects of intellectual property rights (TRIPS)

UNIT – 5: Statistical analysis for chemists (Hours: 6)

Types of data, data collection-Methods and tools, data processing, hypothesis testing, Normal and Binomial distribution, tests of significance: t-test, F-test, chi- square test, ANOVA, multiple range test, regression and correlation.

Features of data analysis with computers and softwares -Microsoft Excel, Origin, SPSS

Practical component Credits: 01

(Laboratory periods:15 classes of 2 hours each)

1. Collection of journal articles on a particular topic using Google Scholar and creating a database.
2. Collection of journal articles on a particular topic using Science Direct and creating a database.
3. Collection of journal articles on a particular topic using Scopus and creating a database.
4. Drawing chemical structure, reactions and mechanisms using Chemsketch or ISIS draw or any other software.

5. Collection of chemical structure using ChemSpider and creating a database.
6. Curve fitting using freely available softwares/apps (any one)
7. Making of power point presentation
8. Experimental learning of safe storage hazardous chemicals
9. Experimental learning of handling of hazardous chemicals
10. Technical writing on topics assigned.
11. Demonstration for checking of plagiarism using recommended software

Essential/recommended readings:

1. Dean, J. R., Jones, A. M., Holmes, D., Reed, R., Weyers, J. & Jones, A. (2011) Practical skills in chemistry. 2nd Ed. Prentice-Hall, Harlow.
2. Hibbert, D. B. & Gooding, J. J. (2006) Data analysis for chemistry. Oxford University Press.
3. Topping, J. (1984) Errors of observation and their treatment. Fourth Ed., Chapman Hall, London.
4. Harris, D. C. Quantitative chemical analysis. 6th Ed., Freeman (2007) Chapters 3-5.
5. Levie, R. de, how to use Excel in analytical chemistry and in general scientific data analysis. Cambridge Univ. Press (2001) 487 pages.
6. Chemical safety matters – IUPAC – IPCS, Cambridge University Press, 1992.
   OSU safety manual 1.01

BSC. (LIFE SCIENCE)- CHEMISTRY COMPONENT

SEMESTER-IV

DISCIPLINE SPECIFIC CORE COURSE CHEM-DSC -10: Chemistry- IV: Chemistry of Carboxylic Acids & their Derivatives, Amines and Heterocycles

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Chemistry of Carboxylic Acids & their Derivatives, Amines and Heterocycles DSC-10: Chemistry- 04	**04**	**02**	**-**	**02**	**Class 12th with Physics, Chemistry, Mathematics**	

Learning Objectives

The Learning Objectives of this course are as follows:

- To introduce the basics of coordination chemistry and which are of immense importance to biological systems, qualitative and quantitative analysis, catalysis, medicines, paints and pigments etc.
- Nomenclature, isomerism, bonding in coordination compounds has been dealt with in sufficient detail along with special emphasis on important coordination compounds in the biological system.

Learning outcomes

By studying this course, students will be able to:

- Understand terms: ligand, denticity of ligands, chelate, coordination number.
- Systematically name coordination compounds.
- Discuss the various types of isomerism possible in Octahedral and Tetrahedral coordination compounds.
- Use Valence Bond Theory to predict the structure and magnetic behaviour of metal complexes and understand the terms inner and outer orbital complexes.
- Explain the meaning of the terms $\Delta o.$, Δt, pairing energy, CFSE, high spin and low spin and how CFSE affects thermodynamic properties like lattice enthalpy and hydration enthalpy.
- Explain magnetic properties and colour of complexes on basis of Crystal Field Theory
- Understand reaction mechanisms of coordination compounds and differentiate between kinetic and thermodynamic stability.
- Discuss the application of coordination compounds in the biological systems such as Heamoglobin, myoglobin and some enzymes

Syllabus

Unit 1: Carboxylic acids and their Derivatives (aliphatic and aromatic) (Hours:13)

Preparation: Oxidation reactions of alcohols, aldehydes and ketones, Acidic and alkaline hydrolysis of esters; Reactions: Hell-Volhard Zelinsky reaction,

Carboxylic acid derivatives (aliphatic): Preparation: Acid chlorides, anhydrides, esters and amides from acids and their interconversion, Claisen condensation. Reactions: Relative reactivities of acid derivatives towards nucleophiles, Reformatsky reaction, Perkin condensation.

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

Unit 2: Amines (aliphatic & aromatic) and Diazonium Salts (Hours:10)

Amines

Preparation: from alkyl halides, Gabriel's Phthalimide synthesis, Hofmann Bromamide reaction. Reactions: Hofmann *vs* Saytzeff elimination, carbylamine test, Hinsberg test, reaction with HNO_2, Schotten-Baumann reaction. Electrophilic substitution (case aniline): nitration, bromination, sulphonation; basicity of amines.

Diazonium salt

Preparation: from aromatic amines; Reactions: conversion to benzene, phenol and dyes.

Unit 3: Heterocyclic Compounds (Hours:07)

Introduction, classification, structure, nomenclature and uses. Preparation and properties of the following heterocyclic compounds with reference to electrophilic and nucleophilic substitution: furan, pyrrole, thiophene, and pyridine.

PRACTICALS: Credits: 02

(Laboratory periods: 60)

1. Systematic qualitative analysis and preparation of suitable crystalline derivative (carboxylic acids, carbonyl, alcohols, phenols, amines (1°, 2°,3°) and amides).
2. Preparation:

    a. Acetylation of Aniline and Phenols.
    b. Benzoylation of Aniline and phenols.

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

References:

Theory:

1. Morrison, R. N.; 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. Ahluwalia, V.K.; Bhagat, P.; Aggarwal, R.; Chandra, R. (2005), **Intermediate for Organic Synthesis**, I.K. International.

4. Solomons, T. W. G.; Fryhle, C. B.; Snyder, S. A. (2016), **Organic Chemistry**, 12th Ed., Wiley.

5. Parashar, R.K., Negi, B. (2016) **Chemistry of Heterocyclic Compounds**, Ane Books Pvt Ltd.

Practical:

1. Ahluwalia, V.K.; Dhingra, S.; Gulati, A. (2005), **College Practical Chemistry**, University Press (India) Ltd.

2. Ahluwalia, V.K.; Dhingra, S. (2004), **Comprehensive Practical Organic Chemistry: Qualitative Analysis**, University Press.

3. Pasricha, S., Chaudhary, A. (2021), **Practical Organic Chemistry: Volume I**, I K International Publishing House Pvt. Ltd., New Delhi.

4. Pasricha, S., Chaudhary, A. (2021), **Practical Organic Chemistry: Volume II**, I K International Publishing House Pvt. Ltd., New Delhi.

5. Vogel, A.I. (1972), **Textbook of Practical Organic Chemistry**, Prentice-Hall.

6. Jeffery, G.H.; Bassett, J.; Mendham, J.; Denney, R.C. (1989), **Vogel's Textbook of Quantitative Chemical Analysis**, John Wiley and Sons.

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BSC. (LIFE SCIENCE)- CHEMISTRY COMPONENT

SEMESTER-V

DISCIPLINE SPECIFIC CORE COURSE CHEM-DSC -13: Chemistry- V: Coordination Chemistry and its Application in Biological Systems

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Coordination Chemistry and its Application in Biological Systems DSC-13 Chemistry- 5	**04**	**02**	**-**	**02**	**Class 12th with Physics, Chemistry, Mathematics**	

Learning Objectives

The Learning Objectives of this course are as follows:

- To introduce the basics of coordination chemistry and which are of immense importance to biological systems, qualitative and quantitative analysis, catalysis, medicines, paints and pigments etc.
- Nomenclature, isomerism, bonding in coordination compounds has been dealt with in sufficient detail along with special emphasis on important coordination compounds in the biological system.

Learning outcomes

By studying this course, students will be able to:

- Understand terms: ligand, denticity of ligands, chelate, coordination number.
- Systematically name coordination compounds.
- Discuss the various types of isomerism possible in Octahedral and Tetrahedral coordination compounds.
- Use Valence Bond Theory to predict the structure and magnetic behaviour of metal complexes and understand the terms inner and outer orbital complexes.
- Explain the meaning of the terms Δo., Δt, pairing energy, CFSE, high spin and low spin and how CFSE affects thermodynamic properties like lattice enthalpy and hydration enthalpy.
- Explain magnetic properties and colour of complexes on basis of Crystal Field Theory

- Understand reaction mechanisms of coordination compounds and differentiate between kinetic and thermodynamic stability.
- Discuss the application of coordination compounds in the biological systems such as Heamoglobin, myoglobin and some enzymes

Syllabus

Unit 1: Introduction to Coordination Compounds (Hours: 6)

Brief discussion with examples of types of ligands, denticity and concept of chelate. IUPAC system of nomenclature of coordination compounds (mononuclear and binuclear) involving simple monodentate and bidentate ligands. Structural and stereoisomerism in complexes with coordination numbers 4 and 6.

Unit 2: Bonding in Coordination Compounds (Hours: 14)

Valence Bond Theory (VBT): Salient features of theory, concept of inner and outer orbital complexes, Drawbacks of VBT.

Crystal Field Theory: Splitting of d orbitals in octahedral symmetry. Crystal field effects for weak and strong fields, Crystal field stabilization energy (CFSE), concept of pairing energy, Factors affecting the magnitude of Δ, Spectrochemical series, Splitting of d orbitals in tetrahedral symmetry, Comparison of CFSE for octahedral and tetrahedral fields, tetragonal distortion of octahedral geometry, Jahn-Teller distortion.

Unit 3: Thermodynamic and Kinetic aspects of Metal Complexes (Hours: 6)

A brief outline of thermodynamic and kinetic stabilities of metal complexes and factors affecting the stability. Substitution reactions of square-planar complexes – Trans effect: cisplatin and transplatin.

Unit 4: Application of coordination compounds in biological systems (Hours: 4)

Haemoglobin, Myoglobin, carboxypeptidase, carbonic anhydrase

Practicals Component **Credits: 02**
(Laboratory periods: 60)

1. Estimation of Mg^{2+} by direct complexometric titrations using EDTA.
2. Estimation of Zn^{2+} by direct complexometric titrations using EDTA.
3. Estimation of Ca^{2+} by direct complexometric titrations using EDTA.
4. Estimation of Zn^{2+} in zinc tablet.
5. Estimation of Ca^{2+} in milk sample.
6. Estimation of total hardness of a given sample of water by complexometric titration.
7. Determination of the composition of the Fe^{3+} - salicylic acid complex / Fe^{2+} -1,10-phenanthroline complex in solution by Job's method
8. Determination of the composition of the Fe^{3+} - salicylic acid complex / Fe^{2+}-1,10-phenanthroline complex in solution by mole ratio method

9. Preparation of the following inorganic compounds:
   a). Tetraamminecopper(II) sulphate
   b). Potassium trioxalatoferrate(III) trihydrate
   c). Chrome alum
10. Any suitable experiment (other than the listed ones) based upon complexation reactions.

References:

Theory:

9. Huheey, J.E.; Keiter, E.A., Keiter; R. L.; Medhi, O.K. (2009), **Inorganic Chemistry- Principles of Structure and Reactivity**, Pearson Education.
10. Shriver, D.D.; Atkins, P.; Langford, C.H. (1994), **Inorganic Chemistry** 2nd Ed., Oxford University Press.
11. Atkins, P.W.; Overton, T.L.; Rourke, J.P.; Weller, M.T.; Armstrong, F.A. (2010), **Inorganic *Chemistry***, 5th Edition, W. H. Freeman and Company.
12. Cotton, F.A.; Wilkinson, G.; Gaus, P.L. **Basic Inorganic Chemistry**, 3rd Edition, Wiley India.
13. Douglas, B.E.; McDaniel, D.H.; Alexander, J.J. (1994), **Concepts and Models of Inorganic Chemistry**, John Wiley & Sons.
14. Greenwood, N.N.; Earnshaw, A. (1997), **Chemistry of the Elements**, 2nd Edition, Elsevier.
15. Lee, J.D.; (2010), **Concise Inorganic Chemistry**, Wiley India.
16. Sodhi G.S., Principles of Inorganic Chemistry, Third Edition, Viva Books, India.

Practicals:

1. Jeffery, G.H.; Bassett, J.; Mendham, J.; Denney, R.C. (1989), **Vogel's Textbook of Quantitative Chemical Analysis**, John Wiley and Sons.
2. Marr, G.; Rockett, B.W. (1972), **Practical Inorganic Chemistry**, Van Nostrand Reinhold.
3. Dua A, Manav N, **Practical Inorganic Chemistry,** (2017), Manakin Press.

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BSC. (LIFE SCIENCE)- CHEMISTRY COMPONENT

SEMESTER-VI

DISCIPLINE SPECIFIC ELECTIVE COURSE CHEM-DSC 16: Chemistry- VI: Conductance, Electrochemistry and Chemical Kinetics

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Conductance, Electrochemistry and Chemical Kinetics DSC-16: Chemistry- 6	**04**	**02**	**-**	**02**	**Class XII with Science**	

Learning Objectives

The Learning Objectives of this course are as follows:

- To develop basic understanding of electrolytic and galvanic cells.
- Measurementof conductance and its applications, measurement of emf and its applications.
- To understand reaction rate, order, activation energy and theories of reaction rates.

Learning outcomes

By studying this course, students will be able to:

- Explain the factors that affect conductance, migration of ions and application of conductance measurement.
- Understand the importance of Nernst equation, measurement of emf, calculations of thermodynamic properties and other parameters from the emf measurements.
- Understand rate law and rate of reaction, theories of reaction rates and catalysts; both chemical and enzymatic.

Syllabus

Unit 1: Conductance **(Hours: 8)**

Conductivity, equivalent and molar conductivity and their variation with dilution for weak and

strong electrolytes, Kohlrausch Law of independent migration of ions, Ionic velocity, mobility and their determination, transference number and its relation to ionic mobility, Conductometric titrations (only acid-base).

Unit 2: Electrochemistry **(Hours: 12)**

Concept of reversible and irreversible electrochemical cells, Standard hydrogen electrode, standard electrode potential, concept of EMF of a cell, measurement of EMF of a cell, Nernst equation and its importance, types of electrodes (Reference and inert electrodes), electrochemical series.

Thermodynamics of a reversible cell, calculation of thermodynamic properties: G, H and S from EMF data. Calculation of equilibrium constant from EMF data. pH determination using glass electrode, Potentiometric titrations-qualitative treatment (acid-base and oxidation-reduction only).

Unit 3: Chemical Kinetics and Catalysis **(Hours: 10)**

The concept of reaction rates, effect of temperature, pressure, catalyst and other factors on reaction rates. Order and molecularity of a reaction, integrated rate equations for zero, first and second order reactions (derivation not required), half–life of a reaction, Concept of activation energy and its calculation from Arrhenius equation.

Catalysis: Types of catalyst, specificity and selectivity, generalized treatment of catalyzed reactions at solid surfaces. Enzyme catalysis, Michaelis-Menten mechanism, acid-base catalysis.

Practical Component: **Credits:02**

Laboratory periods: 60

1. Determination of molar conductance, degree of dissociation and dissociation constant of a weak acid.
2. Perform the following conductometric titrations: Strong acid vs strong base.
3. Perform the following conductometric titrations: Weak acid vs strong base.
4. Determination of TDS of water from different sources.
5. Determination of Soil pH of soil collected from various locations.
6. Perform the potentiometric titrations of strong acid vs strong base
7. Perform the potentiometric titrations of Weak acid vs strong base.
8. Perform the potentiometric titrations of Potassium dichromate vs. Mohr's salt.
9. Perform the potentiometric titrations of $KMnO_4$ vs. Mohr's salt.
10. Study the kinetics of acid hydrolysis of methyl acetate with hydrochloric acid.

References:

Theory:

1. Castellan, G. W .(2004), **Physical Chemistry**, Narosa Publications.
2. Kapoor, K.L. (2015),**A Textbook of Physical Chemistry**, Vol.1, 6th Edition, McGraw Hill Education.
3. Kapoor, K.L. (2015),**A Textbook of Physical Chemistry**, Vol.5, 3rd Edition, McGraw Hill Education.
4. Puri, B.R., Sharma, L.R. and Pathania M.S. (2020), **Principles of Physical Chemistry,** Vishal Publishing Co.

Practical:

1. Khosla, B.D.; Garg, V.C.; Gulati, A.(2015), **Senior Practical Physical Chemistry**, R. Chand & Co.
2. Kapoor, K.L. (2019), **A Textbook of Physical Chemistry**, Vol 7, 1st Edition, McGraw Hill Education.
3. Batra, S.K., Kapoor, V and Gulati, S. (2017) 1st Edition, **Experiments in Physical Chemistry,** Book Age series.

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POOL OF DISCIPLINE SPECIFIC ELECTIVES (DSEs)

SEMESTER III

DISCIPLINE SPECIFIC ELECTIVE COURSE CHEM-DSE -1: Chemistry of Major and Minor Biogenic Elements

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Chem-DSE-1: Chemistry of Major and Minor Biogenic Elements	**04**	**02**	**-**	**02**	**Class XII with Science**	

Learning Objectives

The Learning Objectives of this course are as follows:

- To introduce learners to review periodic properties of main group elements and their role in the biological systems. It further discusses the patterns and trends exhibited by main group elements and their compounds with emphasis on synthesis, structure, bonding and their diverse applications in the environment, industry and in the biological system.
- To develop the interest of students in the frontier areas of inorganic and material chemistry, it gives an insight into how these compounds such as oxides of N and S affect our day-to-day life. Students learn about inorganic polymeric compounds borazine, silicates, silicones, phosphonitrilic compounds and their applications.

Learning outcomes

By studying this course, students will be able to:

- Understand the periodicity in atomic and ionic radii, electronegativity, ionization enthalpy, electron gain enthalpy of elements of the periodic table.
- Understand oxidation states with reference to the existence of elements in unusual and rare oxidation states in alkalides, carbides and nitrides.

- Understand vital role of sodium, potassium, calcium and magnesium ions etc. in biological systems and the role of oxides of N and S in our environment.
- Distribution of major and minor biogenic elements in human beings

Syllabus

Unit 1: Periodic Properties **(Hours: 6)**

Electronic configurations of the atoms. Stability of half-filled and completely filled orbitals, the concept of exchange energy, inert pair effect.
General group trends of main group elements with special reference to size (atomic and ionic), Ionization Enthalpy, Electron Gain Enthalpy, Electronegativity, oxidation states (including rare oxidation states of alkali metals, carbides and nitrides), melting and boiling points, flame colour, metallic character and complex formation tendency (crown ethers and cryptates), Alkali metal solutions in liquid ammonia
Distribution of major and minor biogenic elements in human beings

Unit 2: Structure, Bonding and Properties **(Hours: 16)**

Structure, bonding and properties: Acidic/Basic nature, stability, ionic/covalent nature, oxidation/reduction, hydrolysis, thermal stability of the following:
Hydrides: hydrides of Group 13 (only diborane), Group 14, Group 15 (EH_3 where E = N, P, As, Sb, Bi), Group 16 and Group 17.
Oxides: Oxides of nitrogen, phosphorus and sulphur
Oxoacids: oxoacids of phosphorus, sulphur and chlorine
Halides of phosphorus
Relevance of above compounds in industrial/environmental/biological systems wherever applicable

Unit 3: Preparation, Properties, Structure and Uses **(Hours: 8)**

Preparation, properties, structure and uses of the following compounds: Borazine, Silicates, silicones, Phosphonitrilic halides $\{(PNCl_2)_n$ where n = 3 and 4$\}$

Practicals **Credits:02**
(Laboratory periods: 60)

Qualitative semi-micro analysis of mixtures containing 2 anions and 2 cations (preferably 7-8 mixtures). Emphasis should be given to the understanding of the chemistry of different reactions. The following radicals are suggested:
CO_3^{2-}, NO_2^-, S^{2-}, SO_3^{2-}, SO_4^{2-}, $S_2O_3^{2-}$, CH_3COO^-, F^-, Cl^-, Br^-, I^-, NO_3^-, BO_3^{3-}, $C_2O_4^{2-}$, PO_4^{3-},
NH_4^+, K^+, Pb^{2+}, Cu^{2+}, Cd^{2+}, Bi^{3+}, Sn^{2+}, Sb^{3+}, Fe^{3+}, Al^{3+}, Cr^{3+}, Zn^{2+}, Mn^{2+}, Co^{2+}, Ni^{2+}, Ba^{2+}, Sr^{2+}, Ca^{2+}, Mg^{2+}
The mixtures may contain combination of anions/one interfering anion.
Spot tests should be preferred wherever applicable.

References:

Theory:

1. Lee, J.D.; (2010), **Concise Inorganic Chemistry**, Wiley India.
2. Huheey, J.E.; Keiter, E.A.; Keiter; R. L.; Medhi, O.K. (2009), **Inorganic Chemistry- Principles of Structure and Reactivity**, Pearson Education.
3. Douglas, B.E.; McDaniel, D.H.; Alexander, J.J. (1994), **Concepts and Models of Inorganic Chemistry**, John Wiley & Sons.
4. Atkins, P.W.; Overton, T.L.; Rourke, J.P.; Weller, M.T.; Armstrong, F.A. (2010), Shriver and Atkins **Inorganic Chemistry**, 5th Edition, Oxford University Press.
5. Housecraft, E. H.; Sharpe, A.G. (2018), **Inorganic Chemistry**, 5th Edition, Pearson.

Practicals:

4. Vogel, A.I. (1972), **Qualitative Inorganic Analysis**, Longman.
5. Svehla, G. (1996), **Vogel's Qualitative Inorganic Analysis**, Prentice Hall.
6. Dua A, Manav N, **Practical Inorganic Chemistry,** (2017), Manakin Press.

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DISCIPLINE SPECIFIC ELECTIVE COURSE CHEM-DSE -2: Polynuclear Hydrocarbons, Pharmaceutical Compounds,

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Chem-DSE-2: Polynuclear Hydrocarbons, Pharmaceutical Compounds, UV- Visible & IR Spectroscopy	**04**	**02**	**-**	**02**	**Class XII with Science**	

Learning Objectives

The Learning Objectives of this course are as follows:

- To introduce the chemistry and applications of polynuclear hydrocarbons and heterocyclic compounds.
- Introduction to spectroscopy, an important analytical tool which allows identification of organic compounds by correlating their spectra to structure.

Learning outcomes

By studying this course, students will be able to:

- Understand the fundamentals of polynuclear hydrocarbons and heterocyclic compounds through the study of methods of preparation, properties and chemical reactions with underlying mechanism.
- Gain insight into the basic fundamental principles of IR and UV-Vis spectroscopic techniques.
- Use basic theoretical principles underlying UV-visible and IR spectroscopy as a tool for functional group identification in organic molecules.

Syllabus

UNIT-1: Polynuclear Hydrocarbons **(Hours: 6)**

Introduction, classification, uses, aromaticity of polynuclear compounds, Structure elucidation of naphthalene, preparation and properties of naphthalene and anthracene.

UNIT-2: Pharmaceutical Compounds **(Hours: 12)**

Introduction, classification, general mode of action of antipyretics and analgesics, aspirin; Synthesis, uses and side effects of the following drugs:
Antipyretics - Paracetamol (with synthesis and mode of action); Analgesics- Ibuprofen (with synthesis and overview of the mode of action); Antimalarials - Chloroquine (synthesis and mode of action).
An elementary treatment of Antibiotics and detailed study of chloramphenicol including mode of action. Medicinal values of curcumin (haldi), azadirachtin (neem), vitamin C and antacid (ranitidine)**.**

UNIT-3: UV-Vis and IR Spectroscopy **(Hours: 12)**

UV-Vis and IR Spectroscopy and their application to simple organic molecules. Electromagnetic radiations and their properties; double bond equivalence and hydrogen deficiency. UV-Vis spectroscopy (electronic spectroscopy): General electronic transitions, λ_{max} & ε_{max}, chromophores &auxochromes, bathochromic & hypsochromic shifts. Application of Woodward rules for the calculation of λ_{max} for the following systems: conjugated dienes - alicyclic, homoannular and heteroannular; α, β-unsaturated aldehydes and ketones, charge transfer complex.

Infrared (IR) Spectroscopy: Infrared radiation and types of molecular vibrations, the significance of functional group & fingerprint region. IR spectra of alkanes, alkenes, aromatic hydrocarbons (effect of conjugation and resonance on IR absorptions), simple alcohols (inter and intramolecular hydrogen bonding and IR absorptions), phenol, carbonyl compounds, carboxylic acids and their derivatives (effect of substitution on >C=O stretching absorptions).

Practical component **Credit:02**

(Laboratory periods: 15 classes of 4 hours each)

1. Isolation and estimation of the amount of aspirin in a commercial tablet.
2. Preparation of Aspirin.
3. Synthesis of ibuprofen.
4. Systematic qualitative identification and derivative preparation of organic compounds (Aromatic hydrocarbons, Aryl halides)
5. Detection of simple functional groups through examination of IR spectra (spectra to be provided). IR spectra of simple compounds like phenols, aldehydes, ketones, carboxylic acids may be given.
6. Differentiation between of o-/p-hydroxybenzaldehyde by IR spectroscopy (Spectra to be provided).
7. Differentiation between benzoic acid and cinnamic acid by UV spectroscopy.
8. Diel's Alder reaction using Anthracene and Maleic anhydride.
9. Partial Reduction of m-dinitrobenzene to m-nitroaniline and then analysing the IR spectra of reactant and Product.
10. Laboratory preparation of Paraacetamol.

References:

Theory:

1. Finar, I. L. **Organic Chemistry** (Volume 1 & 2), Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
2. Morrison, R. N.; Boyd, R. N. **Organic Chemistry,** Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
3. Bahl, A; Bahl, B. S. (2012), **Advanced Organic Chemistry**, S. Chand.

4. Pavia, D.L. **Introduction to Spectroscopy**, Cengage learning (India) Pvt. Ltd.
2. Kemp, W. (1991), **Organic Spectroscopy**, Palgrave Macmillan.

Practicals:

1. Ahluwalia, V.K.; Dhingra, S.; Gulati, A. (2005), **College Practical Chemistry,** University Press (India) Ltd.
2. Ahluwalia, V.K.; Dhingra, S. (2004), **Comprehensive Practical Organic Chemistry: Qualitative Analysis**, University Press.
3. Vogel, A.I. (1972), **Textbook of Practical Organic Chemistry**, Prentice-Hall.
4. Pasricha, S., Chaudhary, A. (2021), **Practical Organic Chemistry: Volume I**, I K International Publishing House Pvt. Ltd., New Delhi.
5. Pasricha, S., Chaudhary, A. (2021), **Practical Organic Chemistry: Volume I**, I K International Publishing House Pvt. Ltd., New Delhi.

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

DISCIPLINE SPECIFIC ELECTIVE COURSE CHEM-DSE 3: Chemistry of Colloids and Adsorption

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Chem-DSE 3: Chemistry of Colloids and Adsorption	**04**	**02**	**-**	**02**	**Class XII with Science**	

Learning Objectives

The Learning Objectives of this course are as follows:

- To develop basic concepts of colloids and colloidal phenomenon.
- Preparation and characterization of sols, understanding about applications of colloid in food, petroleum and cosmetic industry.
- Basic understanding of adsorption, types of adsorption, chemistry of adsorption and its applications.

Learning outcomes

By studying this course, students will be able to:

- Understand colloid solutions, preparation of sols.
- Understand the concept of Electrical double layer, charge on colloidal particles.
- Characterize the colloids sols, learn colloid phenomenon like Tyndall effect, Brownian movement, electrophoresis, dialysis, coagulation and flocculation.
- Understand adsorption, types of adsorption. Characteristics, factors affecting adsorption and its applications

Syllabus

Unit 1: Colloidal State **(Hours: 8)**

Distinction among true solutions, colloids and suspensions, components of Colloids, classificationof colloids - lyophilic, lyophobic; Preparation methods and properties of lyophobic solutions, Hydrophile-lyophile balance (HLB), multi molecular, macromolecular and associated colloids (micelles formation), Schulze -Hardy law.

Unit 2: Preparation and properties of colloids **(Hours: 14)** Methods of preparation of colloids, Tyndall effect, Brownian movement, coagulation and flocculation; electrophoresis, dialysis.

Emulsification by surfactants, selection of surfactants as emulsifying agent, colloidal phenomenonin food chemistry, Protein based functional colloids.

UNIT 3: Surface Chemistry **(Hours: 8)**

Adsorption, Distinction between adsorption and absorption, Types of Adsorption, Physisorption and chemisorption and their characteristics, factors affecting adsorption of gases on solids - Freundlich and Langmuir adsorption isotherms, Adsorption from solutions. Applications of Adsorption phenomenon in living systems.

Practical component **Credits: 02**

(Laboratory periods: 60)

7. Preparation of Colloidal Sols of following
   a. Egg Albumin
   b. Starch /Gum
   c. Ferric chloride
   d. Aluminum hydroxide
   e. Antimony Sulphide
8. To find out the precipitation values of Antomony Sulphide sol by using monovalent, bivalent and trivalent cations.
9. To verify the Schulze -Hardy law.
10. To verify the Freundlich's Adsorption isotherms.
11. Study of adsorption of HAc on charcoal and prove the validity of Langmuir's adsorption isotherms
12. Study of adsorption of Oxalic acid on charcoal and prove the validity of Langmuir's adsorption isotherms.

References:

Theory:

7. Puri B. R., Sharma L. R. and Pathania M.S., (2020) Principles of Physical Chemistry, Vishal Publishing Co.Jalandhar, Punjab, India.
8. Kapoor K L, **Text Book of Physical Chemistry, Vol. 4,** McGraw Hill Education (India) Private Limited, Chennai, India.
9. Evans D F and Wennerström's, **The Colloidal Domain**, Second Edition, John Wiley & Sons Inc.
10. Adamson A. W. and Gast A., **Physical Chemistry of Surfaces** (Main text) Sixth Edition, John Wiley & Sons Inc.
11. Berg J. C., **An Introduction to Interfaces and Colloids,** World Scientific Publishing Co., Inc.
    New Jersey.
12. Israelachvili J. N., **Intermolecular and Surface Forces,** Elsevier Inc.

Practical:

3. Giri, S; Bajpai, D.N.; Pandey, O.P. **Practical Chemistry**, S. Chand Limited.
4. Khosla, B.D.; Garg, V.C.; Gulati, A.(2015), **Senior Practical Physical Chemistry**, R. Chand & Co.

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

DISCIPLINE SPECIFIC ELECTIVE COURSE CHEM-DSE -4: Acids & Bases and Aqueous Chemistry of Metal Ions

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Chem-DSE-4: Acids & Bases and Aqueous Chemistry of Metal Ions	**04**	**02**	**-**	**02**	**Class XII with Science**	

Learning Objectives

The Learning Objectives of this course are as follows:

- To provide basic understanding of the various concepts of acids and bases and Buffers to students and the factors responsible for variable acid and bases strength. This will help the learner to understand the importance of pH maintenance for a large number of biological processes especially enzyme systems.
- The unit of Aqueous Chemistry of metal ions provides an insight into the types of reactions a metal ion undergoes in aqueous medium- hydration, hydrolysis, redox, complexation, precipitation. The knowledge of these let a learner ascertain the feasibility of a proposed reaction and also to predict the possible outcomes of a new reaction. This additionally equips a biology student to understand different biological processes involving metal ions in a better way.

Learning outcomes

By studying this course, students will be able to:

- Define the Arrhenius, Bronsted Lowry, Lewis and Hard & soft acids and bases.
- Distinguish one class of acids and bases from the other and will be able to classify different types of available acids (synthetic and natural) under these classes.
- Understand the parameters affecting the relative strength of acids and bases and the effect of solvent on them.
- Explain the effect of mixing a strong/weak acid with a weak/strong base and will be able to calculate the pH of buffers.
- Correlate the concepts of acids and bases to the biological processes, the importance of pH and the buffers in sustaining specific metabolic activities.
- Explain the behavior of metal ions in aqueous solutions in presence of other reagents

- Differentiate between solvation and solvolysis and explain the formation of oxo ions as a result of hydrolysis.
- Write the redox reactions involving metal ions, use the Nernst equation to calculate redox potentials and correlate them with the relative oxidizing/reducing strength of metal ions
- Explain the successive reduction or oxidation of a metal ion capable of displaying more than two oxidation states and hence predict the spontaneity of a redox reaction
- Explain the disproportionation of an oxidation state and the stability of an oxidation state in aqueous medium by comparing the redox potentials with that of water at different pH.
- Explain the chemistry involved in the quantitative chemical analysis involving redox
- reactions like redox titrations.
- Explain the formation of metal complexes based on two different modes of ligand metal interaction.
- Understand the importance of complexation process in stabilizing some oxidation states more than the other.
- Write the reactions involving the precipitation of metal ions, and predict the relative precipitations based on solubility products.
- Explain the identification and separation of metal ions in a mixture based on difference in precipitation behavior of metal ions.
- Correlate the redox, complexation and precipitation behavior of metal ions in aqueous medium to the role of metal ions and metalloproteins in biological systems.

Syllabus

Unit 1: Acids & Bases **(Hours: 10)**

Concepts: Arhenius, Bronsted-Lowry (aqua, hydroxo, oxo), Lewis acids and bases, Hard and Soft acids and bases.
Strength of Acids and Bases: factors affecting relative strength of acids and bases, solvent levelling, superacids and superbases.
Buffers (NH_4OH/NH_4Cl, NaOAc/HOAc, boric acid and borate, Phosphate buffers, Universal Buffer), buffer capacity, calculation of pH of buffer solutions, pH calculation using Handerson-Hasselbalch equation, Applications of Acids & Bases and buffers in biological processes

Unit 2: Aqueous Chemistry of Metal ions **(Hours: 20)**

Solvation effects on metal ions, oxocations and oxoanions
Redox reactions: Half reactions, balancing of redox reactions, Nernst equation, standard potentials and spontaneity, trends in standard potentials, electrochemical series
Redox stability of species in aqueous solutions (influence of pH, effect of solvation, redox reaction with water, disproportionation)
Diagrammatic presentation of potential data: Latimer diagrams, Frost diagrams and Pourbaix diagrams their significance
Applications of redox reactions in quantitative analysis: permanganate, dichromate & iodine titrations
Examples of Redox reactions in biological processes
Complexation behaviour of metal ions: Lewis acid – base type (d block), electrostatic interactions based (s block elements with crown ethers and cryptates), stabilisation of oxidation states by complexation (Cu(I), Mn(III)),
Applications of complexes in biological systems with special mention of metalloenzymes.

Precipitation: Insoluble salts with anions like S^{2-}, SO_4^{2-}, PO_4^{3-}, halides, OH^-, $C_2O_4^{2-}$, CO_3^{2-} and their application in metal ions analysis.

Practical Component: **Credits:02**

(Laboratory periods: 60)

1. Preparation of Potassium trioxalatochromate(III).
2. Preparation of Potassium trisoxalatomanganate(III).
3. Preparation of acetylacetonato complexes of
   a). Cu(II)
   b). Fe(III)
4. Determination of strength of oxalate ions and oxalic acid in a mixture titrimetrically.
5. Determination of available chlorine in bleaching powder iodometrically.
6. Preparation of a phosphate buffer solution and measurement of its pH using pHmeter.
7. Determination of buffer capacity of phosphate buffer.
8. Determination of strength of chloride ions argentometrically
   a). Volhard's Method
   b). Fajan's Method
   c). Mohr's Method
9. pHmetric titration of a strong acid with a strong base.
10. Any suitable experiment other than the listed ones.

References:

Theory:

1. Shriver, D.D.; Atkins, P.; Langford, C.H. (1994), **Inorganic Chemistry** 2nd Ed., Oxford University Press.
2. Atkins, P.W.; Overton, T.L.; Rourke, J.P.; Weller, M.T.; Armstrong, F.A. (2010), **Inorganic Chemistry**, 5th Edition, W. H. Freeman and Company.
3. Lee, J.D.; (2010), **Concise Inorganic Chemistry**, Wiley India.
4. Miessler, G. L. (2008). **Inorganic chemistry**. Pearson Education India.
5. Sharpe, A. G. (1992). **Inorganic chemistry**. Longman Publishing Group.
6. Lehninger, A. L., Nelson, D. L., Cox, M. M., & Cox, M. M. (2005). **Lehninger principles of biochemistry**. Macmillan India.
7. Svehla, G. (2008). **Vogel's qualitative inorganic analysis**, *7/e*. Pearson Education India.

Practicals:

1. Jeffery, G.H.; Bassett, J.; Mendham, J.; Denney, R.C. (1989), Vogel's **Textbook of Quantitative Chemical Analysis**, John Wiley and Sons.

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

DISCIPLINE SPECIFIC ELECTIVE COURSE CHEM-DSE 5 Biomolecule-I

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Chem-DSE 5: Biomolecules-I	**04**	**02**	**-**	**02**	**Class XII with Science**	

Learning Objectives

The Learning Objectives of this course are as follows:

- To understand the process of converting knowledge of chemistry into marketable products for commercial gain.
- To teach students about important biomolecules essential to life processes.
- 2. To discuss aspects of the principles of organic chemistry in the structure and function of important biomolecules.

Learning outcomes

By studying this course, students will be able to:

- Learn about the chemistry of natural and synthetic polymers including fabrics and rubbers.
- Understand the chemistry of biodegradable and conducting polymers and appreciate the need of biodegradable polymers with emphasis on basic principles.
- Comprehend the theory of colour and constitution as well as the chemistry of dyeing.
- Know applications of various types of dyes including those in foods and textiles.
- Understand the chemistry and applications of natural products like terpenoids and alkaloids.

Syllabus

Unit 1: Chemistry of Carbohydrates **(Hours:10)**

Classification of carbohydrates, reducing and non-reducing sugars, biological functions, general properties

and reactions of glucose and fructose, their open chain structure, epimers, mutarotation and anomers, reactions of monosaccharides, determination of the configuration of glucose (Fischer proof), the cyclic structure of glucose. Haworth projections. The cyclic structure of fructose. The linkage between monosaccharides: structure of disaccharides (sucrose, maltose, lactose) and polysaccharides (starch and cellulose) excluding their structure elucidation**.**

Unit 2: Nucleosides, Nucleotides and Nucleic Acids (Hours:10)

Components of Nucleic acids: Adenine, guanine, thymine, cytosine and uracil (structure only), other components of nucleic acids, nucleosides and nucleotides (nomenclature), structure of polynucleotides; structure of DNA (Watson-Crick model) and RNA (types of RNA), difference between DNA and RNA, genetic code, biological roles of DNA and RNA: replication, transcription and translation.

Unit-3: Lipids (Hours:10)

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.

Lipids: Classification. Biological importance of triglycerides and phosphoglycerides and cholesterol; Lipid membrane, Liposomes and their biological functions and underlying applications. Lipoproteins.

Properties, functions and biochemical functions of steroid hormones.

PRACTICALS: Credits: 02
(Laboratory periods: 60)

1. Preparation of osazone of glucose, fructose and Maltose (Comparing the time of formation of the two and the shape of crystals using microscope).
2. Identification of given carbohydrates as
    a. Reducing and Non-reducing
    b. Monosaccharide and Disaccharide
    c. Aldose and Ketose
3. Estimation of glucose by Fehling's solution.
4. Determination of the iodine number of oil.
5. Determination of the saponification number of oil.
6. Identification and separation of mixture of sugars by paper chromatography.
7. Isolation of DNA from cauliflower/ onion.
8. Determination of total sugar content by ferricyanide method (volumetric/colorimetric method).

References:

Theory

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

2. Morrison, R. N.; Boyd, R. N. **Organic Chemistry**, Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).

3. Berg, J. M.; Tymoczko, J. L.; Stryer, L. (2002), **Biochemistry**, W. H. Freeman.

4.Devlin, T.M. (2010), **Textbook of Biochemistry with Clinical Correlation**, Wiley.

5. Satyanarayana, U.; Chakrapani, U. (2017), **Fundamentals of Biochemistry**, Books and Allied (P) Ltd.

6. Lehninger, A.L; Nelson, D.L; Cox, M.M. (2009), Principles of Biochemistry, W. H. Freeman.

Practical:

1. Dean, J.R.; Jones, A.M.; Holmes, D;, Reed, R.; Jones, A.Weyers, J. (2011), **Practical skills in chemistry**, Prentice-Hall.

2. Wilson, K.; Walker, J. (2000), **Principles and techniques of practical biochemistry**, Cambridge University Press.

3. Gowenlock. A.H. (1988), **Varley's Practical Clinical Biochemistry**, CRC Press.

4. Pasricha, S., Chaudhary, A. (2021), **Practical Organic Chemistry**: Volume II, I K International Publishing House Pvt. Ltd., New Delhi.

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

DISCIPLINE SPECIFIC ELECTIVE COURSE CHEM-DSE -6 Quantum Chemistry and Spectroscopy

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Chem-DSE 6: Quantum Chemistry and Spectroscopy	**04**	**02**	**--**	**02**	**Class 12th with Physics, Chemistry, Mathematics**	**NA**

Learning Objectives

The Learning Objectives of this course are as follows:

- To introduce the concepts and methodology of quantum mechanics
- Application of Quantum chemistry to spectroscopy
- To establish the relation between structure determination and spectra.

Learning outcomes

By studying this course, students will be able to:

- Understand basic principles of quantum mechanics: operators, eigen values, averages, probability distributions.
- Understand and use basic concepts of microwave, IR and UV-VIS spectroscopy for interpretation of spectra.

Syllabus

Unit 1: Quantum Chemistry **(Hours: 16)**

Postulates of quantum mechanics, quantum mechanical operators.

Schrodinger equation and its application to free particle and particle in a 1-D box (complete solution),quantization, normalization of wave functions, concept of zero-point energy.

Qualitative treatment of H and H like atoms. Setting up of Schrodinger equation for many electron atoms.

Rotational Motion: Schrödinger equation of a rigid rotator and brief discussion of its results (solution not required). Quantization of rotational energy levels.

Vibrational Motion: Schrödinger equation of a linear harmonic oscillator and brief discussion of its results (solution not required). Quantization of vibrational energy levels.

Unit 2: Spectroscopy **(Hours: 14)**

Electromagnetic radiation and its interaction with matter. Lambert-Beer's law, Jablonski's diagram. Florescence and Phosphorescence.
Difference between atomic and molecular spectra. Born- Oppenheimer approximation: Separation of molecular energies into translational, rotational, vibrational and electronic components.

Microwave Spectroscopy: Microwave (pure rotational) spectra of diatomic molecules. Selection rules.
Structural information derived from rotational spectroscopy.

IR Spectroscopy: Selection rules, IR spectra of diatomic molecules. Structural information derived fromvibrational spectra. Effect of hydrogen bonding (inter- and intramolecular) and substitution on vibrational frequencies.

Electronic Spectroscopy: Electronic excited states. Free electron model and its application to electronicspectra of polyenes. chromophores, auxochromes, bathochromic and hypsochromic shifts.

Practical component **Credits:02**

(Laboratory periods: 60)

UV/Visible spectroscopy

10. Study the 200-500 nm absorbance spectra of $KMnO_4$ and $K_2Cr_2O_7$ (in 0.1 M H_2SO_4) and determine the λ_{max} values. Calculate the energies of the two transitions in different units (J molecule^{-1}, kJ mol^{-1}, cm^{-1}, eV).
11. Study the pH-dependence of the UV-Vis spectrum (200-500 nm) of $K_2Cr_2O_7$
12. 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

13. Verify Lambert-Beer's law and determine the concentration of $CuSO_4$/ $KMnO_4$/ $K_2Cr_2O_7$/ $CoCl_2$ in a solution of unknown concentration
14. Determine the concentrations of $KMnO_4$ and $K_2Cr_2O_7$ in a mixture.
15. Study the kinetics of iodination of propanone in acidic medium.
16. Determine the amount of iron present in a sample using 1, 10-phenanthroline.
17. Determine the dissociation constant of an indicator (phenolphthalein).
18. Study the kinetics of interaction of crystal violet/ phenolphthalein with sodium hydroxide.

References:

Theory:

1. Banwell, C.N.; McCash, E.M.(2006), **Fundamentals of Molecular Spectroscopy**, Tata McGraw- Hill.
2. Kapoor, K.L.(2015),**A Textbook of Physical Chemistry**, McGraw Hill Education, ,Vol 4, 5th Edition, McGraw Hill Education.
3. McQuarrie, D.A.(2016),**Quantum Chemistry**, Viva Books.
4. Chandra, A. K.(2001),**Introductory Quantum Chemistry**, Tata McGraw-Hill.
5. Dua A and Tyagi P, **Molecular Spectroscopy: Quantum to Spectrum**, (2022) Atlantic Publishers & Distributors Pvt Ltd.
6. Dua A, Singh C, **Quantum Chemistry: Classical to Computational** (2015) ManakinPress.

Practical:

4. Khosla, B.D.; Garg, V.C.; Gulati, A. (2015),**Senior Practical Physical Chemistry**, R. Chand & Co, New Delhi.
5. Kapoor, K.L. (2019),**A Textbook of Physical Chemistry**, Vol.7, 1st Edition, McGraw Hill Education.
6. Garland, C. W.; Nibler, J. W.; Shoemaker, D. P.(2003),**Experiments in Physical Chemistry**, 8th Edition, McGraw-Hill, New York.

Additional Resources:

3. Castellan, G. W .(2004),**Physical Chemistry**, Narosa.
4. Petrucci, R. H.(1989),**General Chemistry: Principles and Applications**, Macmillan Publishing

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

DISCIPLINE SPECIFIC ELECTIVE COURSE CHEM-DSE -7: Analytical Methods in Chemistry

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Chem-DSE-7: Analytical Methods in Chemistry	**04**	**02**	**-**	**02**	**Class XII with Science**	

Learning Objectives

The Learning Objectives of this course are as follows:

- To familiarize students with the concepts of sampling, errors in analysis, accuracy, precision and introduce basics of statistical analysis. The course introduces students to important instrumentation and separation techniques routinely used in the laboratory analysis of biological samples.
- To expose students to instrumentation in the practical and they learn to detect and separate analytes in a mixture.

Learning outcomes

By studying this course, students will be able to:

- Understand various sources of errors in chemical analysis.
- Learn about methods to minimize error.
- Understand basic principle of instrumentation (Flame Photometer, UV-vis spectrophotometer, Atomic Absorption spectrophotometer).
- Apply the principles of analysis and instrumentation to analyse soil samples, soft drinks and synthetic mixtures provided in the laboratory.
- Learn basic principles of separation techniques (chromatography and solvent extraction) and apply them to separate mixtures.
- Understand principles of Gravimetric analysis and apply them in determination of Ni^{2+} and Al^{3+}
- Analyse samples independently in the laboratory.

Syllabus

Unit I: Errors in Chemical Analysis **(Hours: 8)**

Types of errors, Accuracy and Precision, Absolute and relative uncertainty, propagation of uncertainty. The Gaussian distribution, mean and standard deviation, confidence intervals.

Unit 2: Optical Methods of Analysis **(Hours: 10)**

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

UV-Visible Spectrophotometry: Basic principles of instrumentation for single and double beam instruments. Determination of concentration of unknown compounds, composition of metal complexes using Job's method of continuous variation and mole ratio method.

Flame Atomic Absorption and Emission Spectroscopy: Basic principles of instrumentation. Techniques of atomization and sample introduction; Method of background correction, sources of chemical interferences and their method of removal.

Application of these techniques in analysis of biological samples.

Unit 3: Separation Techniques **(12 Hours)**

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.

Chromatography: Principles of Chromatographic separations, Classification of Chromatographic techniques, Thin Layer Chromatography, Column Chromatography, efficiency of separation (Resolution, Efficiency of Resolution, Plate Height)

Application of these techniques in analysis of biological samples.

Practical Component **Credits: 02**

(Laboratory periods: 60)

1. Analysis of soil**.**
   (a) Determination of pH of soil, Total soluble salts, carbonate and bicarbonate, calcium and magnesium by titration.
   (b) Estimation of Potassium, calcium and magnesium by flame photometry.
2. Separation of constituents of leaf pigments by thin layer chromatography.
3. Determination of the ion exchange capacity of an anion exchange resin.
4. Determination of the ion exchange capacity of a cation exchange resin.
5. Separation of amino acids by ion exchange chromatography.
6. Spectrophotometric analysis of Co^{2+} and Ni^{2+} ions in a mixture.
7. Spectrophotometric analysis of Caffeine and Benzoic acid in a soft drink
8. Gravimetric estimation of Ni^{2+} using Dimethylglyoxime.
9. Gravimetric estimation of Al^{3+} using oxine.
10. Any suitable experiment (other than the listed ones) based upon analytical techniques discussed in theory section.

References:

Theory:

1. Willard, H.H. (1988), **Instrumental Methods of Analysis**, 7th Edition, Wardsworth Publishing Company.
2. Christian, G.D. (2004), **Analytical Chemistry**, 6th Edition, John Wiley & Sons, New York.
3. Harris, D. C. (2007), **Quantitative Chemical Analysis**, 6th Edition, Freeman.
4. Skoog, D.A.; Holler F.J.; Nieman, T.A. (2005), **Principles of Instrumental Analysis**, Thomson Asia Pvt. Ltd.
5. Jeffery, G.H.; Bassett, J.; Mendham, J.; Denney, R.C. (1989), **Vogel's Textbook of Quantitative Chemical Analysis**, John Wiley and Sons.

Practical:

1. Jeffery, G.H.; Bassett, J.; Mendham, J.; Denney, R.C. (1989), Vogel's **Textbook of Quantitative Chemical Analysis**, John Wiley and Sons.
2. Marr, G.; Rockett, B. W. (1972), **Practical Inorganic Chemistry**, Van Nostrand Reinhold.

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

DISCIPLINE SPECIFIC ELECTIVE COURSE CHEM-DSE 8: Biomolecule-II

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Chem-DSE 8: Biomolecules-II	**04**	**02**	**-**	**02**	**Class XII with Science**	

Learning Objectives

The Learning Objectives of this course are as follows:

- To understand the process of converting knowledge of chemistry into marketable products for commercial gain.
- To teach students about important biomolecules essential to life processes.
- 2. To discuss aspects of the principles of organic chemistry in the structure and function of important biomolecules.

Learning outcomes

By studying this course, students will be able to:

- Learn about the chemistry of natural and synthetic polymers including fabrics and rubbers.
- Understand the chemistry of biodegradable and conducting polymers and appreciate the need of biodegradable polymers with emphasis on basic principles.
- Comprehend the theory of colour and constitution as well as the chemistry of dyeing.
- Know applications of various types of dyes including those in foods and textiles.
- Understand the chemistry and applications of natural products like terpenoids and alkaloids.

Syllabus

Unit 1: Amino acids, Peptides & Proteins **(Lecture : 12)**

Amino Acids and Peptides -Zwitterion, isoelectric point and electrophoresis. Preparation of amino acids: Strecker synthesis and using Gabriel's phthalimide synthesis. Reactions of amino acids: ester of –COOH group, acetylation of $–NH_2$ group, complexation with Cu^{2+} ions, ninhydrin test.

Determination of the primary structure of peptides by degradation Edman degradation (N-terminal) and C– terminal (thiohydantoin and with carboxypeptidase enzyme).

Synthesis of simple peptides (up to dipeptides) by N-protection (*t*-butyloxycarbonyl and phthaloyl) & C-activating groups and Merrifield solid-phase synthesis. An Overview of primary, secondary, tertiary and quaternary structure of proteins.

UNIT 2 : Enzymes **(Hours: 08)**

Classification of enzymes and their uses (mention ribozymes). Mechanism of enzyme action, factors affecting enzyme action, coenzymes and cofactors and their role in biological reactions, specificity of enzyme action (including stereo-specificity), enzyme inhibitors and their importance, and the phenomenon of inhibition (competitive and non-competitive inhibition including allosteric inhibition). Drug action-receptor theory. Structure – activity relationships of drug molecules, binding role of –OH group, $-NH_2$ group, double bond and aromatic ring.

Unit 3: Concept of Energy in Biosystems **(Hours: 10)**

Cells obtain energy by the oxidation of foodstuff (organic molecules). Introduction to metabolism (catabolism, anabolism). ATP: The universal currency of cellular energy, ATP hydrolysis and free energy change. Agents for transfer of electrons in biological redox systems: NAD+, FAD. Conversion of food to energy: Outline of catabolic pathways of carbohydrate-glycolysis, fermentation, Krebs cycle. The caloric value of food, the standard caloric content of food types.

PRACTICALS:
Credits: 02

(Laboratory periods: 60)

1. Qualitative tests for amino acids and proteins.
2. Separation and identification of mixture of amino acids by paper chromatography.
3. Study of the action of salivary amylase on starch under optimum conditions and determine the enzyme activity.
4. Study the effect of temperature on activity of salivary amylase.
5. Isolation of casein from milk.
6. Estimation of proteins by Lowry's method.
7. Estimation of glucose by Fehling's solution.
8. Determination of total sugar content by ferricyanide method (volumetric/colorimetric method).
9. Study of the titration curve of glycine and determine the isoelectric point of glycine.
10. Estimation of proteins by Lowry's method.
11. Estimation of Glycine by Sorensen's method.

References:

Theory:

1. Devlin, T.M. (2010), **Textbook of Biochemistry with Clinical Correlation**, Wiley.

2. Berg, J. M.; Tymoczko, J. L.; Stryer, L. (2019), **Biochemistry**, 9th Ed., W. H. Freeman Co Ltd.

3. Lehninger, A.L; Nelson, D.L; Cox, M.M. (2009), **Principles of Biochemistry**, W. H. Freeman.

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

Practical:

1. Dean, J.R.; Jones, A.M.; Holmes, D., Reed, R.; Jones, A. Weyers, J. (2011), **Practical skills in chemistry**, Prentice-Hall.
2. Wilson, K.; Walker, J. (2000), **Principles and techniques of practical biochemistry**, Cambridge University Press.
3. Gowenlock. A.H. (1988), **Varley's Practical Clinical Biochemistry**, CRC Press.
4. Pasricha, S., Chaudhary, A. (2021), **Practical Organic Chemistry**: Volume II, I K International Publishing House Pvt. Ltd., New Delhi.

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

DISCIPLINE SPECIFIC ELECTIVE COURSE CHEM-DSE 9: Computer Applications in Chemistry

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Chem-DSE 9: Computer Applications in Chemistry	**04**	**02**	**-**	**02**	**Class XII with Science**	

Learning Objectives

The Learning Objectives of this course are as follows:

- To introduce the students to basic computer skills that will help them in solving chemistry problems using spreadsheets and BASIC language.
- To acquaint the students with different software for data tabulation, calculation, graph plotting, data analysis and document preparation.
- To expose the students to the concept of molecular modelling, its applications to various molecular systems, energy minimization techniques, analysis of Mulliken Charge and ESP Plots.

Learning outcomes

By studying this course, students will be able to:

- Become familiar with the simple use of BASIC Language.
- Use software for tabulating data, plotting graphs and charts, carry out statistical analysis of the data.
- Solve chemistry problems and simulate graphs.
- Prepare documents that will incorporate chemical structure, chemical equations, mathematical expressions from chemistry.
- Understand theoretical background of computational techniques and selective application to various molecular systems.
- Learn Energy minimization methods through use of different force fields.
- Learn ESP Plots by suitable soft wares, electron rich and electron deficient sites.
- Compare computational and experimental results and explain deviations.
- Perform Optimization of geometry parameters of a molecule (such as shape, bond length and bond angle) through use of software like Chem Sketch and Argus Lab in interesting hands-on exercises.

Syllabus

Unit 1: Programming using BASIC **(Hours: 20)**

Programming Language – Elements of BASIC language, Numeric and string Constants and Variables, arithmetic expressions, hierarchy of operations, inbuilt functions. Syntax and use of the various QBASIC commands: REM, CLS, INPUT, PRINT, GOTO, IF, IF…THEN, IF...THEN..ELSE, IF and END IF, FOR and NEXT etc., DIM, READ, DATA, GOSUB, RETURN, RESTORE, DEF FNR and Library Functions, Simple programs based on usage of the commands mentioned above.

Statistical analysis using BASIC: Mean, Least square fit - Linear regression, variance, standard deviation.

Unit 2 : Handling of Numerical Data **(Hours: 4)**

Spreadsheet software: MS Excel. Creating a spreadsheet, entering and formatting information, applying basic functions and formulae to the data, drawing charts, tables and graphs, displaying the equation of graph along with the R^2 value, incorporating tables and graphs in Word files, graphical solution of equations, plotting pressure-volume curves of van der Waals gases, Maxwell-Boltzmann distribution, concentration versus time graphs, spectral data, titration curves, etc.

Unit 3: Molecular Modelling **(Hours: 6)**

Introduction to molecular modelling, overview of classical and quantum mechanical methods (molecular mechanics, semi empirical, ab initio and DFT), general considerations and comparison of these methods.

Practical component **Credit:02**
(Laboratory periods: 15 classes of 4 hours each)

Exercises of Programing

7. Calculate pressure of a real gas using Van der Waal's Equation.
8. Calculate the most probable speed, average speed and root men square velocity of an ideal gas.
9. Roots of quadratic equations
10. Binomial coefficient using GOSUB statement.
11. Mean, standard deviation
12. Least square curve fitting method for linear equation.

Plotting graphs using a spreadsheet

4. Van der Waals isotherms
5. Maxwell-Boltzmann distribution curves as function of temperature and molecular weight

6. Plot the conductometric titration curve for

   a) strong acid vs strong base and b) weak acid vs strong base

5. Plot the pH metric titration curve for

   a) strong acid vs strong base and b) weak acid vs strong base and determine the pK_a of the weak acid

7. Plot the graphs for the kinetics of first order reaction and determine the rate constant
8. Plot the UV-vis absorbance spectra and determine the molar absorption coefficient.

Molecular Modelling

6. Optimize and compare the geometry parameters of H_2O and H_2S using ArgusLab.
7. Compare the basicities of N atom in ammonia, methylamine, dimethylamine and trimethylamine using ArgusLab by comparing Mulliken charges and ESP map in ArgusLab.
8. Compare C-C bond lengths and bond order in ethane, ethene and ethyne using ArgusLab.
9. Determine enthalpy of isomerization of cis and trans-2-butene using ArgusLab.
10. Compare the HAH bond angles for the second row hydrides (BeH_2, CH_4, NH_3, H_2O) and compare with the results from qualitative MO theory.

References:

Theory:

7. Levie, R. de. (2001), **How to use Excel in analytical chemistry and in general scientific data analysis**, Cambridge Univ. Press.
8. Venit, S.M. (1996), **Programming in BASIC: Problem solving with structure and style**. Jaico Publishing House.
9. Lewars, E. (2003), **Computational Chemistry,** Kluwer academic Publisher.
10. Cramer, C.J.(2004), **Essentials of Computational Chemistry,** John Wiley & Sons.
11. Hinchcliffe, A. (1996), **Modelling Molecular Structures,** John Wiley & Sons.
12. Leach, A.R.(2001), **Molecular Modelling,** Prentice-Hall.

Practicals

4. Lewars, E. **(2003), Computational Chemistry,** Kluwer academic Publisher.
5. Cramer, C.J. **(2004), Essentials of Computational Chemistry,** John Wiley & Sons.
6. Hinchcliffe, A. **(1996), Modelling Molecular Structures,** John Wiley & Sons.

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DISCIPLINE SPECIFIC ELECTIVE COURSE CHEM-DSE -10: Applied Inorganic Chemistry

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Chem-DSE 10: Applied Inorganic Chemistry	**04**	**02**	**-**	**02**	**Class XII with Science**	

Learning Objectives

The Learning Objectives of this course are as follows:

- To introduce the principles of catalysis. It further discusses the types of catalysts and their industrial applications. It gives an insight into different types of fertilizers and chemistry involved in their manufacturing.
- To learn about applications of metals and inorganic compounds as diagnostic agents and medicines. The course helps develop the interest of students in the frontier areas of applied inorganic and medicinal chemistry.

Learning outcomes

By studying this course, students will be able to:

- Get a general idea of catalysis and describe in detail the mechanism of Wilkinson's catalyst, Zeigler- Natta catalyst and synthetic gasoline manufacture by Fischer-Tropsch process and applications of zeolites and biocatalysis.
- Explain the suitability of fertilizers for different kinds of crops and soil.
- Explain the inorganic compounds and metals in medicine and, specifically, the role of cisplatin in cancer therapy

Syllabus

Unit 1: Catalysis **(Hours: 10)**

General principles of catalysis, properties of catalysts, homogeneous and heterogeneous catalysis (catalytic steps, examples) and their industrial applications, deactivation and regeneration of catalysts, catalytic poison, promoter. Study of the following processes and their mechanism:

1. Alkene hydrogenation (Wilkinson's Catalyst)
2. Synthetic gasoline (Fischer-Tropsch reaction)

3. Polymerisation of ethene and propene using Ziegler-Natta catalyst
4. Application of zeolites as catalysts.
   Introduction and importance of biocatalysis

Unit 2: Fertilizers **(Hours: 8)**

Different types of fertilizers (N, P and K). Importance of fertilizers, chemistry involved in the manufacture of the following fertilizers: Urea, ammonium nitrate, calcium ammonium nitrate, ammonium phosphates, superphosphate of lime and potassium chloride, Environmental aspects of fertilizers.

Unit 3: Medical Applications of Inorganic Compounds **(Hours: 12)**

Introduction, Use of Chelating agents, metal complexes as diagnostic agents, Lithium in mental health, Gold containing drugs, role of metals in Neurodegenerative Diseases, Inorganic compounds in Chemotherapy: Cisplatin; mode of action, basic idea of second and third generation drugs.

Practical Component **Credits:02**
(Laboratory Periods: 60)

1.Preparation of magnesium pyrosilicate (Antacid).
2.Determination of ascorbic acid in vitamin C tablets by iodometric titrations.
3. Preparation of borax.
4. Preparation of boric acid.
5. Catalytic oxidation of potassium sodium tartrate by cobalt(II) chloride.
6. Estimation of boric acid and borax in a mixture by titrimetric analysis
7. Detection of constituents of CAN fertilizer (Calcium, Ammonium and Nitrate ions) fertilizer and estimation of Calcium content.
8. Detection of constituents of Superphosphate fertilizer (Calcium and Phosphate ions) and estimation of phosphoric acid content.
9. Detection of constituents of Dolomite (Calcium, Magnesium and carbonate ions) and determination of composition of Dolomite (Complexometric titration)

References:

Theory:

1. Huheey, J.E.; Keiter, E.A.; Keiter; R. L.; Medhi, O.K. (2009), **Inorganic Chemistry-Principles of Structure and Reactivity**, Pearson Education.
2. Atkins, P.W.; Overton, T.L.; Rourke, J.P.; Weller, M.T.; Armstrong, F.A. (2010), Shriver and Atkins **Inorganic Chemistry**, 5th Edition, Oxford University Press.
3. Housecraft, E. H.; Sharpe, A.G. (2018), **Inorganic Chemistry**, 5th Edition, Pearson.
4. Greenwood, N.N.; Earnshaw, A. (1997), **Chemistry of the Elements**, 2nd Edition, Elsevier (Ziegler Natta Catalyst and Equilibria in Grignard Solution).
5. Lippard, S.J.; Berg, J.M. (1994), **Principles of Bioinorganic Chemistry**, Panima Publishing Company.
6. Spessard, Gary O.; Miessler, Gary L. (1996), **Organometallic Chemistry**, Prentice-Hall.

7. Fertilizers and Their Composition, Characteristics, Quality, Transformations and Applications, Tandon, H.L.S., 2008., **Riegel's Handbook of Industrial Chemistry**, CBS Publishers, New Delhi.
8. Patrick, G. (2017), **Introduction to Medicinal Chemistry**, Oxford University Press.
9. Wolfgang Kaim, Brigite Schwederski, Axel Klein, **Bioinorganic chemistry: Inorganic elements in the chemistry of life,** Jojn Wiley & Sons Inc.

Practicals:

1. Vogel, A.I. (1972), **Qualitative Inorganic Analysis**, Longman.
2. Svehla, G. (1996), **Vogel's Qualitative Inorganic Analysis**, Prentice Hall.
3. Marsh, D.G.; Jacobs, D.L.; Veening, H., J. Chem. Educ., Analysis of commercial vitamin C tablets by iodometric and coulometric titrimetry. 1973, 50 (9), p 626. DOI: 10.1021/ed050p626
4. https://edu.rsc.org/experiments/catalytic-oxidation-of-potassium-sodiumtartrate/1736.article

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

DISCIPLINE SPECIFIC ELECTIVE COURSE CHEM-DSE 11: Chemistry of Polymers, Dyes and Natural Products

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Chem-DSE 11: Chemistry of Polymers, Dyes and Natural Products	**04**	**02**	**-**	**02**	**Class XII with Science**	

Learning Objectives

The Learning Objectives of this course are as follows:

- To understand the process of converting knowledge of chemistry into marketable products for commercial gain.
- To familiarize the basic nomenclature of polymers, dyes and natural products, classification and important terms.

Learning outcomes

By studying this course, students will be able to:

- Learn about the chemistry of natural and synthetic polymers including fabrics and rubbers.
- Understand the chemistry of biodegradable and conducting polymers and appreciate the need of biodegradable polymers with emphasis on basic principles.
- Comprehend the theory of colour and constitution as well as the chemistry of dyeing.
- Know applications of various types of dyes including those in foods and textiles.
- Understand the chemistry and applications of natural products like terpenoids and alkaloids.

Syllabus

UNIT-1: Polymers **(Hours: 12)**

Introduction and classification based on origin, monomer units, thermal response, mode of formation, structure, application and tacticity; di-block, tri-block and amphiphilic polymers; Weight average molecular weight, number average molecular weight, glass transition

temperature (Tg) 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 thermosoftening(PVC, polythene); Fabrics -natural (cellulose and synthetic derivatives of cellulose like rayon and viscose); synthetic (acrylic, polyamide, polyester); Rubbers-natural and synthetic: Buna-N, Buna-S, Neoprene, silicon rubber; Vulcanization; Polymer additives; Introduction to Specialty Polymers: electroluminescent (Organic light emitting diodes), conducting, biodegradable polymers and liquid crystals.

UNIT 2: Dyes **(Hours: 08)**

Classification, Colour and constitution; Mordant and Vat Dyes; Chemistry of dyeing. Synthesis and applications of Azo dyes – Methyl orange, Congo red; Triphenyl methane dyes- Crystal violet; Phthalein Dyes – Phenolphthalein; Natural dyes –Structure elucidation and synthesis of Alizarin and Indigotin; Edible Dyes with examples.

Unit 3: Natural Product Chemistry- An Introduction to Terpenoids and Alkaloids
(Hours: 10)

Terpenes: Introduction, occurrence, classification, uses, isoprene and special isoprene rule; structure elucidation, synthesis and industrial application of citral.
Alkaloids: Introduction, occurrence, classification, uses, general structural features, general methods for structure elucidation including Hoffmann's exhaustive methylation and Emde's method. Structure elucidation, synthesis and physiological action of Nicotine.

Practicals: **-** **Credits: 02**
(Laboratory periods: 60)

1. Preparation of Starch-PVA Film.
2. Recycling of Plastic: Moulding of plastic or Cracking of plastic.
3. Preparation of Urea-formaldehyde resin.
4. Preparation of Methyl Orange.
   (a) Dyeing of different fabrics (cotton, wool, silk) using Alizarin or any other dye.
   (b) Preparation of azo dye on the surface of the fabric.
5. Qualitative test for identification of alkaloids (Dragendorff Reagent and Mayer's reagent test) and terpenoids (Salkowski test).
6. Preparation of Malachite Green.
7. Preparation of perichromic dye using p-amino Phenol and p-nitro benzaldehyde.

References:

Theory

1. Finar, I.L. (2008), **Organic Chemistry**, Volume 2, 5th Edition, Pearson Education
2. Saunders, K. J. (1988), **Organic Polymer Chemistry**,2nd Edition Chapman & Hall, London
3. Campbell, Ian M., (2000), **Introduction to Synthetic Polymers**, 2nd Edition Oxford University Press, USA.
4. Bahadur, P. and Sastry, N.V. (2002) **Principles of Polymer Science** Narosa Publications, New Delhi
5. Patrick, G. **An Introduction to Medicinal Chemistry** (2013), 4th Edition, Oxford University Press.

6. Priscilla Abarca, Patricia Silva, Iriux Almodovar and Marcos Caroli Rezende* Quim. Nova, Vol. 37, No. 4, 745-747, 2014. http://dx.doi.org/10.5935/0100-4042.20140120

Practical:

1. Ashraf S.M., Ahmad S., Riaz U., **A Laboratory Manual of Polymers**, I. K. International Publishing House Pvt. Ltd., New Delh.
2. Hannaford FA J., Smith P. W. G. & Tatchell A. R.; **Vogel's Textbook of Practical Organic Chemistry** Fifth Edition, Longman Scientific and Technical.
3. Pasricha, S., Chaudhary, A. (2021), **Practical Organic Chemistry**: Volume I, I K International Publishing House Pvt. Ltd., New Delhi.

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

DISCIPLINE SPECIFIC ELECTIVE COURSE CHEM-DSE 12: Biophysical Chemistry

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Chem-DSE 12: Biophysical Chemistry	**04**	**02**	**-**	**02**	**Class XII with Science**	

Learning Objectives

The Learning Objectives of this course are as follows:

- To provide students with a sound background of latest techniques used in biophysical research
- To provide them with an understanding of the principles underlying these techniques.

Learning outcomes

By studying this course, students will be able to:

- The students will acquire knowledge of structure and biological functions of proteins and enzyme.
- Students will acquire knowledge about the principles and applications of latest methods used to analyse amino acid and proteins.
- The course will also provide students an opportunity for hands-on-experience to develop their laboratory skills expected for working in a biophysical research lab.

Syllabus

Unit I: Fundamentals of Biological Macromolecules (Hours: 10)

Structure and physical properties of amino acids, structure, function, and folding of proteins, internal rotational angle, conformations of proteins (Ramachandran plot, secondary, tertiary and quaternary structure). Structures of nucleic acids, Properties of nucleosides and nucleotides;composition of nucleic acids, Stabilizing interactions in biomolecules.

Unit II: Biophysical techniques for the Structural and Conformational Analysis (Hours: 20)

Overview : General principle and qualitative treatment of the techniques to understand the structure and characteristics of enzymes, protein and nucleic acid: X-ray crystallography – protein crystals, myoglobin, nitrogenase, pepsinogen; NMR spectroscopy-NMR spectra of

amino acids, UV-vis absorption spectroscopy, Fluorescence spectroscopy and Vibrational spectroscopy. Determination of protein structures by spectroscopic methods (FTIR, NMR), thermodynamics of protein folding by spectroscopic methods, protein conformational study by NMR and fluorescence spectroscopy. Methods for the separation of biomolecules: General principles, including Chromatography; Sedimentation, Moving Boundary Sedimentation, Electrophoresis, Isoelectric focusing.

Practical Component **Credits: 02**

(Laboratory periods: 60)

1. Separate and identify amino acids by paper chromatography.
2. Determine the isoelectric point of the given proteins.
3. Estimation of Proteins by Biuret, Lowry and Bradford.
4. Estimation of Urea.
5. Separation and identification of Sugars/lipids by TLC.
6. To check the purity of the proteins by calculating A260/ A280 ratio spectrophotometrically.
7. Agarose gel electrophoresis to check the size of DNA (For example- Calf ThymusDNA).
8. Characterization of the DNA (genomic/ designed oligonucleotide) as a function of pH, salt-concentration spectrophotometrically.
9. Determination of the isobestic point by titrating DNA sample with any ligand using UV- Visiblespectrophotometer.
10. SDS-PAGE analysis of proteins.

References:

Theory:

1. Lesk, A.M., **Introduction to Protein Science: Architecture, Function, and Genomics**, 2nd edition, 2010, Oxford University Press.
2. Cantor, C.R. and Schimmel, P.R., **Biophysical Chemistry**, 1980, Freeman.
3. Van Holde, K.E., Johnson, W.C. and Ho, P.S., **Principles of Physical Biochemistry**, 2nded,2006, Pearson Education.
4. Harding, S.E. and Chowdhry, B. Z. **Protein-Ligand Interactions**, Oxford UniversityPress.

Practical:

1. Hofmann, A ., Clokie,S., Wilson and Walker's Principles & Techniques of Practical Biochemistry, 2018, Cambridge University Press.

2. Friefelder D. Physical Biochemistry- Application to Biochemistry and Molecular Biology, 1983, WH Freeman and Company.

3. R. N. Roy, Viva and Practical Physiology, Biochemistry and Biophysics, 1998, Books and allied Pvt. Ltd.

4. Sawhney, S.K. and Singh , R.,Introductory Practical Biochemistry , 2nd Edition, 2005, Alpha Science International.

5. Keith Wilson , John Walker, John M. Walker Principles and Techniques of Practical Biochemistry, 5th Edition, 2000, Cambridge University Press.

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CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Research Methodology for Chemists (DSE-13)	04	03	--	01	Class 12th with Physics, Chemistry	

Learning objectives

The objectives of this course are as follows:

- To make the students aware of fundamental but mandatory ethical practices in chemistry.
- To introduce the concept of data analysis.
- To learn to perform literature survey in different modes.
- To make the students aware of safety handling and safe storage of chemicals.
- To make students aware about plagiarism and how to avoid it.
- To teach the use of different e-resources.

Learning outcomes

By studying this course, students will be able to:

- Follow ethical practices in chemistry
- Do Data analysis
- Literature survey in different modes
- Use e-resources.
- Avoid plagiarism, understand the consequences and how to avoid

SYLLABUS OF DSE-13

UNIT – 1: Scope of Research **(Hours: 3)**

Introduction, overview of research process: define research problem, review literature, formulate hypothesis, design research/experiment, collect and analyse data, interpret and report, scope and importance.

UNIT – 2: **Literature Survey, Databases and Research metrics** **(Hours: 15)**

Print: Sources of information: Primary, secondary, tertiary sources; Journals: Journal abbreviations, Digital: Databases and their responsible use: Google Scholar, Web of science,

Scopus, UGC INFONET, SciFinder, PubMed, ResearchGate, E-consortium, e-books; Search techniques: Phrase, Field, Boolean, Proximity, Concept, Limiting/Refining Search Results. Research metrics: Impact factor of Journal, h-index, i10 index, Altmetrics, Citation index. Author identifiers/or profiles: ORCID, Publons, Google Scholar, ResearchGate, VIDWAN

UNIT – 3: Communication in Science (Hours: 12)

Types of technical documents: Full length research paper, book chapters, reviews, short communication, project proposal, Letters to editor, and thesis.
Thesis writing – different steps and software tools (Word processing, LaTeX, Chemdraw, Chemsketch etc) in the design and preparation of thesis, layout, structure (chapter plan) and language of typical reports, Illustrations and tables, bibliography, referencing: Styles (APA, Oxford etc), annotated bibliography, Citation management tools: Mendeley, Zotero and Endnote; footnotes. Oral presentation/posters – planning, software tools, creating and making effective presentation, use of visual aids, importance of effective communication, electronic manuscript submission, effective oral scientific communication and presentation skills.

UNIT – 4: Research and Publication ethics (Hours: 9)

Scientific Conduct: Ethics with respect to science and research, Scientific Misconducts: falsification, fabrication and plagiarism, similarity index, software tools for finding plagiarism (Turnitin, Urkund etc), redundant dublications

Publication Ethics: Introduction, COPE (Committee on Publication Ethics) guidelines; conflicts of interest, publication misconduct: problems that lead to unethical behaviour and vice versa, types, violation of publication ethics, authorship and contributorship, predatory publishers and journals

IPR - Intellectual property rights and patent law, commercialization, copy right, royalty, trade related aspects of intellectual property rights (TRIPS)

UNIT – 5: Statistical analysis for chemists (Hours: 6)

Types of data, data collection-Methods and tools, data processing, hypothesis testing, Normal and Binomial distribution, tests of significance: t-test, F-test, chi- square test, ANOVA, multiple range test, regression and correlation.

Features of data analysis with computers and softwares -Microsoft Excel, Origin, SPSS

Practical component Credits: 01

(Laboratory periods:15 classes of 2 hours each)

12. Collection of journal articles on a particular topic using Google Scholar and creating a database.
13. Collection of journal articles on a particular topic using Science Direct and creating a database.
14. Collection of journal articles on a particular topic using Scopus and creating a database.
15. Drawing chemical structure, reactions and mechanisms using Chemsketch or ISIS draw or any other software.
16. Collection of chemical structure using ChemSpider and creating a database.
17. Curve fitting using freely available softwares/apps (any one)

18. Making of power point presentation
19. Experimental learning of safe storage hazardous chemicals
20. Experimental learning of handling of hazardous chemicals
21. Technical writing on topics assigned.
22. Demonstration for checking of plagiarism using recommended software

Essential/recommended readings:

7. Dean, J. R., Jones, A. M., Holmes, D., Reed, R., Weyers, J. & Jones, A. (2011) Practical skills in chemistry. 2nd Ed. Prentice-Hall, Harlow.
8. Hibbert, D. B. & Gooding, J. J. (2006) Data analysis for chemistry. Oxford University Press.
9. Topping, J. (1984) Errors of observation and their treatment. Fourth Ed., Chapman Hall, London.
10. Harris, D. C. Quantitative chemical analysis. 6th Ed., Freeman (2007) Chapters 3-5.
11. Levie, R. de, how to use Excel in analytical chemistry and in general scientific data analysis. Cambridge Univ. Press (2001) 487 pages.
12. Chemical safety matters – IUPAC – IPCS, Cambridge University Press, 1992.
    OSU safety manual 1.01

COURSES OFFERED BY DEPARTMENT OF CHEMISTRY

B Sc. Life Sciences

Undergraduate Programme of study

(with Chemistry as the Major Disciplines)

Semester-wise Distribution of Discipline Specific Core (DSC) Courses

DISCIPLINE CORE COURSES –02 (4 Credits each)			
SEMESTER	**COURSE CODE**	**NAME OF THE COURSE**	**CREDITS T=Theory Credits P=Practical Credits**
VII	DSC-19	Chemistry of d- and f- block elements, Advanced Organic Spectroscopy and Elements of Quantum Chemistry	T=3 P=1
VIII	DSC-20	Organometallic Chemistry and Bio-catalysis, Application of Reagents in Organic Synthesis and Crystalline Solids & their Magnetic Properties	T=3 P=1

DISCIPLINE SPECIFIC ELECTIVE COURSES – (4 Credits each)			
SEMESTER	**COURSE CODE**	**NAME OF THE COURSE**	**CREDITS T=Theory Credits P=Practical Credits**
VII	**Common Pool of DSE Courses applicable for both B.Sc. Physical Sciences and B.Sc. Life Sciences**		
	DSE-14	Industrial Chemicals and Environment	T=2 P=2
	DSE-15	Advanced Stereochemistry	T=2 P=2
	DSE-16	Reactive Intermediates of Organic Chemistry	T=2 P=2
	DSE-17	Molecular Spectroscopy and Structural Analysis	T=2 P=2
	DSE Course applicable specifically for B.Sc. Life Sciences		
	DSE-18 LS	Nanomedicine and Nanosensing	T=2 P=2
VIII	**Common Pool of DSE Courses applicable for both B.Sc. Physical Sciences and B.Sc. Life Sciences**		
	DSE-19	Fundamentals of Natural Products	T=2 P=2
	DSE-20	Fundamentals of Medicinal Chemistry	T=2 P=2
	DSE-21	Computational Chemistry	T=2 P=2
	DSE-22	Machine Learning and Artificial Intelligence in Chemistry*	T=2 P=2
	DSE Course applicable specifically for B.Sc. Life Sciences		
	DSE-23 LS	Bioelectrochemistry	T=2 P=2
	DSE-24 LS	Nanomaterials and their Biological Applications	T=2 P=2

*** For syllabus content of DSE-22: "**Machine Learning and Artificial Intelligence in Chemistry" refer to DSE syllabus of B.Sc. (H) Chemistry.

Note: A student, studying in 4th year of B.Sc. Physical Science/Life Science Programme, desirous of opting any *Discipline Specific Elective* (DSE) Course from progression of DSE courses available in Semester III-VI of the programme, may be allowed to opt the same in the VIIth or VIIIth semester.

Semester VII

DISCIPLINE-SPECIFIC CORE COURSE - 19 (DSC-19): Chemistry of d- and f- block elements, Advanced Organic Spectroscopy and Elements of Quantum Chemistry

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Chemistry of d- and f- block elements, Advanced Organic Spectroscopy and Elements of Quantum Chemistry **(DSC-19)**	**04**	**03**	**-**	**01**	**Class 12th with Physics, Chemistry**	**--**

Course Objectives

The objectives of this course are as follows:

- To provide thorough knowledge about the d- and f- block elements with respect to the general group trends, physical and chemical properties of these elements.
- To impart the knowledge about synthetic methods and principles of chromatography.
- Understanding spectroscopic techniques and their application in the structural elucidation of organic molecules.
- To familiarize the students with the postulates of quantum chemistry
- To explain how to apply the postulates to derive equations for various models and extend to the hydrogen atom and hydrogen-like atoms.
- To provide an insight into the MO approach of chemical bonding.

Learning outcomes

By studying this course, students will be able to:

- Understand the important properties of transition metals, lanthanoids, and actinoids
- Use Latimer diagrams to predict and identify species which are reducing, oxidizing and tend to disproportionate and calculate skip step potentials.
- Develop understanding on the principles of synthesis of Inorganic compounds and chromatographic separation of metal ions.

- Develop understanding of the basic principles of NMR spectroscopy, such as chemical shift, coupling constant, and anisotropy, and describe how they are affected by molecular structure, and identify organic compounds by analysis and interpretation of spectral data.
- Develop an understanding of quantum mechanical operators, quantization, probability distribution, uncertainty principle
- Understand Schrodinger equations for different types of systems
- Analyse different wave functions and probability distribution curves.

UNIT- 1: Chemistry of Transition Elements (15 Hours)

General group trends with special reference to electronic configuration, colour, variable valency, magnetic properties, catalytic properties, and ability to form complexes. Stability of various oxidation states and e.m.f. (Latimer diagrams), Frost diagrams of Mn and Cr. A brief discussion of differences between the first, second and third transition series

A brief discussion of electronic configuration, oxidation states, colour, spectral and magnetic properties. Lanthanoid contraction (causes and effects), separation of lanthanoids by ion exchange method.

UNIT-2: Spectroscopic Techniques in Organic Chemistry (15 Hours)

Recapitulation of the Spectroscopic Techniques (UV- VIS, IR, and ^{1}H NMR)

Carbon-NMR Spectroscopy
Resolution and multiplicity of ^{13}C NMR, ^{1}H-decoupling, noise decoupling, broadband decoupling; Deuterium, fluorine, and phosphorus coupling; NOE signal enhancement, Off resonance, proton decoupling, Structural applications of CMR. DEPT and general introduction about 2D NMR.

Mass Spectrometry
Theory, Fourier transform mass spectrometry instrumentation (FTMS); Unit mass and molecular ions; Important terms singly, doubly/multiple charged ions, metastable peak, base peak, isotopic mass peaks, relative intensity; Recognition of M^{+} ion peak; Nitrogen rule; Rule of 13; Ionization methods (EI and ESI). General fragmentation rules: McLafferty rearrangement, ortho effect.

ESR Spectroscopy
Basic Principles and applications for organic Compounds.

Structure Elucidation
Structure elucidation of Organic Compounds Using UV, IR, NMR, and Mass Spectra.

UNIT -3: Quantum Mechanics: An overview (6 Hours)

Recapitulation of postulates of quantum mechanics and quantum mechanical operators; Linear and Hermitian operators, commutation rules and Uncertainty principle.

Particle in a 1–D box, quantization of energy levels, zero-point energy, wave functions, probability distribution functions, nodal properties, and qualitative extension to 3-D box (Final Energy expression only) and the concept of degeneracy.

UNIT -4: Quantum Mechanical treatment: Atoms and Molecules (9 Hours)

Vibrational and Rotational Motion: Schrödinger equation of a linear harmonic oscillator and brief qualitative discussion of its results. Schrödinger equation of a rigid rotator and brief qualitative discussion of its results.

Qualitative treatment of hydrogen atom; setting up of Schrödinger equation in spherical polar coordinates, radial part and quantization of energy (only final energy expression). Qualitative idea of indistinguishability of the electrons and their intrinsic spin, spatial and spin wavefunctions, Pauli's Exclusion principle.

Linear Combination of Atomic Orbitals (LCAO), salient features of MO theory and setting up of wavefunction of $\boldsymbol{H_2}$ molecule.

Practical: Credits: 01

(Laboratory periods: 15 classes of 2 hours each)

PART A: INORGANIC CHEMISTRY

Inorganic Preparations

1. Potassium aluminium sulphate $KAl(SO_4)_2.12H_2O$ (potash alum} or
   Potassium chromium sulphate $KCr(SO_4)_2.12H_2O$ (chrome alum}.
2. Manganese phosphate and
3. Sodium peroxoborate

Paper chromatographic separation of following metal ions (minimum two exercise to be done):

4. Ni(II) and Co(II)
5. Cu(II) and Cd(II)
6. Fe(III) and Al(III)

PART B: ORGANIC CHEMISTRY

(Spectra to be provided wherever required)

7. Diels-Alder reaction between maleic anhydride and anthracene and identification of the product using IR and NMR Spectroscopy.
8. Knoevenagel condensation between aromatic aldehydes (benzaldehyde/*p*-nitrobenzaldehyde) and active methylene compounds (malononitrile/ethyl cyanoacetate/ diethylmalonate) and identification of the product using IR and NMR Spectroscopy.
9. Differentiate between maleic and fumaric acid solutions by UV spectroscopy.
10. Demonstration of the separation of the mixture of *p*-nitrophenol and *o*-nitrophenol by column chromatography and their characterization by melting point and spectroscopic techniques.

PART C: PHYSICAL CHEMISTRY

11. Plot the radial wavefunctions and probability distribution for H atom's 1s, 2s, 2p orbitals using software, i.e. MS-EXCEL.
12. (i) Draw probability plots for a particle in a 1-dimensional box for different values of quantum number n- commenting on the number of points of zero probability and then correlating them with the correspondence principle.
    (ii) Calculation of the bond length of conjugated dye molecules (i.e., cyanine/β-carotene) using a particle in 1D box model using MS-EXCEL.

Hands-on/ Instruction Mode:

13. (i) Carry out the calculation of various average values ($\langle x \rangle$, $\langle p \rangle$, $\langle x^2 \rangle$ and $\langle p^2 \rangle$) for the simple harmonic oscillator.
    (ii) Setting up of Schrödinger equation of Many-electron atoms and cite limitations to carry out an exact solution of the problem.
14. Demonstrate the variational treatment of the hydrogen molecule ion and also exhibit Valence bond and Molecular orbital (LCAO) treatment of the hydrogen molecule.

Essential/recommended readings

Theory

1. Lee, J.D.(2010), Concise lnorganic Chemistry, Wiley lndia.
2. Huheey,J.E.; Keiter,E.A.; Keiter;R.L.; Medhi,O.K.(2009), lnorganicChemistry-Principles of Structure and Reactivity, Pearson Education.
3. Atkins, P.W.; Overton, T.L.; Rourke, J.P.; Weller, M.T.; Armstrong, F.A. (2010), Shriver and Atkins Inorganic Chemistry, 5th Edition, Oxford University Press.
4. Miessler, G.L.; Fischer P.J.; Tarr, D. A. (2014), Inorganic Chemistry, 5th Edition, Pearson.
5. Pfennig, B. W. (2015), Principles of Inorganic Chemistry. John Wiley & Sons.
6. Cotton, F.A.; Wilkinson, G. (1999), Advanced Inorganic Chemistry, Wiley-VCH.
7. Das, A. K.; Das, M. (2014), Fundamental Concepts of Inorganic Chemistry, 1st Edition, Volume 1-3, CBS Publishers & Distributors Pvt. Ltd.
8. S. K. Ghuman, A. Sakthivel, D. T. Masram, M. Sathiyendiran, (2017) Electronic and Magnetic properties of transition and inner transition elements and their complexes, Nova Science Publishers, New York.
9. Chandrashekhar,V. (2005}, Inorganic and Organometallic Polymers, 5th Edition, Springer Publications.
10. Kemp, W. Organic Spectroscopy 3rd Ed., W. H. Freeman & Co. (1991).
11. Silverstein, R. M., Bassler, G. C. & Morrill, T. C. Spectroscopic Identification of Organic Compounds. John Wiley & Sons (1981).
12. Pavia, D. L.; Lampmann, G. M.; Kriz, G. S.; Vyvyan, J. R. Introduction to Spectroscopy. Cengage Learning (2014).
13. Organic Structures from spectra; L. D. Field, S. Sternhell and J R Kalman, John Wiley & Sons Ltd., 2007
14. Kapoor, K.L. (2015), A Textbook of Physical Chemistry, McGraw Hill Education, Vol 4, 5th Edition, McGraw Hill Education.
15. Bakhshi, A. K. & Thakral P., Quantum Chemistry Simplified Vidyavani Foundation: New Delhi (2025).
16. House, J.E. (2004), Fundamentals of Quantum Chemistry, 2nd Edition, Elsevier.
17. McQuarrie, D.A. (2016), Quantum Chemistry, Viva Books.

18. Atkins, P.W.; Paula, J.de. (2014), Atkin's Physical Chemistry Ed., 10th Edition, Oxford University Press.
19. Atkins, P.W.; Friedman, R. (2010), Molecular Quantum Mechanics, 5th Edition, Oxford University Press.

Practical:

1. Jeffery, G.H.; Bassett, J.; Mendham, J.; Denney, R.C. (1989), Vogel's Textbook of Quantitative Chemical Analysis, John Wiley and Sons,
2. Harris, D. C.; Lucy, C. A. (2016), Quantitative Chemical Analysis, 9th Edition, Freeman and Company.
3. Day, R. A.; Underwood, A. L. (2012), Quantitative Analysis, Sixth Edition, PHI Learning Private Limited.
4. Marr, G.; Rockett, B.W. (1972), Practical Inorganic Chemistry, Van Nostrand Reinhold.
5. Vogel, A. I. (2012). Quantitative Organic Analysis, Part 3, Pearson Education.
6. Mann, F. G., Saunders, B.C. (2009), Practical Organic Chemistry, Pearson Education.
7. Furniss, B. S., Hannaford, A.J., Smith, P.W.G., Tatchell, A. R. (2012), Vogel's Textbook of Practical Organic Chemistry, Fifth Edition, Pearson.
8. Ahluwalia, V.K., Dhingra, S. (2004), Comprehensive Practical Organic Chemistry: Qualitative Analysis, University Press.
9. Morrill, L. A., Kammeyer, J. K., & Garg, N. K. (2017). Spectroscopy 101: A practical introduction to spectroscopy and analysis for undergraduate organic chemistry laboratories. *J. Chem. Educ.* 94 (10), 1584-1586.
10. Kapoor, K.L. (2015), A Textbook of Physical Chemistry, McGraw Hill Education, Vol 4, 5th Edition, McGraw Hill Education.
11. McQuarrie, D. A. Mathematics for Physical Chemistry University Science Books(2008).
12. Mortimer, R. Mathematics for Physical Chemistry. 3rd Ed. Elsevier (2005).
13. Steiner, E. The Chemical Maths Book Oxford University Press (1996).
14. Yates, P. Chemical Calculations. 2nd Ed. CRC Press (2007).
15. Levie, R. de, How to use Excel in analytical chemistry and in general scientificdata analysis, Cambridge Univ. Press (2001) 487 pages.
16. Noggle, J. H. Physical Chemistry on a Microcomputer. Little Brown & Co. (1985).

Assessment Methods: All examination and assessments methods shall be in line with the University of Delhi guidelines issued from time to time.

Semester VIII

DISCIPLINE SPECIFIC CORE COURSE - 20 (DSC-20): Organometallic Chemistry and Bio- catalysis, Application of Reagents in Organic Synthesis and Crystalline Solids & their Magnetic Properties

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Organometallic Chemistry and Bio-catalysis, Application of Reagents in Organic Synthesis and Crystalline Solids & their Magnetic Properties **(DSC-20)**	**04**	**03**	**--**	**01**	**Class 12th with Physics, Chemistry**	**--**

Course Objectives

The objectives of this course are as follows:

- To imparts basic knowledge of Organometallic compounds and catalysis,
- To enrich students with the knowledge of various types of bonding and structure of organometallic compounds and biocatalysts.
- To impart the theoretical and practical knowledge of catalysts with the view of their industrial applications.
- To facilitate chemical transformations by providing the necessary conditions and catalysis.
- To analyze different crystal systems and understand their properties.
- To study Curie's and Curie-Weiss law and its application to paramagnetic and ferromagnetic materials, respectively.
- To understand the principles of powder-XRD and structural analysis of solids.

Learning outcomes

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

- Understand the role of catalyst in industrial applications.
- Gain sound knowledge of various types of catalyst.
- Get skilled in the scientific method of planning, developing, conducting, reviewing and reporting experiments.

- Get skilled concepts of industrial catalysis which will help them to explore new innovative areas of research
- Understand various reducing agents, oxidizing agents, and their applications in organic synthesis.
- Understand the conversion of specific functional groups without affecting others and maximize yields and selectivity for the desired products
- Analyze the distingtion between lattice, unit cell, and the 14 Bravais lattices, and understand their symmetry and properties.
- Interpret XRD patterns of NaCl, CsCl, and KCl to deduce structural information.
- Understand the Curie-Weiss law and its application to ferromagnetic materials.
- Interpret data obtained from instrumental techniques for structural analysis of crystalline solids.

UNIT- 1: Organometallic Chemistry and Biocatalysis (15 Hours)

Definition and classification with appropriate examples based on nature of metal-carbon bond (ionic, sigma, pi and multicentre bonds), Structure and bonding of methyl lithium and Zeise's salt, Structure and bonding of ferrocene, mononuclear and polynuclear carbonyls of 3d metals, 18-electron rule as applied to carbonyls, π-acceptor behaviour of carbon monoxide (MO diagram of CO to be discussed), synergic effect and use of infrared spectroscopy data to explain the extent of back bonding. Bio-organometallic chemistry: Conjugates of ferrocene with biomolecules such as amino acid and protein, and their applications. Organometallic complexes as radiopharmaceuticals.

Key aspects of Bio-catalysis, Variables affecting bio-catalysis such as temperature, pH, solvent etc., Enzyme catalyzed reactions and their Kinetics. Detailed study of biocatalyst in the metabolism of Hydrogen, carbon, and sulfur. Nanobiocatalysis.

UNIT- 2: Synthesis and Applications of Reagents in Organic Synthesis (15 Hours)

Synthesis and applications of BuLi, Grignard, organoaluminium, and organozinc reagents**.**

Triacetoxyborohydride, Lead Acetate, Phenyliodine (III) diacetate (PIDA), DCC, Tamao-Fleming Oxidation; Dimethyldioxirane (DMDO) Oxidation; DMSO (Barton modification & Swern Oxidation); Oxidation of organic compounds using thallium nitrate, selenium dioxide, phase transfer catalyst, crown ethers, $KMnO_4$, PCC, OsO_4, CrO_3, $K_2Cr_2O_7$**.**

Applications of hydroboration (reductions, oxidations, and carbonylation): Diborane, 9-BBN.

UNIT- 3: Crystalline Solids (11Hours)

Classification and characteristics of crystalline solids, seven crystal systems. Fundamentals of lattice, unit cell and fourteen Bravais lattices. Types of closed-packed structures. Elementary idea of symmetry. Crystal's direction and planes, Miller indices. X-ray diffraction, Bragg's law. PXRD diffraction pattern of NaCl, CsCl, and KCl,

UNIT -4: Magnetic Properties of Solids (4 Hours)

Magnetic moment, Curie law, Curie-Weiss law, mechanism of magnetic ordering, exchange Interaction, domain theory, hysteresis, anisotropy, paramagnetism, ferromagnetism, ferrimagnetism, antiferromagnetism.

Practicals: **Credits: 01**

(Laboratory periods: 15 classes of 2 hours each)

PART A: INORGANIC CHEMISTRY

1. Synthesis of "Zeolite A" catalyst.
2. Zeolite Hydrogen-Y or dil.HC1/dil.H_2SO_4 as a Catalyst for the Preparation of an Ester.
3. Catalytic Synthesis of biaryl.
4. Catalytic Transfer Hydrogenation of Castor Oil

PART B: ORGANIC CHEMISTRY

Identification of the product based on Melting point and spectroscopic techniques (IR, ^{1}HNMR, and ^{13}C NMR spectroscopy, data to be provided).

5. Synthesis of 1,2,3,4-tetrahydrocarbazole from cyclohexanone.
6. Reduction of *p*-nitrobenzaldehyde using $NaBH_4$
7. Synthesis of 2,3-diphenylquinoxaline from benzil and *ortho*-phenylenediamine.
8. Oxidation of benzyl alcohol by $KMnO_4$.

PART C: PHYSICAL CHEMISTRY

9. Analysis of diffraction pattern obtained from Powder X-ray diffractometer. Identifying crystal phase, diffraction peaks with lattice planes for a given compound.
10. Analysis of p-XRD data of a given set of Metals/ compounds* (Ag/Au/Cu/NaCl/CsCl) and confirmation of the type of the cubic system corresponding to given species.
11. Determination of approximate crystallite size using the measured PXRD pattern of a known inorganic compound i.e. TiO_2, ZnO etc by employing Scherer equation.
12. Determination of lattice strain using Williamson-Hall equation and from the measured PXRD pattern of a known inorganic compound for example, TiO_2, ZnO etc.*

*[Diffraction patterns of known sample along with Standard JCPDS file (JCPDS: Joint Committee for Powder Diffraction Studies) be provided to students for analysis]

Essential/recommended readings

Theory:

1. Huheey, J. E.; Keiter, E.A.; Keiter; R. L.; Medhi, O.K. (2009), Inorganic Chemistry-Principles of Structure and Reactivity, Pearson Education.
2. Cotton, F.A.; Wilkinson, G. (1999), Advanced Inorganic Chemistry, Wiley-VCR.
3. Miessler, G.L.; Fischer P.J.; Tarr, D. A. (2014), Inorganic Chemistry, 5th Edition, Pearson.
4. Jens Hagen (2015) Industrial Catalysis: A Practical Approach Wiley VCR Verlag GmbH&Co
5. Gérard Jaouen,(2006) Bioorganometallics, Wiley-VCH Verlag GmbH & Co.
6. Carruthers, W. Modern Methods of Organic Synthesis. Cambridge University Press (1996).
7. Carey, F.A. & Sundberg, R. J. Advanced Organic Chemistry, Parts A & B, Plenum: U.S. (2004).

8. Jonathan Clayden, Nick Greeves, Stuart Warren. Organic Chemistry. Oxford. (2000)
9. Kapoor, K.L. (2015), A Textbook of Physical Chemistry, Vol 1, 5th Edition, Mc Graw Hill Education.
10. Levine I.N. (2009), Physical Chemistry 6th Edition, Mc Graw Hill Education.
11. Pillai S.O., (2022) Solid State Physics 6th Edition, New Age International Publishers.
12. Chakrabarty, (2022) D. K., Solid State Chemistry, 2nd Edition, New Age International Publishers.
13. West, A.R., (2022), Solid State Chemistry and its Applications, 2nd Edition, Wiley Inc.
14. Callister W. D., (2018) Materials Science and Engineering: An Introduction, 10th Edition, Willey Inc.
15. Keer H. V., (Reprint 2005), Principles of the Solid State, New Age International Publishers.

Practical:

1. Williams, D. J.; Huck, B. E.; Wilkinson, A. P. First-Year Undergraduate Laboratory Experiments with Zeolites Chem. Educator 2002, 7, 33-36.
2. Coker, E. N.; Davis, P. J.; Experiments with Zeolites at the Secondary-School Level: Experience from The Netherlands Journal of Chemical Education 1999, 76, 10, 1417.
3. Hanson RW. Catalytic transfer hydogenation reactions for undergraduate practical programs. J Chem Educ. 2009, 74, 430.
4. Alwaseem H, Donahue CJ, Marincean S. Catalytic transfer hydrogenation of castor oil. J Chem. Educ. 2014; 91, 575-8.
5. Ahluwalia, V. K., Dhingra, S. (2004), Comprehensive Practical Organic Chemistry: Qualitative Analysis, University Press.
6. Ahluwalia, V. K., Aggarwal, R. (2004), Comprehensive Practical Organic Chemistry: Preparation and Quantitative Analysis, University Press
7. Pasricha, S., Chaudhary, A. (2021), Practical Organic Chemistry: Volume–I, I K International Publishing house Pvt. Ltd, New Delhi
8. Pasricha, S., Chaudhary, A. (2021), Practical Organic Chemistry: Volume–II, I K International Publishing house Pvt. Ltd, New Delhi
9. Cullity, B. D. (2001) *Elements of X-ray Diffraction*, 3rd ed.; Prentice Hall.
10. Hammond, C. (2015) *The Basics of Crystallography and Diffraction*, 4th ed.; Oxford University Press.
11. Snyder, R. L. (1996) Jenkins, R. *Introduction to X-ray Diffractometry*; Wiley: New York.
12. Hulien M.L., Lekse J.W., Rosmus K. A., Devlin K. P., Glenn J.R., Wisneski S. D., Wildfong P., Lake C. H., MacNeil J. H.Aitken J. A., An Inquiry-Based Project Focused on the X-ray Powder Diffraction Analysis of Common Household Solids, *J. Chem. Educ.* 2015, *92, 12, 2152-2156*.
13. Evans J. S. O., Evans I.R., Structure Analysis from Powder Diffraction Data: Rietveld Refinement in Excel, *J. Chem. Educ.* 2021, *98, 2, 495-505*.
14. https://www.icdd.com/ (International Centre for Diffraction Data)

Assessment Methods: All examination and assessments methods shall be in line with the University of Delhi guidelines issued from time to time.

SEMESTER VII

Common Pool of Discipline Specific Elective Courses applicable for both B.Sc. Life Sciences and B.Sc. Physical Sciences

DISCIPLINE SPECIFIC ELECTIVE COURSE – 14 (DSE-14): Industrial Chemicals and Environment

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Industrial Chemicals and Environment (DSE-14)	**04**	**02**	**--**	**02**	Class12th with Physics, Chemistry Biology	**--**

Course Objectives

The objectives of this course are as follows:

The objective of this course is to make students aware about the intricate relationship between industrial processes, the production and use of chemicals, and their profound impact on the environment. Manufacturing, applications, analysis and hazards of the Inorganic Chemicals. Air and Water pollution, control measures for Air and Water Pollutants, Effluents, waste water treatment and Environment.

Learning Outcomes

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

- Understand manufacturing processes, handling and storage of inorganic chemicals.
- Realize hazardous effects of the inorganic chemicals on human beings and vegetation.
- Understand composition of air, various air pollutants, effects and control measures of air pollutants.
- Understand different sources of water, water quality parameters, impacts of water pollution, industrial effluents and water treatment.

UNIT- 1: Inorganic Chemicals: **(8 Hours)**

Inorganic Chemicals: Manufacture, applications, analysis and hazards in handling the following chemicals: hydrochloric acid, nitric acid, sulphuric acid, caustic soda, borax, bleaching powder, sodium thiosulphate, hydrogen peroxide, potassium dichromate and potassium permanganate

UNIT- 2: Environment and Its Segments **(4 Hours)**

Ecosystems. Biogeochemical cycles of carbon, nitrogen and sulphur. Major regions of atmosphere, chemical and photochemical reactions in atmosphere.

UNIT- 3: Air Pollution and its Effects **(8 Hours)**

Air pollutants; types, sources, particle size and chemical nature; Photochemical smog: its constituents and photochemistry. Major sources of air pollution, Pollution by SO_2, CO_2, CO, NO, H_2S and other foul smelling gases, methods of estimation of CO, NOT, SOA and control procedures, Effects of air pollution on living organisms and vegetation, Greenhouse effect and Global warming, Environmental effects of ozone, Ozone depletion by oxides of nitrogen, chlorofluorocarbons and halogens, Air pollution control, Settling Chambers, Venturi Scrubbers, Cyclones, Electrostatic Precipitators (ESPs).

UNIT-4: Water Pollution **(10 Hours)**

Hydrological cycle, water resources, aquatic ecosystems, Sources and nature of water pollutants, Techniques for measuring water pollution, Impacts of water pollution on hydrological cycle 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, dairy, petroleum and petrochemicals, agro fertilizer. Water quality parameters for wastewater, industrial water and domestic water.

Practicals: **Credits: 02**

(Laboratory periods: 15 classes of 4 hours each)

1. Determination of dissolved oxygen in water.
2. Determination of Chemical Oxygen Demand (COD).
3. Determination of Biological Oxygen Demand (BOD).
4. Percentage of available chlorine in bleaching powder.
5. Measurement of chloride, sulphate and salinity of water samples by simple titration method ($AgNO_3$ and potassium chromate).
6. Estimation of total alkalinity of water samples (CO_3^{2-}, HCO_3^-) using double titration method.
7. Measurement of dissolved CO_2 in water samples.
8. Determination of hexavalent Chromium Cr(VI) concentration in tannery wastes/waste water sample using UV-Vis spectrophotometry technique.
9. Preparation of borax/ boric acid

Essential/recommended readings
Theory:

1. Manahan, S.E. (2017),EnvironmentaI Chemistry, CRC Press
2. Buchel, K.H.; Moretto, H.H.; Woditsch, P.(2003),Industrial Inorganic Chemistry, Wiley-VCH.
3. De, A.K.(2012), Environmental Chemistry, New Age International Pvt., Ltd.
4. Khopkar, S.M.(2010), Environmental Pollution Analysis, New Age International Publisher.

Practical:

1. Vowles, P.D.; Connell, D.W. (1980), Experiments in Environmental Chemistry: A Laboratory Manual, Vol.4, Pergamon Series in Environmental Science.
2. Gopalan, R.; Anand, A.; Sugumar R.W. (2008),A Laboratory Manual for Environmental Chemistry, I. K. International.

Assessment Methods: All examination and assessments methods shall be in line with the University of Delhi guidelines issued from time to time.

DISCIPLINE SPECIFIC ELECTIVE COURSE - 15 (DSE-15):
Advanced Stereochemistry

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Advanced Stereochemistry **(DSE-15)**	**04**	**02**	**--**	**02**	Class12th with Physics, Chemistry	Must have studied the GE Maths paper in the previous two semesters

Course Objectives

To provide a comprehensive understanding of molecular symmetry, isomerism, and chirality, including their applications in organic reactions.

Learning outcomes

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

- The basic concept of chirality in molecules due to their spatial arrangement of atoms that leads to chiroptical properties.
- The three-dimensional arrangement of atoms in a molecule can lead to distinct physical and chemical properties, particularly for stereoisomers. Understanding stereochemistry is crucial for designing effective drugs, predicting reaction outcomes, and developing new materials.
- That, stereochemistry significantly impacts drug action, biological processes, and chemical reactions, influencing factors like drug efficacy, selectivity, and even the rate of chemical reactions.

UNIT -1: (15 Hours)

Stereoisomerism*:* Chiral (stereogenic) centre, principle of axial and planar chirality; Stereochemistry and configurations of biphenyls (atropisomerism), bridged biphenyls, ansa compounds and cyclophanes, allenes, spiranes, alkylidine cycloalkanes, adamantanes, catenanes and helicity.

UNIT -2: (5 Hours)

Topicity and prostereoisomerism: Topicity of ligands and faces and their nomenclature; Stereogenicity, chirogenicity, and pseudoasymmetry, stereogenic and prochiral centres.

UNIT-3: (3 Hours)

Asymmetric induction: Cram's, Prelog's, and Felkin-Ahn model.

Unit-4: (7 Hours)

Cyclostereoisomerism: Configurations, conformations and stability of cyclohexanes (di-, and tri-substituted), cyclohexenes, cyclohexanones, decalin.

Applications of ORD and CD to Stereochemical Problems

Practicals: **Credits: 02**
(Laboratory periods:15 classes of 4 hours each)

1. E/Z and Cis-Trans Isomerism of 2,3-dimethyl-2-butene by ball and stick models
2. Identification of Chiral Centres and Diastereomers by ball and stick models
3. Bromination of cis and trans stilbene
4. Addition of Bromine to trans-Cinnamic Acid
5. Photoinduced isomerization of *cis*-Stilbene to *trans*-Stilbene and *vice versa*
6. Photocatalytic/ thermal isomerization of maleic acid to fumaric acid.[3]
7. Preparation of stilbene dibromide by bromination of *trans*-stilbene.
8. Determination of optical rotation of sucrose, glucose, and fructose using polarimetry and determining their concentration.
9. Two-step synthesis of acetonide from benzil and analysis of its stereochemistry using NMR and IR spectroscopy
10. Determination of specific rotation of (R)-limonene and (S)-limonene using Polarimeter.
11. Proline-catalyzed aldol reaction of cyclohexanone with nitro-substituted benzaldehydes.[5]
12. Preparation of hydroxybenzoin by pinacol coupling reaction: Investigating the Diastereoselectivity of Benzaldehyde Pinacol Coupling Mediated by Al-KOH in Aqueous Media: Affording *meso*- and dl-Hydrobenzoin.[4]

Essential/recommended readings
Theory:

1. Eliel, E. L. (2000), Stereochemistry of Carbon Compounds, Tata McGraw-Hill.
2. Nasipuri, D. (2018), Stereochemistry of Organic Compounds: Principles and Applications, 4th Edition, New Age International

Practical:

1. Microscale Organic Laboratory (Multistep and Multiscale Syntheses). By Dana W. Mayo, Ronald M. Pike, David C. Forbes. 2011
2. Green Organic Chemistry: Strategies, Tools, and Laboratory Experiments, Kenneth M. Doxsee, James E. Hutchison. Thomson-Brooks/Cole, 2004
3. The photochemical isomerization of maleic to fumaric acid: an undergraduate organic chemistry experiment. Albert J. Castro, Suzanne R. Ellenberger, and James P. Sluka. *J. Chem. Edu.* 1983, *60* (6), 521 (DOI: 10.1021/ed060p52)
4. Using ^{1}H NMR Spectroscopy to Investigate the Diastereoselectivity of Benzaldehyde Pinacol Coupling Mediated by Al-KOH in Aqueous Media: An Undergraduate Lab Experiment Involving a Green Carbon–Carbon Bond-Forming Reaction Affording *meso* and dl-Hydrobenzoins. Shahrokh Saba; Isabella Fante; James A. Cordero Jr. *J. Chem. Educ.* 2025, 102, 2, 847–851) doi.org/10.1021/acs.jchemed.4c01379
5. Proline-catalyzed asymmetric reactions. List, Benjamin. *Tetrahedron*. 2002, 58 (28): 5573–5590. doi:10.1016/S0040-4020(02)00516-1

Assessment Methods: All examination and assessments methods shall be in line with the University of Delhi guidelines issued from time to time.

DISCIPLINE SPECIFIC ELECTIVE COURSE - 16 (DSE-16):
Reactive Intermediates of Organic Chemistry

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Reactive Intermediates of Organic Chemistry **(DSE-16)**	**04**	**02**	**--**	**02**	**Class 12th with Physics, Chemistry**	**Must have studied the GE Maths paper in the previous two semesters**

Course Objectives

The objectives of this course are as follows:

To learn and understand the involvement of intermediates, their role in reaction mechanisms, predict their behavior, and apply this knowledge to organic synthesis. Also, to learn and understand the orbital interactions (Woodward-Hoffmann rules) in concerted reactions.

Learning outcomes

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

- Understand the structure-reactivity pattern of reactive intermediates involved in organic reactions.
- Analyse the mechanism of organic reactions involving reactive intermediates and apply these reactions in organic synthesis

Unit 1: Carbocations and Carbanions **(11 Hours)**

Difference between classical and non-classical carbocations. Introduction of neighboring group participation (NGP), ion-pairs, molecular rearrangements in acyclic, monocyclic, and bicyclic systems, stability and reactivity of bridgehead carbocations.

Generation, structure and stability, ambident ions and their general reactions; HSAB principle and its applications.

Unit 2: Carbenes and Nitrenes **(12 Hours)**

Structure of carbenes, generation of carbenes, addition and insertion reactions, rearrangement reactions of carbenes such as Wolff rearrangement, generation and reactions of ylid by carbenoid decomposition. Examples of inter/intramolecular insertions.

Structure of nitrene, generation and reactions of nitrene and related electron-deficient nitrogen intermediates, Curtius, Hoffmann, Schmidt, Beckmann rearrangement reactions.

Unit 3: Ylides **(2 Hours)**

Chemistry of Phosphorus and Sulfur ylides – Wittig and related reactions, Peterson olefination.

Unit 4: **Radicals** **(5 Hours)**

Generation of radical intermediates and their addition to: i) on alkenes, alkynes (inter & intramolecular) for C-C bond formation and Baldwin's rules. ii) fragmentation and rearrangements. Name reactions involving radical intermediates, such as Barton deoxygenation and decarboxylation, McMurry coupling.

Practicals: **Credits: 02**

(Laboratory periods:15 classes of 4 hours each)

(Experiments 1 and 2 are compulsory)

1. Separation, purification, and identification of binary mixtures of organic compounds (neutral and acidic; neutral and basic) using chemical methods and preparation of a suitable crystalline derivative for both the components.
2. **Two-step synthesis**

   2.1 ***To carry out the synthesis of triacetoxybenzene***

   Step 1: Synthesis of *p*-benzoquinone from hydroquinone using $KBrO_3$ and

   Step 2: Synthesis of Triacetoxybenzene from *p*-benzoquinone.

   2.2 ***To carry out the synthesis of p-acetamido benzene sulphonamide***

   Step 1: Synthesis of *p*-Acetamido benzene sulfonyl chloride from acetanilide and

   Step 2: Synthesis of *p*-Acetamido benzene sulphonamide from *p*-Acetamido benzene sulfonyl chloride.

   2.3 ***To carry out the synthesis of benzopinacolone***

   Step 1: Synthesis of benzopinacol from benzophenone

   Step 2: Synthesis of benzopinacolone from benzopinacol *via* pinacol-pinacolone rearrangement.

Essential/recommended readings

Theory:

1. Carey and R. A. Sundberg, Advanced Organic Chemistry, Part B: Reactions and Synthesis, 5thedition, Springer, New York, 2007.
2. Carruthers and I. Coldham, Modern Methods of Organic Synthesis, First South Asian Edition 2005, Cambridge University Press.
3. March and M. B. Smith, March's Advanced Organic Chemistry: Reactions, Mechanisms, and Structure, 6th Edition, Wiley, 2007.

Practical:

1. Vogel, A. I. (2012), Quantitative Organic Analysis, Part 3, Pearson Education.
2. Mann, F. G., Saunders, B.C. (2009), Practical Organic Chemistry, Pearson Education.
3. Furniss, B. S., Hannaford, A.J., Smith, P.W.G., Tatchell, A.R. (2012), Vogel's Textbook of Practical Organic Chemistry, Fifth Edition, Pearson.
4. Ahluwalia, V.K., Dhingra, S. (2004), Comprehensive Practical Organic Chemistry: Qualitative Analysis, University Press.
5. Ahluwalia, V. K., Aggarwal, R. (2004), Comprehensive Practical Organic Chemistry: Preparation and Quantitative Analysis, University Press
6. Pasricha, S., Chaudhary, A. (2021), Practical Organic Chemistry: Volume–I, I K International Publishing house Pvt. Ltd, New Delhi

7. Pasricha, S., Chaudhary, A. (2021), Practical Organic Chemistry: Volume–II, I K International Publishing house Pvt. Ltd, New Delhi

Assessment Methods: All examination and assessments methods shall be in line with the University of Delhi guidelines issued from time to time.

DISCIPLINE SPECIFIC ELECTIVE COURSE – 17 (DSE-17):
Molecular Spectroscopy and Structural Analysis

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Molecular Spectroscopy and Structural Analysis **(DSE-17)**	**04**	**02**	**--**	**02**	**Class 12th with Physics, Chemistry**	**--**

Course Objectives

The objectives of this course are as follows:

- To introduce the fundamental principles of spectroscopy, including the characterization of electromagnetic radiation and the Born-Oppenheimer approximation.
- To explore transition dipole moments and selection rules, with emphasis on symmetry ideas and time-dependent perturbation in spectroscopic processes.
- To analyze the principles and instrumentation of Raman spectroscopy and understand vibrational and rotational Raman spectra.
- To study the spectroscopic techniques for structural analysis i.e. AFM, SEM, and TEM.

Learning outcomes

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

- **U**nderstand the principles of electromagnetic radiation and fundamental spectroscopic concepts, including the Born-Oppenheimer approximation and time-dependent perturbation.
- Analyze Raman spectroscopy and deduce the structure of molecules using vibrational and rotational Raman spectra.
- Describe the Atomic spectra, the spin and orbital selection rules, spectra of complex atoms and basic principles of atomic photoelectron spectroscopy.
- Exhibit their understanding of theoretical basis of rotational, vibrational, raman and NMR spectroscopy.
- Have an insight into spectroscopic techniques for Structural Analysis i.e. SEM, TEM and AFM.

Unit 1: Basic Concepts of Spectroscopy and Atomic Spectra (8 Hours)

Spectroscopy and its importance in chemistry. Heisenberg Uncertainty Principal; Link between spectroscopy and quantum chemistry. Types of spectroscopy. Time dependent perturbation. Einstein coefficients. Integrated absorption coefficients. Transition dipole moments and general selection rules based on symmetry considerations.

Characterization of atomic states. Microstate and spin factoring methods. Hund's rules. Derivation of spin and orbital selection rules (based on recursion relations of Legendre polynomials. Spectra of complex atoms. Zeeman and Stark effects, Atomic photoelectron spectroscopy (Qualitative Discussion only).

Unit 2: Rotational, Vibrational and Raman Spectroscopy (14 Hours)

Rotational spectroscopy Determination of bond lengths and atomic mass. Effect of isotopic substitution. Non-rigid rotator. Classification of polyatomic molecules. Energy levels and spectra of symmetric top molecules and asymmetric top molecules.

Normal coordinate analysis of homonuclear and heteronuclear diatomicmolecules. Anharmonic oscillator; Morse potential. Overtones and hot-bands. Dissociation energies from vibrational data. Vibration-rotation spectra, P, Q and R branches. Breakdown of the Born-Oppenheimer approximation. Nuclear spin effect. Symmetry of normal coordinates.

Stokes and anti-Stokes lines. Polarizability ellipsoids. Rotational and vibrational Raman spectroscopy. Selection rules. Rule of Mutual Exclusion. Polarization of Raman lines.

Unit 3: NMR spectroscopy: (5 Hours)

Larmor precession. Mechanisms of spin-spin and spin-lattice relaxations and quantitative treatment of relaxation. Quantum mechanical treatment of the AB system. Selection rules and relative intensities of lines.

Unit 4: **Microscopic Techniques for Structural Analysis (3 Hours)**

Elementary idea of Scanning Electron Microscope (SEM), Transmission Electron Microscope (TEM), and Atomic Force Microscope (AFM) for structural analysis.

Practicals: Credits: 02
(Laboratory periods:15 classes of 4 hours each)

1. Analyse UV-Vis absorption spectra of conjugated systems (e.g., β-carotene) and determine the HOMO-LUMO gap.
2. Study the effect of structure on the UV spectra of organic compounds.
3. Study the spectra of mesityl oxide/benzophenone in different solvents and classify the observed transitions in terms of $n \rightarrow \pi^*$ and $\pi \rightarrow \pi^*$ transitions. Discuss the shift in transitions relative to those in acetone.
4. Find the stoichiometry of the charge transfer (CT) complex formed between thiocyanate ions and iron (III) by Job's method of continuous variation.
5. Record the UV spectra of a weak acid (α-naphthol) at different pH and determine the dissociation constant in the ground state.

Hands-on/ Demonstration/ Instruction Mode: Demonstration/Discussion of working principle/Hands-on with substantial literature analysis/Laboratory exercise

6. Record and compare IR spectra of alcohols in pure form and diluted in non-polar solvents to understand the effect of hydrogen bonding on O-H stretching frequency.
7. Perform IR and Raman spectroscopy on symmetrical molecules (e.g., CS_2, CO_2) and analyze the mutual exclusion principle.

8. Calculate the force constant (k) of diatomic molecules (e.g., HCl, N_2) from IR spectra.
9. Create a calibration curve and use it to determine the concentration of a fluorophore in unknown samples.
10. Simulate and analyze rotational spectra of rigid rotor molecules.
11. Measure absorbance vs. time data to study the kinetics of fast photochemical reactions (using Time-Resolved Absorption Spectroscopy for Reaction Kinetics).
12. Resolve and assign vibrational fine structure in the UV-Vis spectrum of iodine vapor.

Essential/recommended readings

Theory:

1. Hollas. J. M., *Modern Spectroscopy* 4th Ed., John Wiley & Sons (2004).
2. Satyanarayana, D. N., *Handbook of Molecular Spectroscopy: From radio waves to gamma rays*, I.K. International Publishing House, New Delhi (2015).
3. Kakkar, R., *Atomic & Molecular Spectroscopy,* Cambridge University Press (2015).
4. Brand, J. C. D. & Speakman, J. C. *Molecular Structure: The Physical Approach* 2nd Ed., Edward Arnold: London (1975).
5. Chang, R. *Basic Principles of Spectroscopy* McGraw-Hill, New York, N.Y. (1970).
6. Moore, W. J. *Physical Chemistry* 4th Ed. Prentice-Hall (1972).
7. Kapoor, K.L. (2015), A Textbook of Physical Chemistry, Vol 1, 1st Edition, Mc Graw Hill Education.

Practical:

1. B. D. Khosla, V. C. Garg, A. Gulati, Senior Practical Physical Chemistry, R. Chand & Co, New Delhi.
2. C. N. Banwell, E. M. McCash, Fundamentals of Molecular Spectroscopy.
3. A. Findlay, B.P. Levitt, J.A. Kitchener, Experimental Physical Chemistry.
4. Donald A. McQuarrie and John D. Simon, Physical Chemistry: A Molecular Approach.
5. J. Michael Hollas, Modern Spectroscopy.
6. Douglas A. Skoog, F. James Holler, Stanley R. Crouch, Principles of Instrumental Analysis.
7. Jeanne L. McHale, Molecular Spectroscopy.
8. Donald L. Pavia, Gary M. Lampman, George S. Kriz, Introduction to Spectroscopy.
9. Gurdeep R. Chatwal and Sham K. Anand, Spectroscopy: Atomic and Molecular.
10. Peter Atkins and Ronald Friedman, Molecular Quantum Mechanics.

Assessment Methods: All examination and assessments methods shall be in line with the University of Delhi guidelines issued from time to time.

Discipline Specific Courses Applicable Specifically for B.Sc. Life Sciences

DISCIPLINE SPECIFIC ELECTIVE COURSE – 18 LS (DSE-18 LS): Nanomedicine and Nanosensing

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Nanomedicine and Nanosensing **(DSE-18 LS)**	**04**	**02**	**--**	**02**	**Class 12th with Physics, Chemistry**	**--**

Course Objectives

The objectives of this course are as follows:

- To discuss the various nanomaterials to be used as drug delivery systems.
- To develop an understanding of living system interaction of nanomaterials
- To enable learners to have an insight into the field of nanodiagnostics.
- To explain nature of nanomaterials as nanosensors.

Learning outcomes

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

- Demonstrate understanding of the concept of nanomaterial as efficient drug delivery systems.
- Evaluate Living System Interaction of Nanomaterials, thereby, exhibit foray into field of nanodiagnostics.
- Understand basic principle of gas sensing, chemosensing, biosensing, Optical, electrochemical, magnetic sensing using various nanoparticles.
- Perform hands-on laboratory exercise aimed at designing a variety of nanomaterials and their subsequent application in nanomedicine and nanosensing.

Unit 1: Nanomaterial and Drug Delivery - (8 Hours)

Nanomaterials of biological interest: Lipid-, polymer-(PLGA, PVP), inorganic-based (Gold, iron-oxide and silica) and hybrid nanomaterials. Nanomaterials as drug delivery systems. Encapsulation and release of drugs, photosensitizers (porphyrins), DNA, and other active agents i.e. coumarin dyes. Stimuli-responsive drug release.

Unit 2: Living System Interaction of Nanomaterials (7 Hours)

Interaction of nanomaterials with mammalian cells; Endocytosis, phagocytosis, pinocytosis, and other cell-entry mechanisms. Fate of nanoparticles inside cells. In vitro assays: cell viability, ROS determination, biochemical assays, etc.

Unit 3: Nanodiagnostics **(7 Hours)**

Nanodiagnostics: Basics of optical imaging, MRI, CT imaging, radioimaging. Nanomaterials (gold nanospheres and nanorods, dye-doped silica nanoparticles) for optical imaging, magnetic resonance imaging, CT imaging, radio-imaging, etc. Structural and Functional imaging. Image-guided drug delivery.

Unit 4: Nanosensing **(8 Hours)**

Basic principle of gas sensing, chemosensing, biosensing, Optical, electrochemical, magnetic sensing using various nanoparticles (gold nanospheres and nanorods, iron-oxide nanoparticles, nanographene and nanographene oxide). In vitro diagnostics from simple body fluids such as blood and urine. Microfluidic technology for low volume and high throughput sensing.

Practicals: **Credits: 02**

(Laboratory periods:15 classes of 4 hours each)

Hands-on/Demonstration/ Instruction Mode: Demonstration/ Discussion of working principle/ Hands-on with substantial literature analysis/ Laboratory exercise.

1. (i) Synthesis of nanoparticles: Gold nanospheres and nanorods, nanographene, iron-oxide nanoparticles.
   (ii) Characterization and differentiation of Gold nanospheres and nanorods using spectrophotometric analysis.
2. Preparation of PLGA nanoparticles.
3. Preparation of liposomes, solid-lipid nanoparticles (SLNs),
4. Synthesis of silica and organically modified silica (ormosil) nanoparticles,
5. Estimation of loading capacity of Drug/dye and release kinetics study in liposomes, PLGA nanoparticles, SLNs, ormosil nanoparticles, and ZIF-8 nanoscale frameworks (Any one system).
6. Comparative reaction kinetics study of dye-degradation (rhodamine-B) using Au/ Ag/ Au-Ag nanoparticles.
7. Colorimetric determination of trace amount of metal ions *(Iron or copper)* using gold nanospheres/nanorods.
8. LED-light-activated photothermal experiments using gold nanospheres/nanorods using temperature change measurements.
9. Determination of protein binding capacity of gold nanoparticles using NMR study.

Essential/recommended readings

Theory:

1. Prasad 1. P. N.. Introduction to Nanomedicine and Nanobioengineering. Wiley, 2012.
2. Webster. T. J. Nanomedicine Technologies and Application (2 nd Edition) ScienceDirect, 2023.
3. Jain. K. K. The Handbook of Nanomedicine. Springer, 2017
4. Kulkarni S. K., Nanotechnology: Principles and Practices, Springer Cham, 2014 (978-3-319-09171-6).
5. Singh K., Nanoparticle Therapeutics, Academic Press Elsevier, 2021 (978-0-12-820757-4).

6. Ratner B. D., Hoffman A. S., Schoen F. J., Lemons J. E., Biomaterials Science, Press Elsevier, 2013 (978-0-12-374626-9)
7. Nelson D. L., Cox M., Principles of Biochemistry, WH Freeman, 7th ed. 2017 (978-1319108243)
8. Alberts B., Johnson A., Lewis J., Raff M., Roberts K., Walter P., Molecular Biology of the Cell, 4th ed., Garland Science, 2002, 10: 0-8153-3218-1

Practical:

1. Prasad P. N.. Introduction to Nanomedicine and Nano-bioengineering. Wiley, 2012.
2. Webster. T. J. Nanomedicine Technologies and Application (2 nd Edition) Science Direct, 2023.
3. Jain. K. K. The Handbook of Nanomedicine. Springer, 2017
4. Kumar C., Hormes J., Leuschner C., Nanofabrication Towards Biomedical Applications, Wiley Vch,, 2005 (9783527311156)
5. Greco R. S., Prinz F. B., Smith R. L., Nanoscale Technology in Biological Systems, CRC Press, 2004 (9780849319402).
6. Perera Y. R., South T.M., Hughes A. C., Parkhurst A. N., Williams O.C., Davidson M. B., Wilks C. A., Misna D. A., Fitzkee N.C., Using NMR spectroscopy to measure protein binding capacity on gold nanoparticles, *J. Chem. Educ.* 2020, *97, 3, 820-824*.
7. Bentley A. K., Farhoud M, Ellis A. B., Lisensky G.C., Nickel A-Marie L, Crone W. C., Template Synthesis and Magnetic Manipulation of Nickel Nanowires, *J. Chem. Educ.* 2005, *82, 5, 765-768*.
8. Oliveira M. L., Pagung E., Lorenzini L., Neves T.R., Pereira J.R.P., Ferreira S. A. D., Freitas M. B. J.G. de, Moura P. R.G., Lelis M. F. F., Synthesis of Iron Oxide Nanoparticles and their Application in Photo-Fenton Process: An Undergraduate Experiment in Chemistry, *J. Chem. Educ.* 2025, *102, 1590-1597*.
9. How to Characterize 4−90nm Size Gold Nanospheres with Experimental and Simulated UV−Vis and a Single SEM Image, *J. Chem. Educ.* 2023, *100, 1589-1596*.
10. Nedrygailov I, Brien D. O., Monaghan S., Hurley P, Biswas S., Holmes J.D., Nanowood: A Unique Natural Nanomaterial That Can Be Obtained Using Household Chemicals, *J. Chem. Educ.* 2024, *101, 11, 4931-4936*.

Assessment Methods: All examination and assessments methods shall be in line with the University of Delhi guidelines issued from time to time.

SEMESTER VIII

Discipline Specific Courses (Common Pool) applicable for both B.Sc. Life Sciences and B.Sc. Physical Sciences

DISCIPLINE SPECIFIC ELECTIVE COURSE – 19 (DSE-19)
Fundamentals of Natural Products

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical / Practice		
Fundamentals of Natural Products **(DSE-19)**	**04**	**02**	**--**	**02**	**Class 12th with Physics, Chemistry**	**--**

Course Objectives

The objectives of this course are as follows:

The primary objective of this course is to provide students with a comprehensive understanding of natural product chemistry, including its historical development, modern applications, classification, biosynthesis, and methods for isolation and purification.

Learning outcomes

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

- Understand the scope and significance of natural product chemistry in both historical and modern contexts, particularly its role in drug discovery.
- Analyze and classify major natural product groups-such as alkaloids, terpenoids, flavonoids, phenolics, peptides, glycosides, polyketides, steroids, and hormones-and understand their structures and functions.

Unit 1: Introduction and Classification of Natural Products: **(11 Hours)**

Definition and scope of natural product chemistry, historical significance and modern relevance, Primary vs secondary metabolites, Sources of natural products: terrestrial and marine origin, importance in drug discovery and development.

Alkaloids, Terpenoids, Flavonoids, Phenolics, Peptides and Proteins, Glycosides, Polyketides, Steroids and Hormones. Isoprene rule, mevalonate and non-mevalonate pathways, Shikimic acid pathway.

Unit 2: Isolation and Purification Techniques: **(4 Hours)**

Extraction methods (solvent extraction, Soxhlet, maceration, etc.), Chromatographic techniques (TLC, Column, HPLC, GC-MS), Crystallization and distillation techniques, Bioassay-guided fractionation.

Unit 3: Total Synthesis of Natural Products: (10 Hours)
Artemisinin (Antimalarial); Berberine (anti-inflammatory); Lysergic Acid Diethylamide (Psychedelic drug), and Vitamin B12.

Unit 4: Biosynthesis of Natural Products: (5 Hours)
Artemisinin, Berberine, and Lysergic Acid Diethylamide (LSD).

Practicals: Credits: 02
(Laboratory periods:15 classes of 4 hours each)

1. Isolation of natural products: Isolation of β-carotene from carrots.
2. Isolation of natural products: Isolation of limonene from lemon peel/orange peel.
3. Isolation of natural products: Isolation of caffeine from tea leaves.
4. Isolation of natural products: Isolation of piperene from black pepper.
5. Isolation of natural products: Isolation of eugenol from cloves.
6. Isolation of protein and carbohydrates from seeds –colour test.
7. Synthesis of 7-hydroxy-4-methylcoumarin
8. Synthesis of a simple dipeptide(gly-gly) by DCC coupling using N-protected amino acids.
9. Synthesis of simple amino acids

Essential/recommended readings
Theory:

1. Mann, J.; Davidson, R. S. & Hobbs, J. B., Natural Products: Their Chemistry and Biological Significance, Longman Scientific & Technical (1994)
2. Mann, J. Secondary Metabolites, Oxford University Press, Oxford, UK, (1980)
3. Hanson, J. R., Natural Products: The Secondary Metabolites, The Royal Society of Chemistry, Cambridge, UK (2003)
4. Chatwal, G., Organic Chemistry of Natural Products, Himalaya Publishing House (1994)

Practical:

1. Vogel, A. I. (2012), Quantitative Organic Analysis, Part 3, Pearson Education.
2. Mann, F. G., Saunders, B.C. (2009), Practical Organic Chemistry, Pearson Education.
3. Furniss, B. S., Hannaford, A. J., Smith, P.W.G., Tatchell, A.R. (2012), Vogel's Textbook of Practical Organic Chemistry, Fifth Edition, Pearson.
4. Ahluwalia, V.K., Dhingra, S. (2004), Comprehensive Practical Organic Chemistry: Qualitative Analysis, University Press.
5. Ahluwalia, V. K., Aggarwal, R. (2004), Comprehensive Practical Organic Chemistry: Preparation and Quantitative Analysis, University Press
6. Pasricha, S., Chaudhary, A. (2021), Practical Organic Chemistry: Volume–I, I K International Publishing house Pvt. Ltd, New Delhi
7. Pasricha, S., Chaudhary, A. (2021), Practical Organic Chemistry: Volume–II, I K International Publishing house Pvt. Ltd, New Delhi

Assessment Methods: All examination and assessments methods shall be in line with the University of Delhi guidelines issued from time to time.

DISCIPLINE SPECIFIC ELECTIVE COURSE – 20 (DSE-20)
Fundamentals of Medicinal Chemistry

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical / Practice		
Fundamentals of Medicinal Chemistry **(DSE-20)**	**04**	**02**	**--**	**02**	**Class 12th with Physics, Chemistry**	**--**

Course Objectives

The objectives of this course are as follows:

This course aims to introduce students to the foundational concepts of medicinal chemistry, highlighting its historical development and the significance of natural products as drug sources. Additionally, the course examines the structure, synthesis, therapeutic use, and basic SAR of key drugs like Ibuprofen, Paracetamol, Aspirin, and Penicillin.

Learning outcomes

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

- Understand the development and role of medicinal chemistry, understand the stages of drug discovery, and evaluate drug screening and clinical processes.
- Interpret how stereochemical and physicochemical properties influence drug behavior and efficacy.

Unit 1: Introduction to Medicinal Chemistry and Drug discovery: **(15 Hours)**

History and development of medicinal Chemistry. Sources of drugs, including natural products with examples, Stages of drug discovery, Stereochemical aspects, Physicochemical properties: solubility, acid-base, partition coefficient.

Target identification and validation, Screening of drugs, High throughput screening (HTS), Random and Systematic screening. Structure activity relationship (SAR), Hit identification, and Lead optimization

Unit 2: Pharmacokinetics (ADME): **(5 Hours)**

Drug administration/absorption, drug distribution, drug metabolism - Phase 1 and Phase 2, drug excretion, Half-Life of drugs, and Clinical trials.

Unit 3: Representative Synthetic Drugs: **(7 Hours)**

Structure, Synthesis, and Therapeutic Value of Representative Drugs: Fluconazole (antifungal), Penicillin (antibiotic), Isoniazid (antibiotic), and Azidothymidine (AZT; anti-HIV).

Unit 4: Bioin-formatics: Use of computational tools for drug design. **(3 Hours)**

Practicals: **Credits: 02**

(Laboratory periods:15 classes of 4 hours each)

1. Isolation and estimation of aspirin from commercial tablets
2. Synthesis of paracetamol from *p*-aminophenol
3. Synthesis of benzotriazole/benzimidazole.
4. Synthesis of 5,5'-Diphenylhydantoin.
5. Synthesis of dihydropyridine (DHP)/dihydropyrimidine (DHPM).
6. Study of physicochemical properties of pharmaceutically active compounds using computational methods.
7. Synthesis of Benzocaine, a topical pain reliever.
8. Isolation of Caffeine from tea leaves using solvent extraction techniques.
9. Estimation of Vitamin C.

Essential/recommended readings

Theory:

1. Patrick, G. L. *Introduction to Medicinal Chemistry*, Oxford University Press (2001)
2. Lemke, T. L. & William, *D. A., Foye's Principles of Medicinal Chemistry*, 5th Ed., USA (2002)
3. Dunlap, N. K. & Huryn, D. M., *Medicinal Chemistry*, Garland Science, New York (2018)
4. Mark W. Holladay, Richard B. Silverman. *The Organic Chemistry of Drug Design and Drug Action,* 3rd Ed. Academic Press (2014)

Practical:

1. Vogel, A. I. (2012), Quantitative Organic Analysis, Part 3, Pearson Education.
2. Mann, F. G., Saunders, B.C. (2009), Practical Organic Chemistry, Pearson Education.
3. Furniss, B. S., Hannaford, A. J., Smith, P.W.G., Tatchell, A.R. (2012), Vogel's Textbook of Practical Organic Chemistry, Fifth Edition, Pearson.
4. Ahluwalia, V.K., Dhingra, S. (2004), Comprehensive Practical Organic Chemistry: Qualitative Analysis, University Press.
5. Ahluwalia, V. K., Aggarwal, R. (2004), Comprehensive Practical Organic Chemistry: Preparation and Quantitative Analysis, University Press
6. Pasricha, S., Chaudhary, A. (2021), Practical Organic Chemistry: Volume–I, I K International Publishing house Pvt. Ltd, New Delhi
7. Pasricha, S., Chaudhary, A. (2021), Practical Organic Chemistry: Volume–II, I K International Publishing house Pvt. Ltd, New Delhi

Assessment Methods: All examination and assessments methods shall be in line with the University of Delhi guidelines issued from time to time.

DISCIPLINE SPECIFIC ELECTIVE COURSE - 21 (DSE-21)
Computational Chemistry

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Computational Chemistry **(DSE-21)**	**04**	**02**	**--**	**02**	**Class 12th with Physics, Chemistry**	**--**

Course Objectives

The objectives of this course are as follows:

- To introduce the fundamental concepts and theoretical background of computational chemistry.
- To develop an understanding of quantum mechanical, semi-empirical and molecular mechanical methods used in molecular modeling and molecular dynamics.
- To enable learners to perform geometry optimization, energy calculations, and vibrational analysis using computational tools.
- To teach the interpretation of computational results in the context of chemical structure, and reactivity.
- To expose students to various software packages commonly used in computational chemistry
- To provide hands-on experience with setting up, running, and analyzing computational chemistry simulations.

Learning outcomes

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

- Demonstrate a solid understanding of key computational methods such as ab initio, semi-empirical, and molecular mechanical methods.
- Apply computational tools to predict and analyze molecular properties, geometries, and reaction mechanisms.
- Perform and interpret quantum chemical and molecular simulation calculations using standard software packages.
- Evaluate the accuracy and limitations of various computational approaches in relation to experimental data.
- Design and conduct computational experiments to solve problems in chemical research and development.

Unit 1: Fundamentals of Computational Chemistry **(6 Hours)**

Conceptual background of computational chemistry and molecular modeling, Z-matrix of simple molecules, Born-Oppenheimer approximation and Potential Energy Surfaces (minima

and maxima), harmonic frequency calculations and intrinsic reaction coordinate. Charge analysis (Milliken. NBO, etc.). Cost and efficiency.

Unit 2: Molecular Mechanics and Molecular Dynamics (12 Hours)

Molecular Mechanics: Force Fields, Non-bonded interactions (van der Waals and electrostatic, hydrogen bonding), Parameterization. The applications of MM, the disadvantages, and the different variants of MM (MM1, MM2, MM3, MM4, AMBER, OPLS, etc).; Molecular Dynamics: Ensembles (microcanonical, canonical, isothermal – isobaric), Concept of periodic box, Ergodic hypothesis. Leapfrog and Verlet Algorithms (qualitative treatment), Typical MD simulations.

Unit 3: Semi-empirical Methods (3 Hours)

Brief idea of semi-empirical method; CNDO, INDO, MNDO, AM1, PM3.

Unit 4: Quantum Mechanical Methods (9 Hours)

Brief idea of quantum mechanical methods; HF, MP2, DFT, CC, and CI (conceptual and qualitative discussion only)

Conceptual ideas of Basis sets (STOs and GTOs), diffuse and polarization functions, Basis set superposition error (BSSE), Effective Core Potentials (ECP), and HOMO-LUMO. Awareness of available computational chemistry software.

Practicals: Credits: 02

(Laboratory periods:15 classes of 4 hours each)

1. Find the Z-matrix of diatomic (i.e., H_2, HCl), triatomic (i.e., H_2O, HNO, HCN) and tetratomic (i.e., H_2CO, HNO_2, BH_3, cis- and trans-diazene) molecules, etc.
2. Determine the optimized geometry of HF, HCl, and HBr molecules and compare the optimized geometrical parameters, formal charges, vibrational frequencies, and dipole moments using AM1, HF, and DFT (using at least three different basis sets).
3. Determine the optimized geometry of HF, HCl, and HBr molecules and compare the optimized geometrical parameters, formal charges, vibrational frequencies, and dipole moments by DFT method at least three different basis sets using any suitable method.
4. Determine the optimized geometry of H_2O, H_2S, and H_2Se molecules and compare the optimized geometrical parameters, formal charges, vibrational frequencies, and dipole moments by HF, DFT and MP2 methods using at least three different basis sets.
5. Calculate and compare the C-C, C=C and C≡C bond dissociation energies of ethane, ethylene, and acetylene molecules, respectively, using any suitable method/basis set.
6. Calculate and compare the bond dissociation energies of HF, HCl, and HBr molecules using any suitable method/basis set.
7. Generate the potential energy surface diagram for the rotational profile of the ethane molecule around the C–C bond.
8. Generate the potential energy surface diagram for the rotational profile of the butane molecule around the C_2–C_3 bond
9. Determination of Frontier Molecular orbitals of H_2, CO, HF, H_2O, H_2CO and benzene molecules using any suitable method/basis set.

10. Determine the activation energy for the isomerization of cis-diazene to trans-diazene by computing the equilibrium geometries and the transition state structure using any suitable method/basis set.
11. Calculate the intrinsic reaction coordinate (IRC) for cis-diazene to trans-diazene transformation using any suitable method/basis set.
12. Using optimized geometries, calculate the reaction enthalpy at 298 K for the following industrially important reactions (Haber-Bosch process) based on the enthalpies of the involved species: $CH_4 + H_2O \rightarrow CO + 3H_2$
13. Calculate formaldehyde/benzene's electronic UV/Visible absorption spectrum.
14. Based on the conceptual DFT, calculate the ionization potential (IP), electron affinity (EA), electronegativity, and electron chemical potential of a given set of molecules.
15. Study the mechanism of SN_2 reaction between Cl^- and CH_3Br involving a Walden inversion computationally.
16. Compute the resonance energy of benzene by comparison of its enthalpy of hydrogenation with that of cyclohexene.
17. Predict the aromaticity of thiophene with respect to benzene by comparing their enthalpies of hydrogenation.
18. Arrange 1-hexene, 2-methyl-2-pentene, (E)-3-methyl-2-pentene, (Z)-3-methyl-2-pentene, and 2,3-dimethyl-2-butene in order of increasing stability.
19. Compare the basicity of the nitrogen atoms in ammonia, methylamine, dimethylamine, and trimethylamine by comparison of their charges and ESP maps.
20. Compare the HXH bond angles for the second-row hydrides (BeH_2, CH_4, NH_3, H_2O) and compare with the results from qualitative MO theory (here, X = Be, C, N and O).
21. (a) Compare the shapes of the molecules: 1-butanol, 2-butanol, 2-methyl-1-propanol, and 2-methyl-2-propanol. Note the dipole moment of each molecule. (b) Show how the shapes affect the trend in boiling points: (118 ºC, 100 ºC, 108 ºC, 82 ºC, respectively).

Note: Minimum 12 exercise to be performed**.** Any other practical may also be performed as directed by the instructor.

NB: *Some suggested free open-source software tools include:*
(a) *For visualization and basic tasks: Avogadro, Jmol, RasMol, Molden, IQmol, PyMOL, VMD, MacMolPlt, ArgusLab, ChemCraft (for 150 days) or any other software may be used.*

(b) *For calculations and simulations: Avogadro, ArgusLab, Dalton, Ergo, GAMESS, ORCA, NW Chem, MPQC, Psi4, Quantum ESPRESSO, ABINIT, CP2K, TINKER or any other available software may be used.*

References:

1. C. J. Cramer, *Essentials of Computational Chemistry-Theories and Models*, John Wiley and Sons Ltd., 2nd Ed., 2004.
2. F. Jensen, *Introduction to Computational Chemistry*, John Wiley and Sons Ltd., 3rd Ed., 2017.

3. Free and open source software for computational chemistry education, S. Lehtola and A. J. Karttune, *Comput Mol Sci*. (2022); 12, e1610. doi: 10.1002/wcms.1610
4. Online manual of
   a) *Gaussian 16,* www.gaussian.com
   b) *GAMESS,* www.msg.ameslab.gov/gamess
   c) *Q-Chem, https://manual.q-chem.com/latest/*
5. J. B. Foresman and Æ Frisch, *Exploring Chemistry with Electronic Structure Methods*, 3rd ed., Gaussian, Inc.: Wallingford, CT, 2015.

Assessment Methods: All examination and assessments methods shall be in line with the University of Delhi guidelines issued from time to time.

DISCIPLINE SPECIFIC ELECTIVE COURSE - 22 (DSE-22): Machine Learning and Artificial Intelligence in Chemistry

***For syllabus content of Discipline Specific Elective-22: (DSE-22)** "Machine Learning and Artificial Intelligence in Chemistry refer to the pool of DSE courses in 4th year syllabus of **B.Sc. (H) Chemistry**.

Discipline Specific Courses Applicable Specifically for B.Sc. Life Sciences

DISCIPLINE SPECIFIC ELECTIVE COURSE – 23 LS (DSE-23 LS)
Bioelectrochemistry

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical / Practice		
Bioelectro-chemistry **(DSE-23 LS)**	**04**	**02**	**--**	**02**	**Class 12th with Physics, Chemistry**	**--**

Course Objectives

The objectives of this course are as follows:

- To provide a conceptual understanding of the various types of electrodes and the electrochemical processes.
- To equip the students with conceptual understanding of the electrical double layer and Equivalent circuit models of EDL; Gouy-Chapman Model etc.
- To help build an insight into Interfacial Electron Transfer in Biological Systems.
- To provide an understanding of the concept of bio-electrocatalysis and electrochemical communication in biological organisms.

Learning outcomes

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

- Differentiate between different electro systems and account for the electrochemical processes at the electrodes.
- Demonstrate their understanding of the electrical double layer, membrane potential and the concept of interfacial electron transfer in biological systems.
- Exhibit their understanding of Chemical signalling, electrical signalling. Electrochemical mechanisms of the nervous system
- Develop an insight into Bioelectrocatalysis Using Enzymes electrodes.

Unit 1: Electrode and Electrochemical Processes **(8 Hours)**

Qualitative conceptual description of working and Counter Electrodes, Reference Electrodes: standard hydrogen electrode (SHE), or normal hydrogen electrode (NHE), saturated calomel electrode (SCE), silver-silver chloride electrode, potential of zero charge, open-circuit potential of the cell, overpotentials.

Faradaic and Nonfaradaic Processes: Ideally polarizable electrode, Capacitance and Charge of an Electrode, supporting electrolyte, Nernst equation, Nernst potential and biological systems.

Description of the Electrical Double Layer: Stern Potential, Zeta potential. Membrane potentials, simplistic theories of membrane potentials, electrical conduction in biological organisms: electronics and protonics.

Unit 2: Electrical Double Layer (8 Hours)

Description of the Electrical Double Layer: inner and outer compact layer Helmholtz, Stern layer, Diffuse Layer, specifically and non-specifically adsorbed ions, Potential profile across the double-layer region in the absence of specific adsorption of ions, Equivalent circuit models of EDL, Gouy-Chapman Model (Qualitative discussion only)

Brief qualitative discussion of basic principle and application of electrophoeresis, Electrochemical impedance spectroscopy and cyclic voltammetry techniques.

Unit 3: Interfacial Electron Transfer in Biological Systems (6 Hours)

Electrode kinetics, Butler-Volmer equation, adsorption of proteins onto metals from solution, electron transfer from biomaterials to simple redox ions in solution, theoretical aspects of electron transfer from solid proteins to ions in solution.

Unit 4: Electrochemical Communication and Bio-Electrocatalysis (8 Hours)

Chemical signalling, electrical signalling. Electrochemical mechanisms of the nervous system, theory of the spike potential. Monitoring neurotransmitters in the intact brain and other single-cell studies.

Bio-Electrocatalysis, electrodes carrying enzymes, electrochemical enzyme-catalyzed oxidation of styrene.

Practicals: Credits: 02

(Laboratory periods:15 classes of 4 hours each)

1. Conductometric Titration of a Charge Transfer System, the formation of charge transfer complex between an electron donor and acceptor is studied and the stoichiometry of the complex is determined by following the variation of conductance of the solution with concentration of the donor and acceptor.
2. Effect of ionic strength on reaction rate (persulfate-iodine reaction).
3. Potentiometric determination of solubility and solubility product of AgCl(s) in water.
4. Potentiometric determination of mean ionic activity coefficient of HCl at different concentrations.
5. Potentiometric titration of Phosphoric acid vs NaOH.
6. Determination of dissociation constant of acetic acid from its potentiometric titration curve.

Hands-on/Demonstration/ Instruction Mode: Demonstration/ Discussion of working principle/ Hands-on with substantial literature analysis/ Laboratory exercise.

7. To measure the Vitamin C content of commercial Orange Juice using Pencil Lead as a working electrode in cyclic voltammetry.
8. Synthesis and Cyclic voltammetry study of Nano-wood, prepared using household Chemicals.
9. Record cyclic voltammogram for a reversible heterogeneous electron transfer system with varying scan rates,
   (i) Determine anodic and cathodic peak current ratio.

(ii) Determine anodic and cathodic peak potential difference.
(iii) Plot peak current vs square root of scan rates.
(Use aqueous solution of 10 mM $K_4Fe(CN)_6$ + $K_3Fe(CN)_6$ + 1.5 M $NaNO_3$)

10. Record cyclic voltammogram for a quasi-reversible heterogeneous electron transfer system with varying scan rates,
(i) Determine anodic and cathodic peak current ratio.
(ii) Determine anodic and cathodic peak potential difference.
(iii) Plot peak current vs square root of scan rates.
(Use aqueous solution of 10mM $Fe(NH_4)_2(SO_4)_2$ + $Fe(NH_4)(SO_4)_2$ + 1 M $HClO_4$)
11. Record the CV of aqueous solution of sulphuric acid (0.5 M) at Pt electrode as working electrode and counter electrode.
(i) Interpret and explain various peaks and region of the CV and their significance.
Determine the area and roughness factor of the electrode by Pt oxide region.

Essential/recommended readings

Theory:

1. Bockris, J. O' M. & Reddy, A. K. N. Modern Electrochemistry 2A: Fundamentals of Electrodics 2nd Ed., Springer (2001).
2. Bockris, J. O' M. & Reddy, A. K. N. Modern Electrochemistry 2B: Electrodics in Chemistry, Engineering, Biology and Environmental Science 2nd Ed., Springer (2001).
3. Bard, A. J. Faulkner, L. R. Electrochemical Methods: Fundamentals and Applications, 2nd Ed., John Wiley & Sons: New York, 2002.
4. Oldham, K. B., Myland, J. C. and Bond, A. M. Electrochemical Science and Technology: Fundamental and Applications, John Wiley & Sons, Ltd. (2012).
5. Brett, C. M. A. & Brett, A. M. O. Electrochemistry, Oxford University Press (1993).
6. Koryta, J., Dvorak, J. & Kavan, L. Principles of Electrochemistry John Wiley & Sons: NY (1993).
7. Bagotsky, V.S., Fundamentals of Electrochemistry 2nd Ed. Wiley – Interscience, (2006)
8. Hamann, Carl H., Hamneff, Andrew & Vielstich, Wolf., Electrochemistry, 2nd Ed. (2007)

Practical:

1. Khosla B. D., Garg V. C., Gulati A., Senior Practical Physical Chemistry, R. Chand & Co, New Delhi.
2. Holze R., (2019) Experimental Electrochemistry: A laboratory Textbook, Wiley-VCH.
3. Brabec V., Walz D., Milazzo G., Experimental techniques in Bioelectrochemistry, Springer.
4. Bartlett P. N., Bioelectrochemistry: Fundamentals, Experimental Techniques and Applications, John Wiley & Sons Inc.
5. Elgrishi, N.; Rountree, K. J.; McCarthy, B. D.; Rountree, E. S.; Eisenhart, T. T.; Dempsey, J. L. A Practical Beginner's Guide to Cyclic Voltammetry, *J. Chem. Educ.* **2018**, *95*, *2*, 197–206.
6. Field, R. J.; Schneider, F. W. Oscillating Chemical Reactions and Nonlinear Dynamics, *J. Chem. Educ.* **1989**, *66*, *3*, 195–204.
7. King D, Friend J., Kariuki J., *Measuring Vitamin C Content of Commercial Orange Juice Using a Pencil Lead Electrode, J. Chem. Educ.* **2010**, *87*, *5*, 507–509.
8. Lima D, Singh V, Bulleeraz K, Lussier J. A., Kuss S., Electrifying Fruit Juice: Integrating Applied Electroanalytical Chemistry into the Undergraduate Curriculum, *J. Chem. Educ.* **2024**, *101, 7, 2938-2946*.

Assessment Methods: All examination and assessments methods shall be in line with the University of Delhi guidelines issued from time to time.

DISCIPLINE SPECIFIC ELECTIVE COURSE – 24 LS (DSE-24 LS)

Nanomaterials and their Biological Applications

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Nanomaterials and their Biological Applications **(DSE-24 LS)**	**04**	**02**	**--**	**02**	Class12th with Physics, Chemistry Biology	**--**

Course Objectives

The objectives of this course are as follows:

- To study about fundamentals and applications of Advanced Inorganic materials.
- To understand the mechanism of synthesis of hydrogels, composites, mesoporous materials.
- To understand the fabrication of materials for their notable applications in living systems.
- To know how these materials are making life easier in this era and are great sources of industrial growth and technological changes.

Learning outcomes

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

- Understand various materials, their synthesis and properties.
- Explain the mechanism of growth of self-assembled nanostructures.
- Explain the importance of hydrogels composites, mesoporous materials and their applications.
- Understand the usage of materials in various fields ranging from modern life to Human health, and environment.
- Develop skills in the scientific method of planning, developing, conducting, reviewing and reporting experiments.

Unit1: Nanomaterials **(8 Hours)**

Overview of nanostructures and nanomaterials, classification, preparation and optical properties of gold and silver metallic nanoparticles, concept of surface plasmon resonance, carbon nanotubes, inorganic nanowires, Bioinorganic nanomaterials, DNA and its nanomaterials, natural and artificial nanomaterials, self-assembled nanostructures, control of nanoarchitecture, one dimensional control.

Unit 2: Composite materials **(7 Hours)**

Introduction, limitations of conventional engineering materials, role of matrix in composites, classification, matrix materials, reinforcements, metal-matrix composites, polymer-matrix composites, fibre-reinforced composites, bio-nanocomposites, environmental effects on composites, applications of composites.

Unit 3: Hydrogels: **(10 Hours)**

Introduction, natural, synthetic, and hybrid hydrogels, Properties of hydrogels, different methods of synthesis, notable hydrogel systems such as alginate-based, PEGDA, and PVA hydrogels, Applications of hydrogels such as environmental remediation, Food packaging, sensor, and biomedical.

Unit 4: Nanomaterials for Biomedical Applications **(5 Hours)**

Inorganic nanomaterials: silica, carbon based, metallic, oxides.

Biomedical applications: Quantum dots, gold nanoparticles, and magnetic nanoparticles for imaging, biosensing, therapeutics and diagnostics. Polymeric nanoparticles, dendrimers, and carbon nanotubes applied to drug delivery systems. Nanomaterials such as nanofibers, and nanocomposite materials as scaffold materials for tissue engineering and regeneration. Nanotoxicology.

Practical: **Credits: 02**

1. Synthesis of hydrogels and study of swelling behavior.
2. Preparation of zeolite A and removal of Mg and Ca ions from water samples quantitatively using zeolite.
3. Synthesis of ZnO, NiO nanoparticles by green approach methods and characterization using UV-visible spectrophotometer.
4. Synthesis of Cu doped ZnO nanoparticles.
5. Synthesis of CuS, MnS and CdS nanoparticles and their characterization using UV- visible spectrophotometer.
6. Synthesis of gold and silver nanoparticles and study of their optical properties as a function of size.

Recommended Texts:

Theory:

1. West, A. R. (2014), Solid State Chemistry and Its Application, Wiley.
2. Smart, L. E.; Moore, E. A., (2012), Solid State Chemistry: An Introduction CRC Press Taylor & Francis.
3. Rao, C. N. R.; Gopalakrishnan, J. (1997), New Direction in Solid State Chemistry, Cambridge University Press.
4. Xu, C.; Zang Y. S.; Begin S.; Thanh N. T. K.; Nanoscale, 2022,14, 7441-7443.
5. Poole Jr.; Charles P.; Owens, Frank J. (2003), Introduction to Nanotechnology, John Wiley and Sons.

Practical:

1. Cheng, K.H.; Jacobson, A.J.; Whittingham, M.S. (1981), Hexagonal Tungsten Trioxide and Its Intercalation Chemistry, Solid State Ionics, 5, 1981, 355-358.
2. Ghorbani H.R.; Mehr, F.P; Pazoki, H; Rahmani, B.M.; Synthesis of ZnO Nanoparticles by Precipitation Method, Orient J Chem 2015, 31(2).
3. A.K. Sharma, R. Sharma, B. Pani, A. Sarkar, M. Tripathi, Engineering the Future with Hydrogels: Advancements in Energy Storage Devices and Biomedical Technologies. New Journal of Chemistry, RSC, 2024, 48, 10347-10369.
4. Xu, C.; Zang Y. S.; Begin S.; Thanh N. T. K.; Nanoscale, 2022,14, 7441-7443.

Assessment Methods: All examination and assessments methods shall be in line with the University of Delhi guidelines issued from time to time.

List of Instruments/Software required for Implementation of Fourth year Course of Study for each College

1. UV- Vis Spectrophotometer
2. Table top IR Spectrophotometer
3. ChemDraw, GaussView6/ GaussView5 and Gaussian 16/Gaussian 09 Software
4. Access to p-XRD NMR Spectrophotometer in Department of Chemistry/USIC
5. Rota Evaporator
6. Sonicator
7. Cyclic Voltammeter/ Potentiostate-Galvanostate