Appendix-17
Resolution No. 27 {27-1 (27-1-1)}

DEPARTMENT OF CHEMISTRY
Semester -IV/V/VI
BSc. (Physical Sciences)- 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-IV	**04**	**02**	**-**	**02**	**Class 12th with Physics, Chemistry, Mathematics**	

Learning Objectives

The Learning Objectives of this course are as follows:

- To make students learn about the chemistry of carboxylic acids and their derivatives (aliphatic and aromatic)
- To give basic understanding of amines (aliphatic & aromatic), diazonium salts
- To provide basic understanding of heterocyclic systems.

Learning outcomes

By studying this course, students will be able to:

- Understand reactions of carboxylic acids, esters, amides, amines and diazonium salts
- Understand the concept of protection and deprotection.
- Use the synthetic chemistry learnt in this course to do functional group transformations.
- Gain theoretical understanding of chemistry of heterocyclic compounds.

Syllabus

Unit 1: Carboxylic Acids and their Derivatives (aliphatic and aromatic) (1 3 Lectures)

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 (Lectures:10)

Amines

Preparation: from alkyl halides, Gabriel's Phthalimide synthesis, Hoffmann bromamide reaction. Reactions: Hoffmann *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 (Lectures: 7)

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.

Practical Component: 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.

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.

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

SEMESTER V

DISCIPLINE SPECIFIC CORE COURSE CHEM-DSC -13: Chemistry- V: Coordination Chemistry and Organometallics

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 Organometallics DSC-13: Chemistry- V	**04**	**02**	**-**	**02**	**Class 12th with Physics, Chemistry, Mathematics**	

Learning Objectives

The Learning Objectives of this course are as follows:

- To develop basic understanding of coordination chemistry and organometallics which are of immense importance to biological systems, qualitative quantitative analysis, catalysis, medicines, paints and pigments etc.
- The students learn nomenclature, isomerism and bonding in coordination compounds with special emphasis on important coordination compounds in the biological system.
- To understand classification of organometallic compounds, the concept of hapticity and the 18-electron rule governing the stability of a wide variety of organometallic species with special emphasis on metal carbonyls.

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

- Apply 18-electron rule to rationalize the stability of metal carbonyls and related species.
- Learn how IR data can be used to understand extent of back bonding in metal carbonyls.

Syllabus

Unit 1: Introduction to Coordination compounds **(Lectures: 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 **(Lectures: 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: Organometallic Chemistry **(Lectures: 10)**

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 IR data to explain extent of back bonding.

Practical 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 total hardness of a given sample of water by complexometric titration.
5. Determination of the composition of the Fe^{3+} - salicylic acid complex / Fe^{2+}-1, 10-phenanthroline complex in solution by Job's method.
6. Determination of the composition of the Fe^{3+} - salicylic acid complex / Fe^{2+}-1,10-phenanthroline complex in solution by mole ratio method

7. Preparation of the following inorganic compounds:
   a). Tetraamminecopper(II) sulphate
   b). Potassium trioxalatoferrate(III) trihydrate
   c). Chrome alum
   d). *Cis*- and *trans*-Potassium diaquadioxalatochromate(III)
8. Any suitable experiment (other than the listed ones) based upon complexation reactions.

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. Shriver, D.D.; Atkins, P.; Langford, C.H. (1994), **Inorganic Chemistry** 2nd Ed., Oxford University Press.
3. 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.
4. Cotton, F.A.; Wilkinson, G.; Gaus, P.L. **Basic Inorganic Chemistry**, 3rd Edition, Wiley India.
5. Douglas, B.E.; McDaniel, D.H.; Alexander, J.J. (1994), **Concepts and Models of Inorganic Chemistry**, John Wiley & Sons.
6. Greenwood, N.N.; Earnshaw, A. (1997), **Chemistry of the Elements**, 2nd Edition, Elsevier.
7. Lee, J.D.; (2010), **Concise Inorganic Chemistry**, Wiley India.
8. Sodhi G.S., **Principles of Inorganic Chemistry**, 3rd 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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SEMESTER VI

DISCIPLINE SPECIFIC CORE COURSE -16: Chemistry -VI 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		
Quantum Chemistry and Spectroscopy DSC-16: Chemistry-VI	**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 **(Lectures: 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 **(Lectures: 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

1. 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).
2. Study the pH-dependence of the UV-Vis spectrum (200-500 nm) of $K_2Cr_2O_7$
3. 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

4. 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
5. Determine the concentrations of KMnO4 and $K_2Cr_2O_7$ in a mixture.
6. Study the kinetics of iodination of propanone in acidic medium.
7. Determine the amount of iron present in a sample using 1, 10-phenanthroline.
8. Determine the dissociation constant of an indicator (phenolphthalein).
9. 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:

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, McGraw Hill Education.
3. Garland, C. W.; Nibler, J. W.; Shoemaker, D. P.(2003),**Experiments in Physical Chemistry**, 8th Edition, McGraw-Hill, New York.

Additional Resources:

1. Castellan, G. W .(2004),**Physical Chemistry**, Narosa.
2. 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.

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 **(Lectures: 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 Lectures)**

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 **(Lectures: 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 Lectures)**

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.

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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 **(Lectures: 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 **(Lectures: 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 **(Lectures: 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.

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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 **(Lectures: 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 **(Lectures: 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 **(Lectures: 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 **(Lectures: 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 (Lectures: 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 (Lectures: 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 **(Lectures: 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 **(Lectures: 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 **(Lectures: 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 **(Lectures: 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 **(Lectures: 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 **(Lectures: 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 **(Lectures: 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.

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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 **(Lectures: 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 **(Lectures: 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 **(Lectures: 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 **(Lectures: 6)**

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

UNIT-2: Pharmaceutical Compounds **(Lectures: 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 **(Lectures: 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 **(Lectures: 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 **(Lectures: 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 **(Lectures: 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 **(Lectures: 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 (Lectures: 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 (Lectures: 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.

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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 **(Lectures: 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 **(Lectures: 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
(Lectures: 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 **(Lectures: 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 **(Lectures: 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.

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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 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 **(Lectures: 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 **(Lectures: 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 **(Lectures: 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 **(Lectures: 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 **(Lectures: 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