UNIVERSITY OF DELHI

COURSE NAME: B.Sc (Hons) Chemistry

(SEMESTER – 1)

based on
Undergraduate Curriculum Framework 2022 (UGCF)
(Effective from Academic Year 2022-23)

University of Delhi

List of DSC Papers

Course Title	Nature of the Course	Total Credits	Components			Eligibility Criteria/ Prerequisite	Contents of the course and reference is in
			Lecture	Tutorial	Practical		
Atomic Structure & Chemical Bonding	DSC 1: INORGANIC CHEMISTRY – I	4	3	1	0		**Annexure-I**
Basic Concepts and Aliphatic Hydrocarbons	DSC 2: ORGANIC CHEMISTRY - I	4	3	1	0		
Gaseous and Liquid state	DSC-3: Physical Chemistry-I	4	2	2	0		

GE Pool A: Semester I, III, V (ODD SEMESTERS)

Course Title	Nature of the Course	Total Credits	Components			Eligibility Criteria/ Prerequisite	Contents of the course and reference is in
			Lecture	Tutorial	Practical		
Atomic Structure and Chemical Bonding	GE-1	4	2	0	2		**Annexure-II**
Bioinorganic Chemistry	GE-3	4	2	0	2		
Basic Concepts of Organic Chemistry	GE-4	4	2	0	2		
States of Matter	GE-7		2	0	2		
Conductance and Electrochemistry	GE-9		2	0	2		
Chemistry of Food Nutrients	GE-11		2	0	2		
Chemistry: Statistical Methods and Data Analysis	GE-12		2	0	2		
Medicines in Daily Life	GE-13		2	0	2		
Chemistry and Society	GE-15		2	0	2		
Radio-chemistry in Energy, Medicine and Environment	GE-19		3	0	1		
Chemistry in Indology and Physical & Mental Well Being	GE-21		3	0	1		

Syllabus for Undergraduate Programme in Chemistry

DISCIPLINE SPECIFIC CORE (DSC) COURSES

SEMESTER I

Course Code: DSC 1: INORGANIC CHEMISTRY – I

Course Title: Atomic Structure & Chemical Bonding

Total Credits: 04 (Credits: Theory-03, Practical-01)

Total Lectures: Theory- 45, Practical- 15 classes of 2 hours each

Objectives: The course reviews the structure of the atom, which is a necessary pre-requisite in understanding the nature of chemical bonding in compounds. It provides basic knowledge about ionic and covalent bonding, and explains that chemical bonding is best regarded as a continuum between the two cases. It discusses the periodicity in properties with reference to the *s* and *p* block, which is necessary in understanding their group chemistry. The student will also learn about the fundamentals of acid-base and redox titrimetric analysis.

Learning Outcomes:

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

- Solve the conceptual questions using the knowledge gained by studying the quantum mechanical model of the atom, quantum numbers, electronic configuration, radial and angular distribution curves, shapes of s, p, and d orbitals, and periodicity in atomic radii, ionic radii, ionization enthalpy and electron affinity of elements.
- Draw the plausible structures and geometries of molecules using radius ratio rules, VSEPR theory and MO diagrams (homo- & hetero-nuclear diatomic molecules).
- Understand the concept of lattice energy using Born-Landé and Kapustinskii equation.
- Calibrate the apparatus used in titrimetric analysis and prepare standard solutions for titration
- Understand the theory and application of various acid-base and redox titrations.
- Comprehend the theory of acid-base indicators

Unit 1: **Lectures: 14**

Atomic Structure: Recapitulation of concept of atom in ancient India, Bohr's theory & its limitations, atomic spectrum of hydrogen atom.

de Broglie equation, Heisenberg's Uncertainty Principle and its significance. Postulates of wave mechanics, Time independent Schrödinger's wave equation, well behaved wave function, significance of ψ and ψ^2. Quantum mechanical treatment of H- atom, Quantumnumbers and their significance. Normalized and orthogonal wave functions. Sign of wave functions. Radial

and angular wave functions for hydrogen atom. Radial function plots, radial probability distribution plots, angular distribution curves. Shapes of *s*, *p*, and *d* orbitals, Relative energies of orbitals.

Pauli's Exclusion Principle, Hund's rule of maximum spin multiplicity, Aufbau principle and its limitations.

Unit 2: Periodic properties of Elements & Periodic Trends **Lectures: 6**

Brief discussion of the following properties of the elements, with reference to *s*- & *p*-block and their trends:

(a) Effective nuclear charge, shielding or screening effect and Slater's rules

(b) Atomic and ionic radii

(c) Ionization enthalpy (Successive ionization enthalpies)

(d) Electron gain enthalpy

(e) Electronegativity, Pauling's scale of electronegativity. Variation of electronegativity with bond order and hybridization.

Unit 3: Ionic bond **Lectures: 12**

General characteristics, types of ions, size effects, radius ratio rule and its limitations. Packing of ions in crystals. Lattice energy, Born-Landé equation with derivation, Madelung constant, importance of Kapustinskii equation for lattice energy. Born-Haber cycle and its applications.

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

Unit 4: Covalent bond **Lectures: 13**

Valence shell electron pair repulsion (VSEPR) theory, shapes of the following simple molecules and ions containing lone pairs and bond pairs of electrons: H_2O, NH_3, PCl_3, PCl_5, SF_6, ClF_3, I_3, BrF_2^+, PCl_6^-, ICl_2^- ICl_4^-, and SO_4^{2-}. Application of VSEPR theory in predicting trends in bond lengths and bond angles.

Valence Bond theory (*Heitler-London* approach). Hybridization, equivalent and non-equivalent hybrid orbitals, Bent's rule.

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

Molecular orbital diagrams of homo & hetero diatomic molecules [N_2,O_2, C_2, B_2, F_2, CO, NO] and their ions; HCl (idea of s-p mixing and orbital interaction to be given).

Practicals: Inorganic Chemistry-I **Credits: 01**

(Laboratory periods: 15 classes of 2 hours each)

1. Titrimetric Analysis:

(i) Calibration and use of apparatus

(ii) Preparation of solutions ofdifferent Molarity/Normality.

2. Acid-Base Titrations: Principles of acid-base titrations to be discussed.

(i) Estimation of oxalic acid using standardized NaOH solution

(ii) Estimation of sodium carbonate using standardized HCl.

(iii)Estimation of carbonate and hydroxide present together in a mixture.

(iv) Estimation of carbonate and bicarbonate present together in a mixture.

3. Redox Titration: Principles of oxidation-reduction titrations to be discussed.

(i) Estimation of oxalic acid using standardized $KMnO_4$ solution

(ii) Estimation of water of crystallization in Mohr's salt by titrating with $KMnO_4$.

(iii) Estimation of oxalic acid and sodium oxalate in a given mixture.

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. Pfennig, B. W. (2015), **Principles of Inorganic Chemistry.** John Wiley & Sons.
6. Housecraft, C. E.; Sharpe, A. G., (2018), Inorganic Chemistry, 5th Edition, Pearson.
7. Wulfsberg, G (2002), **Inorganic Chemistry,** Viva Books Private Limited.
8. Miessler, G.L.; Fischer P.J.; Tarr, D. A. (2014), **Inorganic Chemistry**, 5th Edition, Pearson.
9. Shiver, D.; Weller, M.; Overton, T.; Rourke, J.; Armstrong, F. (2014), **Inorganic Chemistry**, 6th Edition, Freeman & Company
10. Das, A. K.; Das, M. (2014), **Fundamental Concepts of Inorganic Chemistry**, 1st Edition, Volume CBS Publishers & Distributors Pvt. Ltd.

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. Harris, D. C.; Lucy,C. A.(2016), **Quantitative Chemical Analysis,** 9th Edition, Freeman and Company

Teaching Learning Process:

- Conventional chalk and board teaching,

- Class interactions and discussions
- Power point presentation on important topics

Assessment Methods:

- Presentations by Individual Student/ Group of Students
- Class Tests at Periodic Intervals.
- Written assignment(s)
- Continuous evaluation during laboratory classes.
- Mock Practical
- Viva-voce
- End semester University Theory/ Practical Examination

Keywords: Atomic Structure, Wave function, Quantum Numbers, Electronegativity, Ionic Bonding, Dipole Moment, VSEPR Theory, Covalent Bonding, Multiple Bonding, Molecular Orbitals, Bonding MO, Antibonding MO, Homonuclear, Heteronuclear, Titrimetric Analysis, Acid-Base Titrations, Redox Titrations, Acid-Base Indicators

Course Code: DSC 2: ORGANIC CHEMISTRY - I

Course Title: Basic Concepts and Aliphatic Hydrocarbons

Total Credits: 04 (Credits: Theory-03, Practical-01)

Total Lectures: Theory- 45, Practical- 15 classes of 2 hour each

Objectives: The core course Organic Chemistry I is designed in a manner that it forms a cardinal part of the learning of organic chemistry for the subsequent semesters. The course is infused with the recapitulation of fundamental concepts 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, the functional groups-alkanes, alkenes, alkynes are introduced. The constitution of the course strongly aids in the paramount learning of the concepts and their applications.

Learning Outcomes:

On completion of the course, the student will be able to:

- Understand and explain the electronic displacements and reactive intermediates and their applications in basic concepts.
- Formulate the mechanistic route of organic reactions by recalling and correlating the fundamental concepts.
- Identify and comprehend mechanism for free radical substitution, electrophilic addition, nucleophilic substitution and elimination reactions.
- Understand the fundamental concepts of stereochemistry.
- Understand and suitably use the chemistry of hydrocarbons

Unit I: Basic Concepts of Organic Chemistry — Lectures: 8

Electronic displacements and their applications: inductive, electromeric, resonance and mesomeric effects and hyperconjugation. Dipole moment, acidity and basicity.

Homolytic and heterolytic fissions with suitable examples. Types, shape and relative stability of carbocations, carbanions, carbenes and free radicals.

Electrophiles & nucleophiles, and introduction to types of organic reactions: addition, elimination and substitution reactions.

Unit II: Stereochemistry — Lectures: 18

Stereoisomerism: Optical activity and optical isomerism, asymmetry, chirality, enantiomers, diastereomers. specific rotation; Configuration and projection formulae: Newman, Sawhorse, Fischer and their interconversion. Chirality in molecules with one and two stereocentres; meso configuration.

Racemic mixture and their resolution. Relative and absolute configuration: D/L and R/S designations (CIP rules).

Geometrical isomerism: *cis-trans*, *syn-anti* and *E/Z* notations.

Conformational Isomerism: Alkanes (Conformations, relative stability and energy diagrams of Ethane, Propane

and butane). Relative stability of cycloalkanes (Baeyer strain theory), Cyclohexane conformations with energy diagram. Conformations of monosubstituted cyclohexanes.

Unit III: Aliphatic Hydrocarbons **Lectures: 19**

Alkanes: Preparation, Halogenation of alkanes, Concept of relative reactivity v/s selectivity.

Alkenes and Alkynes: Methods of preparation of alkenes using Mechanisms of E1, E2, E1cb reactions, Saytzeff and Hoffmann eliminations. Electrophilic additions, mechanism with suitable examples, (Markownikoff/Anti-markownikoff addition), *syn* and *anti*-addition; addition of H_2, X_2, oxymercuration-demercuration, hydroboration-oxidation, ozonolysis, hydroxylation, reaction with NBS, Reactions of alkynes; acidity, Alkylation of terminal alkynes, electrophilic addition: hydration to form carbonyl compounds, Relative reactivity of alkenes and alkynes, 1,2-and 1,4-addition reactions in conjugated dienes, Diels Alder reaction (excluding stereochemistry)

Practical **Credits: 01**

(Laboratory periods: 15 classes of 2 hour each)

Note: *Students should be provided with handouts prior to the practical class*

1. Calibration of a thermometer and determination of the melting points of the organic compounds using any one of the following methods-Kjeldahl method, electrically heated melting point apparatus and BODMEL).

2. Concept of melting point and mixed melting point.

3. Concept of recrystallisation using alcohol/water/alcohol-water systems (Any two).
4. Determination of boiling point of liquid compounds (boiling point lower than and more than 100 °C by distillation, capillary method and BODMEL method)

5. Separation of a mixture of two amino acids/sugars by radial/ascending paper chromatography.

6. Separation of a mixture of *o*-and *p*-nitrophenol or *o*-and *p*-aminophenol by thin layer chromatography (TLC).

7. Detection of extra elements

References:

Theory

1. Morrison, R.N., Boyd, R.N., Bhattacharjee, S.K. (2010), **Organic Chemistry**, 7th Edition, Dorling Kindersley (India) Pvt. Ltd., Pearson Education.
2. Finar, I.L. (2002), **Organic Chemistry**, Volume 1, 6th Edition, Dorling Kindersley (India) Pvt. Ltd., Pearson Education.
3. Eliel, E.L., Wilen, S.H. (1994), **Stereochemistry of Organic Compounds**; Wiley: London.

Practicals

1. Mann, F.G., Saunders, B.C. (2009), **Practical Organic Chemistry**, 4th Edition, Pearson Education.
2. Ahluwalia, V.K., Dhingra, S. (2004), **Comprehensive Practical Organic Chemistry: Qualitative Analysis**, University Press.
3. Furniss, B.S., Hannaford, A.J., Smith, P.W.G.; Tatchell, A.R (2004), **Vogel's Textbook of Practical Organic Chemistry**, Pearson.
4. Leonard, J., Lygo, B., Procter, G. (2013) **Advanced Practical Organic Chemistry**, 3rd Edition, CRC Press.
5. Pasricha, S., Chaudhary, A. (2021), **Practical Organic Chemistry: Volume–I**, I K International Publishing house Pvt. Ltd, New Delhi

Additional Resources:

2. Solomons, T.W.G., Fryhle, C.B., Snyder, S.A. (2017), **Organic Chemistry**, 12th Edition, Wiley.
3. Bruice, P.Y. (2020), **Organic Chemistry**, 8th Edition, Pearson.
4. Clayden, J., Greeves, N., Warren, S. (2014), **Organic Chemistry**, Oxford.
5. Nasipuri, D. (2018), **Stereochemistry of Organic Compounds: Principles and Applications**, 4th Edition, New Age International.
6. Gunstone, F.D. (1975), **Guidebook to Stereochemistry**, Prentice Hall Press.
7. Gupta, S.S. (2018), **Basic Stereochemistry of Organic Molecules,** 2nd Edition, Oxford University Press.

Teaching Learning Process:

- Lectures in class rooms
- Peer learning
- Hands-on learning using 3-D models, videos, presentations, seminars
- ICT-Pedagogy Integration
- Industry visits

Assessment Methods:

- Continuous Evaluation: Monitoring the progress of student's learning
- Class Tests, Worksheets and Quizzes
- Presentations, Projects and Assignments and Group Discussions: Enhances critical thinking skills and personality
- Semester-end Examination: Critical indicator of student's learning and teaching methods adopted by teachers throughout the semester.

Keywords:

Electronic effects, Reactive intermediates, Stereochemistry, Types of organic reactions, Alkanes, Alkenes, Alkynes.

Course Code: DSC-3: Physical Chemistry-I

Course Title: Gaseous and Liquid state

Total Credits: 04 (Credits: Theory-02, Practical-02)

Total Lectures: Theory- 30, Practical- 15 classes of 4 hour each

Objectives: The objective of this course is to develop basic and advance concepts regarding gases and liquids. It aims to study the similarity and differences between the two states of matter and reasons responsible for these. The objective of the practicals is to develop skills for working in physical chemistry laboratory. The student will perform experiments based on the concepts learnt in Physical chemistry-I course.

Learning Outcomes:

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

- Derive mathematical expressions for different properties of gas and liquid and understand their physical significance.
- Apply the concepts of gas equations and liquids while studying other chemistry courses and every-day life.
- Handle stalagmometer and Ostwald viscometer properly.
- Determine the density of aqueous solutions.
- Dilute the given solutions as per required concentrations.
- Data reduction using numerical and graphical methods.

Unit 1: Gaseous state — Lectures: 24

Kinetic theory of gases- postulates and derivation of kinetic gas equation, Maxwell distribution of molecular velocities and its use in evaluating average, root mean square and most probable velocities and average kinetic energy. Definition, expression, applications and temperature and pressure dependence of each one of the following properties of ideal gases: Collision frequency, Collision diameter, Mean free path. Coefficient of viscosity, definition, units and origin of viscosity of gases, relation between mean free path and coefficient of viscosity, temperature and pressure dependence of viscosity of a gas, calculation of molecular diameter from viscosity

Barometric distribution law, its derivation and applications, alternative forms of barometric distribution law in terms of density and number of molecules per unit volume, effect of height, temperature and molecular mass of the gas on barometric distribution

Behaviour of real gases- Compressibility factor, Z , Variation of compressibility factor with pressure at constant temperature *(plot of Z vs P)* for different gases (H_2, CO_2, CH_4 and NH_3), Cause of deviations from ideal gas behaviour and explanation of the observed behaviour of real gases in the light of molecular interactions

van der Waals (vdW) equation of state, Limitations of ideal gas equation of state and its modifications in the form of derivation of van der Waal equation, Physical significance of van der Waals constants, application of van der Waal equation to explain the observed behaviour of real gases.

Isotherms of real gases- Critical state, relation between critical constants and van der Waals constants, correlation of critical temperature of gases with intermolecular forces of attraction, Continuity of states, Limitations of van der Waals equation, Reduced equation of state and law of corresponding states (statement only).

Virial equation of state-Physical significance of second and third virial coefficients, van der Waals equation expressed in virial form, Relations between virial coefficients and van der Waals constants

Unit 2: Liquid state — Lectures: 6

Nature of liquid state, qualitative treatment of the structure of the liquid state

Physical properties of liquids-vapour pressure, its origin and definition, Vapour pressure of liquids and intermolecular forces, and boiling point

Surface tension, its origin and definition, Capillary action in relation to cohesive and adhesive forces, determination of surface tension by (i) using stalagmometer (drop number and drop mass method both) and (ii) capillary rise method, Effects of addition of sodium chloride, ethanol and detergent on the surface tension of water and its interpretation in terms of molecular interactions, Role of surface tension in the cleansing action of detergents

Coefficient of viscosity and its origin in liquids, Interpretation of viscosity data of pure liquids (water, ethanol, ether and glycerol) in the light of molecular interactions, Effects of addition of sodium chloride, ethanol and polymer on the viscosity of water, relative viscosity, specific viscosity and reduced viscosity of a solution, comparison of the origin of viscosity of liquids and gases, effect of temperature on the viscosity of a liquid and its comparison with that of a gas.

Practical — Credits: 02

(Laboratory periods: 15 classes of 4 hours each)

1. **Gases**
   a. To verify the Charles law using Charles law apparatus
   b. To determine the value of universal gas constant R using the reaction
   $Mg(s) + 2HCl\ (aq) \rightarrow MgCl_2\ (aq) + H_2\ (g)$

2. **Surface tension measurements using stalagmometer**
   a. Determine the surface tension of a liquid by drop number method.
   b. Determine the surface tension of a liquid by drop weight method.
   c. Study the variation of surface tension with different concentration of detergent solutions. Determine CMC.
   d. Study the effect of the addition of solutes on the surface tension of water at room temperature and explain the observations in terms of molecular interactions:
      (i) sugar
      (ii) ethanol
      (iii) sodium chloride
   e. Study the variation of surface tension with different concentration of sodium chloride solutions.

3. **Viscosity measurement using Ostwald's viscometer**
   a. Determination of co-efficient of viscosity of two unknown aqueous solution.
   b. Study the variation of viscosity with different concentration of sugar solutions.

c. Study the effect of the addition of solutes such as (i) polymer (ii) ethanol (iii) sodium chloride on the viscosity of water at room temperature and explain the observations in terms of molecular interactions
d. Study the variation of viscosity of water with the amounts of a solute and calculate the intrinsic viscosity at room temperature.
e. Determine the viscosity average molecular mass of the polymer (PVA) using viscosity measurements.

References:

Theory:

1. Atkins, P.W.; Paula, J.de. (2014), **Atkin's Physical Chemistry Ed**., 10th Edition, Oxford University 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, McGraw Hill Education.

Practical:

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

Teaching Learning Process:

- Teaching Learning process is largely student focused
- Blend of conventional blackboard teaching and modern teaching learning tools
- Focus on real life applications of concepts
- Problem solving and quizzes for enhanced understanding of the concepts
- Engaging students in cooperative learning.
- Pre-lab learning of theoretical concept of the experiment.
- Performing the experiment, recording the data, calculating the result.
- Interpreting the result.
- Comparing the results of the class.
- Discussing the sources of error.

Assessment Methods:

- Presentations by Individual Student/ Group of Students
- Class Tests at Periodic Intervals.
- Written assignment(s)
- Continuous evaluation of laboratory work and record file.
- Oral assessment, quizzes.
- Mock practical examination.
- End semester University Theory Examination

Keywords: States of matter, ideal/real gases, critical constants, viscosity, surface tension, stalagmometer, Ostwald's viscometer.

Appendix-39
Resolution No. 38 {38-1 [38-1-3(6)]}

INDEX

DEPARTMENT OF CHEMISTRY
SEMESTER – II

B.SC. (Hons.) Chemistry

DISCIPLINE SPECIFIC CORE COURSE -4 (DSC-4): CHEMISTRY OF S- AND P-BLOCK 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		
Chemistry of s- and p-Block Elements (DSC-4: Inorganic Chemistry - II)	04	03	--	01	Class 12th with Physics, Chemistry, Mathematics	

Learning objectives

The objectives of this course are as follows:

- To develop the general principles of metallurgy and s-, p-block elements.
- To introduce the terms minerals, ores, concentration, benefaction, calcination, roasting, refining, etc. and explain the principles of oxidation and reduction as applied to the extraction procedures.
- To make students ware of different methods of purification of metals, such as electrolytic, oxidative refining, VanArkel-De Boer process and Mond's process are discussed and applications of thermodynamic concepts like that of Gibbs energy and entropy to the extraction of metals.
- To familiarize students with the patterns and trends exhibited by s- and p-block elements and their compounds with emphasis on synthesis, structure, bonding and uses.
- To impart information about the fundamentals of internal and external redox indicators, and iodometric/iodimetric titrations.

Learning outcomes

By studying this course, students will be able to:

- Explain the fundamental principles of metallurgy as well as the importance of recovery of by-products during extraction.
- Apply thermodynamic concepts like that of Gibbs energy and entropy to the principles of extraction of metals.
- Describe the characteristics of s- and p- block elements and apply them for synthesis.
- Apply the concept and use of internal and external redox indicators
- Explain the theory and application of iodometric and iodimetric titrimetric analysis.

SYLLABUS OF DSC-4

UNIT – 1: General Principles of Metallurgy (2 Weeks)

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. Brief discussion of metals and alloys used in ancient and medieval India.

UNIT – 2: **Chemistry of s- Block Elements (5 Weeks)**

General characteristics: melting point, flame colouration, reducing nature, diagonal relationships and anomalous behavior of first member of each group. Reactions of alkali and alkaline earth metals with oxygen, hydrogen, nitrogen and water.

Common features such as ease of formation, thermal stability, energetics of dissolution, and solubility of the following alkali and alkaline earth metal compounds: hydrides, oxides, peroxides, superoxides, carbonates, nitrates, sulphates.

Complex formation tendency of s-block elements; structure of the following complexes: crown ethers and cryptates of Group I; basic beryllium acetate, beryllium nitrate, EDTA complexes of calcium and magnesium.

Solutions of alkali metals in liquid ammonia and their properties

UNIT – 3: Chemistry of *p*-Block Elements (3 Weeks)

Electronic configuration, atomic and ionic size, metallic/non-metallic character, melting point, ionization enthalpy, electron gain enthalpy, electronegativity, Catenation, Allotropy of C, P, S; inert pair effect, diagonal relationship between B and Si and anomalous behaviour of first member of each group.

UNIT – 4: Compounds of *p*-Block Elements (5 Weeks)

Acidic/basic nature, stability, ionic/covalent nature, oxidation/reduction, hydrolysis, action of heat on the following:

- Hydrides of Group 13 (only diborane), Group 14, Group 15 (EH_3 where E = N, P, As, Sb, Bi), Group 16 and Group 17.
- Oxoacids of phosphorus, sulphur and chlorine
- Interhalogen and pseudohalogen compound
- Clathrate compounds of noble gases, xenon fluorides (MO treatment of XeF_2).

Practical component

1. **Redox Titrations**
   (i) Estimation of Fe(II) with $K_2Cr_2O_7$ using diphenylamine as internal indicator.
   (ii) Estimation of Fe(II) with $K_2Cr_2O_7$ using N-phenyl anthranilic acid as internal indicator.
   (iii) Estimation of Fe(II) with $K_2Cr_2O_7$ using external indicator.

2. Iodo/Iodimetric Titrations

(i) Estimation of Cu(II) using sodium thiosulphate solution (Iodometrically).

(ii) Estimation of $K_2Cr_2O_7$ using sodium thiosulphate solution (Iodometrically).

(iii) Estimation of antimony in tartaremetic iodimetrically.

(iv) Estimation of Iodine content in iodized salt.

Essential/recommended readings

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. 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. Housecraft, C. E.; Sharpe, A. G., (2018), **Inorganic Chemistry**, 5thEdition, Pearson.
6. Canham, G. R., Overton, T. (2014), **Descriptive Inorganic Chemistry,** 6th Edition, Freeman and Company.
7. Greenwood, N. N.; Earnsaw, A., (1997), **Chemistry of Elements**, 2nd Edition, Elsevier.

Practicals:

1. Jeffery, G. H.; Bassett, J.; Mendham, J.; Denney, R. C. (1989), Vogel's Text book 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**, 6th Edition, PHI Learning Private Limited.

DISCIPLINE SPECIFIC CORE COURSE – 5 (DSC-5): HALOALKANES, ARENES, HALOARENES, ALCOHOLS, PHENOLS, ETHERS AND EPOXIDES

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		
Haloalkanes, Arenes,	04	02	-	02	Class 12th with	

Haloarenes, Alcohols, Phenols, Ethers and Epoxides (DSC-5: Organic Chemistry-II)					Physics, Chemistry, Mathematics	

Learning Objectives

The Learning Objectives of this course are as follows:

- To impart understanding of the chemistry of organic functional groups, which include haloalkanes, aromatic hydrocarbons, haloarenes and some oxygen containing functional groups, along with their reactivity patterns.
- To develop understanding of detailed reactions and mechanistic pathways for each functional group to unravel the spectrum of organic chemistry and the extent of organic transformations.
- To aid in the paramount learning of the concepts and their applications.

Learning outcomes

On completion of the course, the student will be able to:

- Explain and use reactions of arenes, haloarenes and some oxygen containing functional groups for practical applications.
- Apply the concept of protection and deprotection in organic synthesis.
- Use the synthetic chemistry learnt in this course to do functional group transformations.
- Propose plausible mechanisms for the reactions under study.

SYLLABUS OF DSC-5

Unit - 1: Haloalkanes (05 Weeks)

Alkyl halides: Methods of preparation and properties, nucleophilic substitution reactions – S_N1, S_N2 and S_Ni mechanisms with stereochemical aspects and effect of solvent; nucleophilic substitution v/s elimination.

Organometallic compounds of Mg (Grignard reagent) – Use in synthesis of organic compounds.

Unit - 2: Aromatic Hydrocarbons (03 Weeks)

Concept of Aromaticity and anti-aromaticity; Electrophilic aromatic substitution: halogenation, nitration, sulphonation, Friedel Crafts alkylation/acylation with their mechanism. Directing effects of groups in electrophilic substitution.

Unit - 3: Aryl halides (02 Weeks)

Preparation (including preparation from diazonium salts) and properties, nucleophilic aromatic substitution; S_NAr, Benzyne mechanism. Relative reactivity of alkyl, allyl, benzyl, vinyl and aryl halides towards nucleophilic substitution reactions.

Unit - 4: Alcohols, Phenols, Ethers & Epoxides (05 Weeks)

Alcohols: Relative reactivity of 1°, 2°, 3° alcohols, reactions of alcohols with sodium, HX (Lucas test), esterification, oxidation (with PCC, alkaline $KMnO_4$, acidic dichromate, conc. HNO_3). Oppenauer oxidation; Diols: oxidation of diols by periodic acid and lead tetraacetate, Pinacol-Pinacolone rearrangement.

Phenols: Preparation using Cumene hydroperoxide, Acidity and factors affecting it, Kolbe's–Schmidt reactions, Riemer-Tiemann reaction, Houben–Hoesch condensation, Schotten–Baumann reaction, Fries and Claisen rearrangements and their mechanism. Ethers and Epoxides: Acid and Base catalyzed cleavage reactions.

Practical

1. Acetylation of any one of the following compounds: amines (aniline, *o*-, *m*-, *p*-toluidines and *o*-, *m*-, *p*-anisidine) and phenols (*β*-naphthol, salicylic acid) by any one method:
   i. Using conventional method ii. Using green approach
2. Benzolyation of one of the following amines (aniline, *o*-, *m*-, *p*-toluidines and *o*, *m*-, *p*-anisidine) or one of the following phenols (*β*-naphthol, resorcinol, *p*-cresol) by Schotten-Baumann reaction.
3. Bromination of acetanilide/aniline/phenol by anyone of the following:
   (a) Green method b) Conventional method
4. Nitration of nitrobenzene/chlorobenzene/phenols.
5. Haloform reaction of ethanol.
6. Oxidation of benzyl alcohol to benzoic acid
7. Estimation of the given sample of phenol/amine by:
   a) Acetylation b) Bromate-Bromide method
8. Functional group tests for alcohols, phenols, carboxylic acids, phenols, carbonyl compounds, esters.

Essential/recommended readings

Theory:

1. Morrison, R. N., Boyd, R. N., Bhattacharjee, S.K. (2010), **Organic Chemistry**, 7th Edition, Dorling Kindersley (India) Pvt. Ltd., Pearson Education.
2. Finar, I.L. (2002), **Organic Chemistry**, Volume 1, 6th Edition, 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. (2017), **Organic Chemistry**, 12th Edition, Wiley.

Practical:

1. Mann, F.G., Saunders, B.C. (2009), **Practical Organic Chemistry**, 4th Edition, Pearson Education.
2. Furniss, B.S., Hannaford, A.J., Smith, P.W.G., Tatchell, A.R. (2005), **Vogel's Textbook of Practical Organic Chemistry**, Pearson.

3. Ahluwalia, V.K., Aggarwal, R. (2004), **Comprehensive Practical Organic Chemistry: Preparation and Quantitative Analysis**, University Press.
4. Ahluwalia, V.K., Dhingra, S. (2004), **Comprehensive Practical Organic Chemistry: Qualitative Analysis**, University Press.
5. Pasricha, S., Chaudhary, A. (2021), **Practical Organic Chemistry: Volume–I**, I K International Publishing house Pvt. Ltd, New Delhi
6. Pasricha, S., Chaudhary, A. (2021), **Practical Organic Chemistry: Volume–II**, I K International Publishing house Pvt. Ltd, New Delhi

Suggestive readings

1. Carey, F.A., Sundberg, R. J. (2008), **Advanced Organic Chemistry: Part B: Reaction and Synthesis**, Springer.
2. Bruice, P.Y. (2020), **Organic Chemistry**, 3rd Edition, Pearson.
3. Patrick, G. (2012), **BIOS Instant Notes in Organic Chemistry**, Viva Books.
4. Parashar, R.K., Ahluwalia, V.K. (2018), **Organic Reaction Mechanism,** 4th Edition, Narosa Publishing House.

DISCIPLINE SPECIFIC CORE COURSE – 6 (DSC-6): Thermodynamics and its 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		
Chemical Thermodynamics and its Applications (DSC – 6: Physical Chemistry – II)	04	03	-	01	Class XII with Physics, Chemistry and Mathematics	

Learning Objectives

The Learning Objectives of this course are as follows:

- To make students understand thermodynamic concepts, terminology, properties of thermodynamic systems, laws of thermodynamics and their correlation with other branches of physical chemistry and make them able to apply thermodynamic concepts to the system of variable compositions, equilibrium and colligative properties.

Learning outcomes

On completion of the course, the student will be able to:

- Explain and apply the three laws of thermodynamics, concept of State and Path functions, extensive and intensive properties to solve critical problems.
- Derive the expressions of ΔU, ΔH, ΔS, ΔG, ΔA for an ideal gas under different conditions and use them for solving real world problems.
- Explain the concept of partial molar properties.

SYLLABUS OF DSC-6

UNIT – 1: Basic Concepts of Chemical Thermodynamics (2 Weeks)

Intensive and extensive variables; state and path functions; isolated, closed and open systems.

Mathematical treatment - Exact and inexact differential, Partial derivatives, Euler's reciprocity rule, cyclic rule.

UNIT – 2: First law and Thermochemistry (5 Weeks)

Concept of heat, Q, work, W, internal energy, U, and statement of first law; enthalpy, H, relation between heat capacities, Joule Thompson Porous Plug experiment, Nature of Joule Thompson coefficient, calculations of Q, W, ΔU and ΔH for reversible, irreversible and free expansion of gases (ideal and van der Waals) under isothermal and adiabatic conditions.

Enthalpy of reactions: standard states; enthalpy of neutralization, enthalpy of hydration, enthalpy of formation and enthalpy of combustion and its applications, bond dissociation energy and bond enthalpy; effect of temperature (Kirchhoff's equations) on enthalpy of reactions.

UNIT – 3: Second Law (5 Weeks)

Concept of entropy; statement of the second law of thermodynamics, Carnot cycle. Calculation of entropy change for reversible and irreversible processes (for ideal gases). Free Energy Functions: Gibbs and Helmholtz energy; variation of S, G, A with T, V, P; Free energy change and spontaneity (for ideal gases). Relation between Joule-Thomson coefficient and other thermodynamic parameters; inversion temperature; Gibbs-Helmholtz equation; Maxwell relations; thermodynamic equation of state.

UNIT – 4: Third Law (1 Week)

Statement of third law, unattainability of absolute zero, calculation of absolute entropy of molecules, concept of residual entropy, calculation of absolute entropy of solid, liquid and gases.

UNIT – 5: Systems of Variable Composition (2 Weeks)

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

Practical

Thermochemistry:

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

Any other experiment carried out in the class.

Essential/recommended readings
Theory:

1. Peter, A.; Paula, J. de. (2011), **Physical Chemistry**, 9th Edition, Oxford University Press.
2. Castellan, G. W. (2004), **Physical Chemistry**, 4th Edition, Narosa.
3. Kapoor, K.L. (2015), **A Textbook of Physical Chemistry**, Vol 2, 6th Edition, McGraw Hill Education.
4. Kapoor, K.L., **A Textbook of Physical Chemistry**, Vol 3, 5th Edition, McGraw Hill Education.
5. McQuarrie, D. A.; Simon, J. D. (2004), **Molecular Thermodynamics**, Viva Books Pvt. Ltd.

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.

Suggestive readings

1. Levine, I.N. (2010), **Physical Chemistry**, Tata Mc Graw Hill.
2. Assael, M. J.; Goodwin, A. R. H.; Stamatoudis, M.; Wakeham, W. A.; Will, S. (2011), **Commonly asked Questions in Thermodynamic**s. CRC Press.

Annexure-4.01.50(i)
Item No. 4-1-50

INDEX

DEPARTMENT OF CHEMISTRY

Semester-III

Category-I
B Sc. (Hons) Chemistry

DISCIPLINE SPECIFIC CORE COURSE -7 (DSC-7): Chemistry of d- and f- block Elements & Quantitative Inorganic 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		
Chemistry of d- and f- Elements & quantitative Inorganic Analysis (DSC-7)	**04**	**02**	--	**02**	Class 12th with Physics, Chemistry, Mathematics	--

Learning 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 familiarize the students with the d- and f-block elements and get an idea about horizontal similarity in a period in addition to vertical similarity in a group.
- To impart the knowledge about inorganic polymer
- To give an idea about the principles of gravimetric analysis.

Learning outcomes

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

- List 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.
- Describe the classification, structure and applications of Inorganic Polymers.
- List and use the principles of gravimetric analysis for quantitative analysis

SYLLABUS OF DSC-7

UNIT – 1: Transition Elements (12 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

UNIT – 2: Lanthanoids and Actinoids (8 Hours)

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 – 3: Inorganic Polymer (8 Hours)

Comparison with organic polymers, classification, structure and applications of following inorganic polymers:

- Borates
- Silicates, silicones
- Phosphates
- Phosphazenes (for cyclic polymers, only trimer is to be discussed)

UNIT – 4: Principles of gravimetric analysis (2 Hours)

Particle size, Precipitation, Coagulation, Peptization, Co-precipitation, Digestion, Filtration and washing the precipitate, Drying and ignition the precipitate

Practical component Credits: 02

(Laboratory periods:15 classes of 4 hours each)

(A) Gravimetry

1. Estimation of Ni(II) using dimethylglyoxime (DMG).
2. Estimation of copper as CuSCN.
3. Estimation of iron as Fe_2O_3 by precipitating iron as $Fe(OH)_3$. (by homogeneous and heterogeneous method)
4. Estimation of Al(III) by precipitating with oxime and weighing as $Al(oxime)_3$ (aluminiumoxinate).

(B) 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

(**C) Paper chromatographic separation of following metal ions (minimum two should be done):**

1. Ni(II) and Co(II)
2. Cu(II) and Cd(II)
3. Fe(III) and Al(III)

Essential/recommended readings

Theory:

1. Lee, J.D.(2010),**ConciseInorganicChemistry**,WileyIndia.
2. Huheey,J.E.;Keiter,E.A.;Keiter;R.L.;Medhi,O.K.(2009),**InorganicChemistry-PrinciplesofStructureandReactivity**,PearsonEducation.
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. Chandrashekhar,V. (2005), **Inorganic and Organometallic Polymers** , 5th Edition, Springer Publications

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.

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

DISCIPLINE SPECIFIC CORE COURSE -8 (DSC-8): Carbonyls, Carboxylic acids, Amines, Nitro compounds, Nitriles, Isonitriles and Diazonium salts

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		
Carbonyls, Carboxylic Acids, Amines, Nitro Compounds, Nitriles, Isonitriles and Diazonium salts (DSC-8)	04	03	--	01	Class 12^{th} with Physics, Chemistry, Mathematics	

Learning objectives

The objectives of this course are as follows:

- To infuse students with the details of the chemistry of aldehydes, ketones, carboxylic acids and their derivatives, nitro, amines and diazonium salts.
- To make students aware of the chemical synthesis, properties, reactions and key applications of the listed classes of compounds and develop understanding of detailed mechanistic pathways for each functional group to unravel the spectrum of organic chemistry and the extent of organic transformations.
- To aid in the paramount learning of the concepts and their applications.

Learning outcomes

By studying this course, students will be able to:

- Explain the chemistry of oxygen and nitrogen containing compounds.
- Use the synthetic chemistry learnt in this course to do functional group transformations.
- Propose plausible mechanisms for the reactions under study.

SYLLABUS OF DSC-8

UNIT – 1: Carbonyls, Carboxylic acid & their derivatives (27 Hours)

Carbonyl Compounds: Reaction of carbonyl compounds with ammonia derivatives, Aldol and Benzoin condensation, Knoevenagel condensation, Claisen-Schmidt, Perkin, Cannizzaro and Wittig reaction, Beckmann and Benzil-Benzilic acid rearrangements, haloform reaction and Baeyer Villiger oxidation, α-substitution reactions, oxidations and reductions (Clemmensen, Wolff Kishner, $LiAlH_4$, $NaBH_4$, MPV, PDC), addition reactions of α,β-unsaturated carbonyl compounds: Michael addition.
Carboxylic acids and derivatives: Effect of substituents on acidic strength on carboxylic acids, HVZ reaction, typical reactions of dicarboxylic acids and hydroxy acids. Comparative study of nucleophilic acyl substitution for acid chlorides, anhydrides, esters and amides, Mechanism of acidic and alkaline hydrolysis of esters, Dieckmann and Reformatsky reactions, Hoffmann-bromamide degradation and Curtius rearrangement.
Active methylene compounds: Keto-enol tautomerism. Preparation and synthetic applications of diethyl malonate and ethyl acetoacetate.

UNIT – 2: **Nitro Compounds, Amines, Diazonium salts, Nitriles and Isonitriles (18 Hours)**

Nitro compounds: General methods of preparation: from alkyl halides, alkanes, oxidation of amines and oximes. Henry reaction, Nef reaction, Reduction-electrolytic reduction, reaction with nitrous acid, reduction in acidic, basic and neutral medium (for aromatic compounds)

Amines: Preparation**,** chirality in amines (pyramidal inversion), Basicity of amines: Effect of substituents, solvent and steric effects, distinction between Primary, secondary and tertiary amines using Hinsberg's method and nitrous acid, Gabriel Phthalimide synthesis, Carbylamine reaction, Mannich reaction, Hoffmann's exhaustive methylation, Hofmann-elimination reaction and Cope elimination.

Diazonium Salts**:** Synthetic applications of diazonium salts including preparation of arenes, haloarenes, phenols, cyano and nitro compounds; Coupling reactions of diazonium salts (preparation of azo dyes).

Nitriles: Preparation using following reactions: Dehydration of amides and aldoximes, substitution reaction in alkyl halides and tosylates, from Grignard reagents and from dehydrogenation of primary amines. Properties: Physical properties, discussion on the following reactions with mechanism: Reaction with Grignard reagent, hydrolysis, addition reaction with HX, NH_3, reaction with aqueous ROH, Reduction reactions-catalytic reduction and Stephen's reaction, Condensation reactions-Thorpe Nitrile Condensation.

Isonitriles: Preparation from the following reactions: Carbylamine reaction, substitution in alkyl halides and dehydrogenation of N-substituted formamides. Properties: Physical properties, discussion on the following reactions with mechanism: Hydrolysis, reduction, addition of– HX, X_2 and sulphur, Grignard reaction, oxidation and rearrangement.

Practical component **Credits: 01**
(Laboratory periods:15 classes of 2 hours each)

1. Preparation of oximes for aldehydes/ketones (like benzaldehyde, ethyl methyl ketone, cyclohexanone etc.)
2. Preparation of semicarbazone derivatives for aldehydes/ketones (like benzaldehyde, ethyl methyl ketone, cyclohexanone etc.)
3. Hydrolysis of amides/esters.
4. Selective reduction of *m*-dinitrobenzene to *m*-nitroaniline.
5. Preparation of S-benzylisothiouronium salts for water soluble and water insoluble carboxylic acids.
6. Systematic qualitative analysis of the given organic compounds containing monofunctional groups (aromatic hydrocarbons, alcohols, phenol) and preparation of one suitable derivative.

Students should be exposed to preparative routes for the synthesis of 3,5-dinitrobenzoate, benzoates, acetate derivatives.

Note: The above derivatives should be prepared using 0.5-1.0 g of the organic compound. The solid samples must be collected and may be used for recrystallization, melting point and compound analysis**.**

Essential/recommended readings

Theory:

1. Morrison, R. N., Boyd, R. N., Bhattacharjee, S.K. (2010), **Organic Chemistry**, 7th Edition, Dorling Kindersley (India) Pvt. Ltd., Pearson Education.
2. Finar, I.L. **Organic Chemistry** Volume 1, Dorling Kindersley (India) Pvt. Ltd., Pearson Education.
3. Finar, I.L. **Organic Chemistry** Volume 2, Dorling Kindersley (India) Pvt. Ltd., Pearson Education.
4. Solomons, T.W.G., Fryhle, C.B.; Snyder, S.A. (2017), **Organic Chemistry**, 12th Edition, Wiley.

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**, 5th 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.

Suggestive Readings

1. Mukherji, S.M., Singh, S.P. (2017), **Reaction Mechanism in Organic Chemistry**, Trinity Press.
2. Singh,J., Awasthi, S. K., Singh, Jaya, **Fundamentals of Organic Chemistry-III**, Pragati Prakashan (2023)
3. Carey, F.A., Sundberg, R. J. (2008), **Advanced Organic Chemistry: Part B: Reaction and Synthesis**, Springer.
4. Bruice, P.Y. (2015), **Organic Chemistry,** 3rd Edition, Pearson.
5. Patrick, G. (2003), **BIOS Instant Notes in Organic Chemistry**, Viva Books.

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

DISCIPLINE SPECIFIC CORE COURSE – 9 (DSC-9): Chemical equilibrium, Ionic equilibrium, conductance and solid state

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 equilibrium, Ionic equilibrium, conductance and solid state (DSC-9)	**04**	**03**	**-**	**01**	**Class XII with Physics, Chemistry and Mathematics**	

Learning Objectives:

The Learning Objectives of this course are as follows:

- To make students understand the concept of chemical equilibrium and ionic equilibrium.
- To introduce the concept of electrolytes, ionization of various electrolytes, pH.
- To explain the applications of ionization in buffer, hydrolysis, acid-base titrations and indicators.
- To introduce the concept of electrolytic conductance with respect to strong and weak electrolytes and then extend it to understand concepts like ionic mobility, transference and related properties.
- To develop the advance concept of solid state with emphasis on crystal structures in general and cubic crystals in details.

Learning Outcomes:

By studying this course, students will be able to:

- Apply the concept of equilibrium to various physical and chemical processes.
- Derive and express the equilibrium constant for various reactions at equilibrium.
- Use Le Chatelier's principle to predict the thermodynamic conditions required to get maximum yield of a reaction

- Apply the concept of equilibrium to various ionic reactions.
- List different types of electrolytes and their properties related to conductance in aqueous solutions.
- Use conductance measurements for calculating many properties of the electrolytes.
- Prepare buffer solutions of appropriate pH.
- Explain the crystal properties and predict the crystal structures of cubic systems form the XRD.
- Use the instruments like pH-meter and conductivity meters.

SYLLABUS OF DSC-9

UNIT – 1: Chemical Equilibrium (6 Hours)

Criteria of thermodynamic equilibrium, degree of advancement of reaction, Chemical equilibria in ideal gases, Thermodynamic derivation of relation between Gibbs free energy of a reaction and reaction quotient, Equilibrium constants and their dependence on temperature, pressure and concentration, Le Chatelier's Principle (Quantitative treatment), Free energy of mixing and spontaneity (qualitative discussion).

UNIT – 2: Ionic equilibrium (12 Hours)

Strong, moderate and weak electrolytes, Arrhenius theory of electrolytic dissociation, degree of ionization, factors affecting degree of ionization, ionization constant and ionic product of water. Ionization of weak acids and bases, pH scale, common ion effect; dissociation constants of mono and diprotic acids. Salt hydrolysis-calculation of hydrolysis constant, degree of hydrolysis and pH for different salts. Buffer solutions; derivation of Henderson equation and its applications. Solubility and solubility product of sparingly soluble salts – applications of solubility product principle. Qualitative treatment of acid – base titration curves. Theory of acid–base indicators; selection of indicators and their limitations.

UNIT – 3: Conductance (12 Hours)

Quantitative aspects of Faraday's laws of electrolysis, Conductivity, equivalent and molar conductivity and their variation with dilution for weak and strong electrolytes. Molar conductivity at infinite dilution. Kohlrausch's law of independent migration of ions. Debye-Huckel-Onsager equation, Wien effect, Debye-Falkenhagen effect, Walden's rule. Ionic velocity, mobility and their determination, transference number and its relation to ionic mobility, determination of transference number using Moving Boundary methods. Applications of conductance measurement: (i) degree of dissociation of weak electrolytes, (ii) ionic product of water (iii) solubility and solubility product of sparingly soluble salts, (iv) conductometric titrations (v) hydrolysis constants of salts.

UNIT – 4: Solid state (15 Hours)

Nature of the solid state, law of constancy of interfacial angles, law of rational indices, Miller indices, elementary idea of symmetry, seven crystal systems and fourteen Bravais lattices; X-ray diffraction, Bragg's law, a simple account of rotating crystal method and powder pattern method. Analysis of powder diffraction patterns of NaCl, CsCl and KCl.

Practical component Credit:01

(Laboratory periods: 15 classes of 2 hours each)

pH metry:

1. Study the effect of addition of HCl/NaOH on pH to the solutions of acetic acid, sodium acetate and their mixtures.
2. Preparation of buffer solutions of different pH values
   a. Sodium acetate-acetic acid
   b. Ammonium chloride-ammonium hydroxide
3. pH metric titration of
   a. Strong acid with strong base
   b. Weak acid with strong base. Determination of dissociation constant of a weak acid.

Conductometry:

1. Determination of cell constant
2. Determination of conductivity, molar conductivity, degree of dissociation and dissociation constant of a weak acid.
3. Perform the following conductometric titrations:
   a. Strong acid vs. strong base
   b. Weak acid vs. strong base
   c. Mixture of strong acid and weak acid vs. strong base
   d. Strong acid vs. weak base

p-XRD *(p-XRD crystal pattern to be provided to the students)*

1. Differentiate and classify the given set of the diffraction pattern as crystalline materials or amorphous (Glass) substance.
2. Carry out analysis of a given set of p-XRD and determine the type of the cubic crystal structure
   a. NaCl
   b. CsCl
   c. KCl
3. Determination of approximate crystal size from a given set of p-XRD

Essential/recommended readings

Theory

1. Peter, A.; Paula, J. de. (2011), **Physical Chemistry**, 9th Edition, Oxford University Press.

2. Castellan, G. W. (2004), **Physical Chemistry**, 4th Edition, Narosa.
3. Kapoor, K.L. (2015), **A Textbook of Physical Chemistry**, Vol 2, 6th Edition, McGraw Hill Education.
4. McQuarrie, D. A.; Simon, J. D. (2004), **Molecular Thermodynamics**, Viva Books Pvt. Ltd.
5. Kapoor, K.L. (2015),**A Textbook of Physical Chemistry**, Vol 1, 6th Edition, McGraw Hill Education.

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.

Suggestive readings

1. Levine, I.N. (2010), **Physical Chemistry**, Tata Mc Graw Hill.

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

ANNEXURE-4.02.03
AC-26.05.2023

DEPARTMENT OF CHEMISTRY
SEMESTER-IV

B Sc. (Hons) Chemistry

(with Chemistry as the Core Discipline)

DISCIPLINE SPECIFIC CORE COURSE - 10(DSC-10): Coordination Chemistry and Reaction Mechanism

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 Reaction Mechanism (DSC-10: Inorganic Chemistry - IV)	04	03	--	01	Class 12th with Physics, Chemistry, Mathematics	--

Learning Objectives

The Objectives of this course are as follows:

- To familiarize the students with coordination compounds which find manifold applications in diverse areas.
- To acquaint the student with the concept of Inorganic reaction mechanism.

Learning Outcomes

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

- Explain the terms- ligand, denticity of ligands, chelate, coordination number and use standard rules to name coordination compounds.
- Discuss the various types of isomerism possible in such 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 Δ_o, Δ_t, pairing energy, CFSE, high spin and low spin complexes and how CFSE affects thermodynamic properties like lattice enthalpy and hydration enthalpy.

- Explain magnetic properties and colour of complexes on the basis of Crystal Field Theory.
- Explain the reaction mechanism of coordination compounds and differentiate between kinetic and thermodynamic stability.

SYLLABUS OF DSC-10

Unit-1: Coordination Chemistry **(Lectures: 28)**

Werner's Coordination theory, simple problems based on this theory

IUPAC nomenclature of coordination compounds, isomerism in coordination compounds (coordination numbers 4 and 6). Valence bond theory and its application to complexes of coordination numbers 4 and 6.

Crystal field theory, measurement of Δ_o. Calculation of CFSE in weak and strong fields, concept of pairing energies, factors affecting the magnitude of Δ_o. Octahedral vs. tetrahedral coordination, tetragonal distortions from octahedral geometry: Jahn-Teller theorem, square planar geometry. Qualitative aspect of Ligand field and MO Theory (for octahedral σ-donor, π- acceptor and π- donor complexes).

Unit-2: Stability of complexes and Inorganic Reaction Mechanism: **(Lectures: 17)**

Brief discussion of thermodynamic and kinetic stability, Factors affecting stability of complexes, such as chelate effect, macrocyclic effect, resonance effect etc., trends in step wise formation constant, interpretation of lability and inertness based on VBT and CFT.

Introduction to inorganic reaction mechanisms, concept of reaction pathways, transition state, intermediate and activated complex. Substitution reactions in square planar complexes, factors affecting the rate of Substitution reactions in square planar complexes- such as charge effect, solvent effect and Trans- effect (Theories of trans-effect).

Practical component
Practical: **Credits: 01**
(Laboratory periods: 15 classes of 2 hours each)

(A) Argentometry

Estimation of Cl^-

(i) By Mohr's method

(ii) By Vohlard's method and

(iii) By Fajan's method

(B) Complexometric Titrations:

(i) Complexometric estimation of Mg^{2+}/ Zn^{2+} using EDTA

(ii) Estimation of total hardness of water samples

(iii) Estimation of Ca^{2+} in solution by substitution method

(iv) Estimation of Ca/Mg in drugs or biological samples**.**

(C) Properties of Complexes

Synthesis of ammine complexes of Ni(II) and its ligand exchange reactions (e.g. bidentate ligands like acetylacetone, dimethyl glyoxime, glycine) by substitution method.

Essential/recommended readings

Theory:

1. 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.
2. Miessler, G.L.; Fischer P.J.; Tarr, D. A. (2014), **Inorganic Chemistry**, Fifth Edition, Pearson.
3. Huheey, J.E.; Keiter, E.A.; Keiter; R. L.; Medhi, O.K. (2009), **Inorganic Chemistry-Principles of Structure and Reactivity**, Pearson Education.
4. Pfennig, B. W. (2015), **Principles of Inorganic Chemistry,** John Wiley & Sons.
5. Cotton, F.A.; Wilkinson, G.(1999), **Advanced Inorganic Chemistry,** Wiley-VCH.
6. Sodhi G.S. (2018), **Principles of Inorganic Chemistry,** 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. 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.

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

DISCIPLINE SPECIFIC CORE COURSE -11 (DSC-11): Carbohydrates, Lipids and Heterocyclic 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		
Carbohydrates, Lipids and Heterocyclic Compounds (DSC-11, Organic Chemistry IV)	04	03	--	01	Class 12th with Physics, Chemistry	--

Learning Objectives

The Objectives of this course are as follows:

- To familiarize students with the chemistry of carbohydrates, lipids, and heterocyclic compounds
- To enable students to develop novel, efficient, convenient, selective and environmentally benign synthetic methods for synthesis of heterocyclic compounds.

Learning outcomes

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

- Describe uses and applications carbohydrates, lipids and heterocycles
- Use the knowledge gained from study of carbohydrates, lipids and heterocycles to propose greener and better synthetic routes.
- Use the chemistry and biology of carbohydrates, lipids and heterocycles to better serve the mankind.

SYLLABUS OF DSC-11

Unit-1: Carbohydrates & Lipids (Lectures: 24)

Monosaccharides: Constitution and absolute configuration of glucose and fructose, epimers and anomers, mutarotation, determination of ring size of glucose and fructose, Haworth projection and conformational structures; Interconversion of aldoses and ketoses; Killiani-Fischer synthesis and Ruff degradation; Linkage between monosaccharides: Comparative study of the structure of disaccharides (sucrose, maltose, lactose) and polysaccharides (starch, cellulose and glycogen) excluding their structure elucidation. Reactions of disaccharides-reducing property, hydrolysis, methylation and acetylation.
Lipids: Introduction to lipids, classification. Oils and fats: Common fatty acids present in oils and fats, Omega-3&6 fatty acids, trans fats, hydrogenation, hydrolysis, acid value, saponification value, iodine number. Biological importance of triglycerides, phospholipids, glycolipids, and steroids (cholesterol).

Unit-2: Heterocyclic Compounds (Lectures:21)

Classification and nomenclature of heterocyclic compounds (containing only one hetero atom). Structure, aromaticity in 5-membered and 6-membered rings containing one heteroatom; Basicity and relative reactivity towards electrophilic substitution reactions (amongst five membered and six membered rings.

General methods of synthesis for: furan, thiophene, pyrrole (Paal-Knorr synthesis, Hantzsch synthesis), pyridine (Hantzsch synthesis), indole (Fischer Indole synthesis), quinoline (Skraup synthesis, Friedlander's synthesis, Knorr quinoline synthesis, Doebner-Miller synthesis)

Properties: Physical properties, discussion on the following reaction (with mechanism) for furan, pyrrole, thiophene, pyridine, indole and quinoline: Electrophilic substitution- nitration, sulphonation, halogenation, formylation, acylation, mercuration and carboxylation. Oxidation, reduction, addition, reactions showing acidic /basic character, reaction with diazonium salts, ring opening, ring expansion and nucleophilic substitution reaction wherever applicable should be discussed.

Practical: Credits: 01
(Laboratory periods: 15 classes of 2 hours each)

1. Estimation of sugars by using Fehling solution.
2. Functional group tests for amine, nitro and amides.
3. Determination of saponification value of the given oil.
4. Determination of iodine number of the given oil.
5. Systematic qualitative analysis of the given organic compounds containing monofunctional groups (carboxylic acids, carbonyl compounds, carbohydrates and esters) and preparation of one suitable derivative.

Essential/recommended readings

Theory:

1. Berg, J.M., Tymoczko, J.L., Stryer, L. (2019), **Biochemistry**, 9th Edition W.H. Freeman and Co.
2. Nelson, D.L., Cox, M.M., Lehninger, A.L. (2017), **Principles of Biochemistry**. W.H. Freeman and Co., International Edition.
3. Morrison, R. N., Boyd, R. N., Bhattacharjee, S.K. (2010), **Organic Chemistry**, 7th Edition, Dorling Kindersley (India) Pvt. Ltd., Pearson Education.
4. Parashar, R.K., Negi, B. (2016) **Chemistry of Heterocyclic Compounds**, Ane Books Pvt Ltd.
5. Kuashik, S., Singh, A. (2023), **Biomolecules: From Genes to Proteins**, Ist Edition, Berlin, Boston: De Gruyter.
6. Finar, I.L., (2012), **Organic Chemistry** Volume 1, 6th Edition, Pearson Education.
7. Singh J, Awasthi S K, Singh J, **Fundamentals of Organic Chemistry**, Pragati Prakashan Meerut.

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. Ahluwalia, V.K., Dhingra, S. (2004), **Comprehensive Practical Organic Chemistry: Qualitative Analysis**, University Press.
4. Ahluwalia, V.K., Aggarwal, R. (2004), **Comprehensive Practical Organic Chemistry: Preparation and Quantitative Analysis**, University Press
5. Pasricha, S., Chaudhary, A. (2021), **Practical Organic Chemistry: Volume–I**, I K International Publishing house Pvt. Ltd, New Delhi
6. 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 CORE COURSE-12 (DSC-12): Electrochemical Cells, Chemical Kinetics and Catalysis

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		
Electrochemical Cells, Chemical Kinetics and Catalysis (DSC-12, Physical Chemistry IV)	04	03	--	01	Class 12th with Physics, Chemistry, Mathematics	--

Learning Objectives

The Objectives of this course are as follows:

- To provide a detailed understanding about galvanic cells and their types
- To explain the applications of galvanic cells and EMF measurements.
- To get an understanding of the kinetics of simple and complex chemical reactions
- To give basic concept about catalysts and enzymes.
- To teach the working of potentiometer and different electrodes for performing potentiometric titrations
- To explain the experimental study of kinetics of simple reactions

Learning outcomes

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

- Explain the working of electrochemical cells and different types of galvanic cell.
- Devise a spontaneous galvanic cell using various combinations of half-cells.
- Understand the concept of concentration cell
- Use the appropriate galvanic cell to measure pH, calculate thermodynamic parameters and perform potentiometric titrations.
- Write rate law and derive rate equations for simple and complex reactions and understanding of theories of reaction rates.
- Understand different types of catalysts and mechanism of enzyme catalysis.
- Perform potentiometric titrations using appropriate electrodes for quantitative analysis.
- Set up experiments to study the kinetics of simple reactions.

SYLLABUS OF DSC-12

Unit-1: Electrochemical Cells **(Lectures: 21)**

Rules of oxidation/reduction of ions based on half-cell potentials, Chemical cells, reversible and irreversible cells with examples. Electromotive force of a cell and its measurement, Nernst equation; Standard electrode (reduction) potential and its application to different kinds of half-cells. Application of EMF measurements in determining (i) free energy, enthalpy and entropy of a cell reaction, (ii) equilibrium constants, and (iii) pH values, using hydrogen, quinone-hydroquinone, glass and SbO/Sb_2O_3 electrodes. Concentration cells with and without transference, liquid junction potential; determination of activity coefficients and transference numbers. Qualitative discussion of potentiometric titrations (acid-base, redox, precipitation). Structure of electric double layer (qualitative aspects only).

Unit-2: Chemical Kinetics **(Lectures: 18)**

Order and molecularity of a reaction, rate laws in terms of the advancement of a reaction, differential and integrated form of rate expressions up to second order reactions, experimental methods for determination of rate laws, kinetics of complex reactions (integrated rate expressions up to first order only): (i) Opposing reactions (ii) parallel reactions and (iii) consecutive reactions and their differential rate equations (steady-state approximation in reaction mechanisms) (iv) chain reactions.

Temperature dependence of reaction rates; Arrhenius equation; activation energy. Collision theory of reaction rates, Lindemann mechanism, qualitative treatment of the theory of absolute reaction rates, introduction to electrode kinetics (qualitative aspects only).

Unit-3: Catalysis: **(Lectures: 6)**

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

Practical: **Credits: 01**

(Laboratory periods: 15 classes of 2 hours each)

(A) Potentiometry:

Perform the following potentiometric titrations:

1. Strong acid vs. strong base
2. Weak acid vs. strong base
3. Dibasic acid vs. strong base
4. Mixture of strong and weak acid vs strong base
5. Potassium dichromate vs. Mohr's salt

(B) Chemical Kinetics:

Study the kinetics of the following reactions

1. Iodide-persulphate reaction by Initial rate method
2. Acid hydrolysis of methyl acetate with hydrochloric acid.
3. Saponification of ethyl acetate by conductometric measurements.

Suggested experiments

1. To study the kinetics of Iodide-persulphate reaction using integrated rate method.
2. Comparison of the strengths of HCl and H_2SO_4 by studying kinetics of hydrolysis of methyl acetate.

Essential/recommended readings
Theory:

1. Atkins, P.W.; Paula, J.de. (2014), **Atkin's Physical Chemistry Ed**., 10th Edition, Oxford University 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 3, 6th Edition, McGraw Hill Education.
5. Kapoor, K.L. (2015), **A Textbook of Physical Chemistry**, Vol 5, 3rd Edition, McGraw Hill Education.
6. Laidler K.J. (2003), **Chemical Kinetics**, 3rd Edition, Pearson Education India.

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

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

SEMESTER-V

BSC. (HONS.) CHEMISTRY

DISCIPLINE SPECIFIC CORE COURSE -13 (DSC-13): Basics of Organometallic 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		
Basics of Organometallic Chemistry (DSC-13)- Inorganic Chemistry-V	04	03	--	01	Class 12th with Physics, Chemistry, Mathematics	-

Learning Objectives

The Objectives of this course are as follows:

- To familiarize the students with the interactions of metal atom with organic molecules (or not so typical organic molecule), which is in an entirely different fashion as compared to coordination compounds.
- To familiarize the students with the structure and bonding in organometallic compounds
- To familiarize the student with how organometallic compounds can act as good catalysts for organic transformations and hencehave industrial importance associated with medicines, bioorganic synthesis, and energy production.

Learning Outcomes

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

- Identify and classify organometallic compounds of different types.
- Explain the stability of organometallic compounds and hence the requirement of special experimental conditions for their synthesis.
- Explain the bonding modes through VBT and MOT in these compounds.
- Explain the chemical nature of these compounds through various reactions thus acquiring skills to understand their applications.
- Explain the mechanism of catalysis by these compounds. This may prepare the student to predict the catalytic pathways for new reactions

SYLLABUS OF DSC-13

Unit-1: Introduction to Organometallic Chemistry (Lectures: 6)

Definition**,** brief history, classification of organometallic compounds on the basis of bond type. Common notation used in organometallic chemistry, concept of hapticity of organic ligands, importance of organometallic chemistry, organometallic compounds as reagents, additives, and catalysts. Introduction to the 18-electron rule or effective atomic number rule, electron count of mononuclear, polynuclear and substituted metal carbonyls of 3d series and finding metal-metal bonds.

Unit-2: Structure and Bonding in Organometallic Compounds (Lectures: 12)

Structures of mononuclear and binuclear carbonyls of Cr, Mn, Fe, Co and Ni using VBT.

Molecular orbital theory applied to organometallic compounds, description of bonding of two electron ligands to transition metals. π-acceptor behavior of CO (MO diagram of CO to be discussed), π-bonding of CO with metal (synergic effect) and use of IR data to explain extent of back bonding, bonding modes of CO, symmetry of metal carbonyls.

Bonding between metal atoms and organic π- systems: linear (ethylene, allyl, butadiene) and cyclic (cyclopentadiene, benzene), Zeise's salt and comparison of synergic effect with that in carbonyls.

Metal alkyls and Metal-carbene complexes

Unit-3: Synthesis, Reactions and Applications of Organometallic Compounds (Lecture: 16)

General methods of synthesis of metal carbonyls: direct carbonylation, reductive carbonylation, thermal and photochemical decomposition, of mono and binuclear carbonyls of 3d series.

Reaction of metal carbonyls: reduction, oxidation, photochemical substitution, migratory insertion of carbonyls, and nucleophilic addition of CO.

Synthesis of metal-alkene complexes through ligand addition, reduction and substitution and reaction of metal bound alkenes, Zeise's salt

Metal–sandwich compounds**:** Ferrocene: synthesis, physical properties and reactions: acylation, sulfonation, alkylation metallation, acetylation, chloromercuration, Mannich reaction, comparison of aromaticity and reactivity of ferrocene with that of benzene.

Synthesis and reactions of Metal alkyls and Metal-carbenes

Unit-4: Catalysis by Organometallic Compounds (Lectures: 11)

General principles of catalysis, properties of catalysts, homogeneous and heterogeneous catalysis. (Catalytic steps, examples and industrial applications), deactivation and regeneration of catalysts, (catalytic poisons and promoter).

Organometallic catalysis of the following reactions of commercial importance and their mechanism:

1. Alkene hydrogenation (using Wilkinson's Catalyst)
2. Synthetic gasoline preparation (Fischer Tropsch reaction)
3. Polymerisation of ethene using Ziegler-Natta catalyst
4. Wacker oxidation process (Smidth process)
5. Hydroformylation reaction (Oxo-process)
6. Monsanto Acetic Acid process

Theoretical aspects of enlisted practicals are also to be included in the theory paper.

Practical component

Practical: **Credits: 01**
(Laboratory periods: 15 classes of 2 hours each)

1. To study and compare the UV-Vis spectrum of ferrocene (in methanol or acetonitrile) and potassium ferrocyanide (in water).
2. To study the cyclic voltammogram of ferrocene.
3. Preparation of Bis(acetylacetonato)copper(II) complex and characterisation through UV-Visible spectrum of its aqueous solution..
4. Preparation of tris(acetylacetonato)manganese(III) complex.
5. Preparation of Potassium tris(oxalato)ferrate(III) complex.
6. Preparation of Tetraamminecopper(II) sulphate monohydrate complex.
7. Preparation of Pentaamminechloridocobalt(III) chloride.
8. Preparation of Hexaamminecobalt(III) chloride
9. Determination of number of chloride ions in ionisation sphere to confirm the formula of complexes prepared in (6) and (7) through potentiometric titration or conductance measurements. (See reference 5 & 6 of Practicals)
10. Compare and interpret the visible spectrum of complexes prepared in (6) and (7) for shifts in wavelength maxima.

Any other organometallic compounds synthesised from time to time may also be included.

Essential/recommended readings

Theory:

1. Gary L Miesler, Paul J Ficsher, and Donald A Tarr, **Inorganic Chemistry** 5th Edition , Pearson.
2. Shriver & Atkins **Inorganic Chemistry,** Edn V, W.H. Freeman and Company.
3. F.A. Cotton & G. Wilkinson, Advanced Inorganic Chemistry, 5th Edition.
4. William W. Porterfield, Inorganic Chemistry, Ist Edition.
5. Huheey, J.E.; Keiter, E.A., Keiter; R. L.; Medhi, O.K. (2009), **Inorganic Chemistry-Principles of Structure and Reactivity**, Pearson Education.
6. Principles of Organometallic Chemistry by M.L.H Green, Coward, G.E Coates and K.Wade 3rd Edition.
7. Cotton, F.A.; Wilkinson, G.; Gaus, P.L. **Basic Inorganic Chemistry**, 3rd Edition, Wiley India.
8. Greenwood, N.N.; Earnshaw, A. (1997), **Chemistry of the Elements**, 2nd Edition, Elsevier.
9. Gupta, B. D., Elias, A. J., (2013) **Basic Organometallic Chemistry: Concepts, Syntheses and Applications,** 2nd Edition, Universities Press.

Practicals:

1. ChemTexts (2020) 6:22, https://doi.org/10.1007/s40828-020-00119-6
2. J. Chem Education: 1971, Volume 48(2), 133
3. Front. Chem. Sci. Eng. 2013, 7(3): 329–337, DOI 10.1007/s11705-013-1339-0
4. Orbital: Electron. J. Chem. 2019, 11 (6): 348-354
6. Vogel's text book of quantitative chemical analysis. Edn V

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

DISCIPLINE SPECIFIC CORE COURSE - 14 (DSC-14): Nucleic Acids, Amino Acids, Proteins and Enzymes

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		
Nucleic Acids, Amino Acids, Proteins and Enzymes (DSC-14, Organic Chemistry-V)	**04**	**02**	**--**	**02**	Class 12th with Physics, Chemistry	**--**

Learning Objectives

The objectives of this course are as follows:

- To familiarize students with the fascinating chemistry and biology of biomolecules, *i.e.*, nucleic acids and proteins etc..
- To develop the interest of students in the basic concepts of heredity, which are imparted through replication, transcription, and translation processes.
- To discuss basic fundamentals of enzyme action and inhibition, which forms the basis of drug action.

Learning outcomes

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

- Demonstrate how structure of biomolecules determines their reactivity and biological role.
- Gain insight into concepts of heredity through the study of genetic code, replication, transcription, and translation
- Demonstrate basic understanding of enzyme action and role of inhibitors
- Use knowledge gained to solve real world problems.

SYLLABUS OF DSC-14

Unit-1: Nucleic Acids **(Lectures: 8)**

Structure of components of nucleic acids: Bases, Sugars, Nucleosides and Nucleotides. Nomenclature of nucleosides and nucleotides, structure of polynucleotides (DNA and RNA) and factors stabilizing them, biological roles of DNA and RNA; Concept of heredity: Genetic Code, Replication, Transcription and Translation.

Unit-2: Amino Acids, Peptides and Proteins **(Lectures: 14)**

Amino acids and their classification; α-amino acids - Synthesis, ionic properties, and reactions. zwitterions, pKa values, isoelectric point, and electrophoresis; Study of peptides: determination of their primary structure-end group analysis; Synthesis of peptides using N-protecting, C-protecting and C-activating groups, Solid-phase synthesis; Overview of primary, secondary and tertiary structures of proteins, protein denaturation.

Unit-3: Enzymes **(Lectures: 8)**

Introduction, classification, and characteristics of enzymes. Salient features of active site of enzymes. Mechanism of enzyme action (taking trypsin as an example), factors affecting enzyme action, coenzymes, and cofactors (including ATP, NAD, FAD), specificity of enzyme action (including stereospecificity). Enzyme inhibitors and their importance, phenomenon of inhibition (competitive, uncompetitive, and non-competitive inhibition including allosteric inhibition).

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

1. Study of the titration curve of glycine.
2. Estimation of glycine by Sorenson Formol Titration
3. Qualitative analysis of proteins- Ninhydrin test, Biuret test, Millon's reagent test, Xanthoproteic test.
4. Estimation of proteins by Lowry's method.
5. Study of the action of salivary amylase on starch at room temperature.
6. Effect of temperature on the action of salivary amylase.
7. Effect of pH on the action of salivary amylase
8. Study the inhibition of α-Amylase by copper sulphate
9. Isolation and estimation of DNA using cauliflower/onion.

Essential/recommended readings

Theory:

1. Berg, J.M., Tymoczko, J.L., Stryer, L. (2019), **Biochemistry**, Nineth Edition W.H. Freeman and Co.
2. Nelson, D.L., Cox, M.M., Lehninger, A.L. (2017), **Principles of Biochemistry**. W.H. Freeman and Co., International Edition.

3. Murray, R.K., Granner, D.K., Mayes, P.A., Rodwell, V.W. (2009), **Harper's Illustrated Biochemistry**. Lange Medical Books/McGraw-Hill.
4. Brown, T.A. (2018), **Biochemistry**, (First Indian Edition) Viva Books.
5. Kuashik, S., Singh, A. (2023), **Biomolecules: From Genes to Proteins**, First Edition, Berlin, Boston: De Gruyter.
6. Voet, D., Voet, J.G. (2010), **Biochemistry**, Fourth Edition, Wiley.
7. Singh J, Awasthi S K, Singh J, **Fundamentals of Organic Chemistry**, Pragati Prakashan Meerut.

Additional Resources:

1. Finar, I.L. (2008), **Organic Chemistry**, Volume 2, Fifth Edition, Pearson Education.
2. Bruice, P.Y. (2020), **Organic Chemistry,** Egighth Edition, Pearson Education.

Practicals:

1. **Manual of Biochemistry Workshop** (2012), Department of Chemistry, University of Delhi.
2. Kumar, A., Garg, S., Garg, N. (2015), **Biochemical Tests: Principles and Protocols**. Viva Books.
3. 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 CORE COURSE-15 (DSC-15): Quantum Chemistry and Organic Chemistry IV Covalent bonding

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 Covalent bonding (DSC-15, Physical Chemistry V)	**04**	**03**	**--**	**01**	**Class 12th with Physics, Chemistry, Mathematics**	

Learning objectives

The objectives of this course are as follows:

- To make students understand the limitations of classical mechanics and the need of quantum chemistry
- 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 hydrogen atom and hydrogen like atoms.
- To explain the valence bond and molecular orbital theories and their applications to simple molecules
- To explain the use of some computational software

Learning outcomes

By studying this course, students will be able to:

- Explain the limitations of classical mechanics and solution in terms of quantum mechanics for atomic/molecular systems.
- Develop an understanding of quantum mechanical operators, quantization, probability distribution, uncertainty principle
- Set up Schrodinger equations for different types of systems
- Explain the concept of covalent bonding based on valence bond theory and molecular orbital theory.
- Perform calculations using different software and plot different wavefunctions and probability distribution curves.
- Perform simple calculations using appropriate quantum mechanical methods in different computational software

SYLLABUS OF DSC-15

Unit-1: Quantum Chemistry **(Lectures: 22)**

Postulates of quantum mechanics, quantum mechanical operators and commutation rules, Schrödinger equation and its application to free particle and particle in a box rigorous treatment), quantization of energy levels, zero-point energy and Heisenberg Uncertainty principle; wave functions, probability distribution functions, nodal properties, Extension to two and three- dimensional boxes, separation of variables, degeneracy.

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

Angular momentum. Rigid rotator model of rotation of diatomic molecule. Schrödinger equation in Cartesian and spherical polar coordinates (derivation not required). Separation of variables. Spherical harmonics. Discussion of solution (Qualitative).

Unit-2: Hydrogen atom **(Lectures: 08)**

Qualitative treatment of hydrogen atom and hydrogen-like ions: setting up of Schrödinger equation in spherical polar coordinates, radial part and quantization of energy (only final energy expression). Average and most probable distances of electron from nucleus. Zeeman effect, Introduction of spin quantum number and magnetic spin quantum number Setting up of Schrödinger equation for many electron atoms (He, Li), Indistinguishability of electrons and Pauli exclusion principle, Need for approximation methods. Statement of variation theorem and application to simple systems (particle-in-a-box, harmonic oscillator, hydrogen atom).

Unit-3: Covalent bonding **(Lectures: 15)**

Setting up of Schrödinger equation, Born-Openheimer approximation, LCAO-MO treatment of H_2^+ and its qualitative extension to H_2, Valence bond (VB) treatment of H_2, Comparison of LCAO-MO and VB wave functions of H_2 and their refinements, Qualitative description of LCAO-MO of homonuclear and heteronuclear diatomic molecules-HF and LiH.

Practical component

Practical: **Credits: 01**

(Laboratory periods: 15 classes of 2 hours each)

1. Plot the radial wavefunctions and probability distribution for H atom's 1s, 2s, 2p orbital using software like EXCEL.
2. Using a software such as ArgusLab, plot HOMO, LUMO and ESP maps of various molecules.
3. 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 correlate them with the correspondence principle.
4. Plot the electron density contour maps of sigma molecular orbitals for diatomic homonuclear molecules.
5. Plotting of the wave function and probability curve for simple harmonic motion and interpret the results for first two levels.

6. Plotting energy as a function of distance for simple harmonic motion - parabolic curve.
7. Using software such as ArgusLab calculate properties such as dipole moment and Mulliken charges using quantum mechanical methods.

Note: Any other suitable software may also be used .

Essential/recommended readings

Theory:

1. Kapoor, K.L. (2015), **A Textbook of Physical Chemistry**, McGraw Hill Education, Vol 4, 5th Edition, McGraw Hill Education.
2. House, J.E. (2004), **Fundamentals of Quantum Chemistry**, 2nd Edition, Elsevier.
3. McQuarrie, D.A. (2016), **Quantum Chemistry**, Viva Books.
4. Chandra, A. K. (2001), **Introductory Quantum Chemistry**, Tata McGraw-Hill.
5. House, J.E. (2004), **Fundamentals of Quantum Chemistry**, 2nd Edition, Elsevier

Suggested Readings

1. Atkins, P.W.; Friedman, R. (2010), **Molecular Quantum Mechanics**, 5th Edition, Oxford University Press.

Practical:

1. McQuarrie, D. A. **Mathematics for Physical Chemistry** University Science Books (2008).
2. Mortimer, R. **Mathematics for Physical Chemistry**. 3rd Ed. Elsevier (2005).
3. Steiner, E**. The Chemical Maths Book** Oxford University Press (1996).
4. Yates, P. **Chemical Calculations**. 2nd Ed. CRC Press (2007).
5. Levie, R. de, **How to use Excel in analytical chemistry and in general scientific data analysis**, Cambridge Univ. Press (2001) 487 pages.
6. Noggle, J. H. **Physical Chemistry on a Microcomputer**. Little Brown & Co. (1985).

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

Pool of DSE for III/IV/V/VI Semester

1. Inorganic Materials of Industrial Importance
2. Green Chemistry in Organic Synthesis
3. Solutions, Colligative properties, Phase Equilibria and adsorption
4. Nuclear and Environmental Chemistry
5. Reactions, Reagents and Chemical Process
6. Polymers, Colloids, Surfaces and Interfaces
7. Novel Inorganic Solids
8. Applied Organic Chemistry
9. Applications of Computers in Chemistry
10. Analytical Methods in Chemistry
11. Basic Principles of Food Chemistry
12. Computational Methods & Molecular Modelling
13. Research Methodology for Chemists

POOL OF DSE FOR III/IV/V/VI SEMESTER

DISCIPLINE SPECIFIC ELECTIVE COURSE - 1 (DSE-1): 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		
Inorganic Materials of Industrial Importance (DSE-1)	**04**	**03**	**--**	**01**	Class 12th with Physics, Chemistry	--

Learning Objectives

The objectives of this course are as follows:

- To make students understand the diverse roles of inorganic materials in the industry and to give an insight into how these raw materials are converted into products used in day-to-day life.
- To make students learn about silicates, fertilizers, surface coatings, batteries, engineering materials for mechanical construction.
- To develop the interest of students in the frontier areas of inorganic and material chemistry.

Learning outcomes

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

- State the composition and applications of the different kinds of glass.
- State the composition of cement and discuss the mechanism of setting of cement.
- Defend the suitability of fertilizers for different kinds of crops and soil.
- Explain the process of formulation of paints and the basic principle behind the protection offered by the surface coatings.
- Describe the principle, working and applications of different batteries.
- Evaluate the synthesis and properties of nano-dimensional materials, various semiconductor and superconductor oxides.

SYLLABUS OF DSE-1

Unit 1: Silicate Industries **(2 Weeks)**

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.

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 (2 Weeks)

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

Unit 3: Surface Coatings (6 Weeks)

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.

Unit 4: Batteries (3 Weeks)

Primary and secondary batteries, characteristics of an Ideal Battery, principle, working, applications and comparison of the following batteries: Pb- acid battery, Li-metal batteries, Li-ion batteries, Li-polymer batteries, solid state electrolyte batteries, fuel cells, solar cells and polymer cells.

Unit 5: Nano dimensional materials (2 Weeks)

Introduction to zero, one and two-dimensional nanomaterial: Synthesis, properties and applications of fullerenes, carbon nanotubes, carbon fibres, semiconducting and superconducting oxides.

Practical component

Practicals: Credits:

01 (Laboratory periods:15 classes of 2 hours each)

(At least four experiments to be performed)

1. Detection of constituents of Ammonium Sulphate fertilizer (Ammonium and Sulphate ions) by qualitative analysis and determine its free acidity.

2. Detection of constituents of CAN fertilizer (Calcium, Ammonium and Nitrate ions) fertilizer and estimation of Calcium content.

3. Detection of constituents of Superphosphate fertilizer (Calcium and Phosphate ions) and estimation of phosphoric acid content.

4. Analysis of (Cu, Ni) in alloy or synthetic samples (methods involving Gravimetry and Spectrophotometry).

5. Analysis of (Cu, Zn) in alloy or synthetic samples (Multiple methods involving Iodometry, and Potentiometry).

6. Synthesis of pure ZnO and Cu doped ZnO nanoparticles.

7. Synthesis of silver nanoparticles by green and chemical approach methods and its characterization using UV-visible spectrophotometer

Essential/recommended readings

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. Atkins, P.W.; Overton, T.L.; Rourke, J.P.; Weller, M.T.; Armstrong, F.A.(2010),**Shriver and Atkins Inorganic Chemistry**, W. H. Freeman and Company.
4. Kent, J. A. (ed**)** (1997), **Riegel's Handbook of Industrial Chemistry**, CBS Publishers, New Delhi.
5. Poole Jr.; Charles P.; Owens, Frank J.(2003), **Introduction to Nanotechnology**, John Wiley and Sons.

Practical:

1. Svehla, G.(1996),**Vogel's Qualitative Inorganic Analysis**, Prentice Hall.
2. Banewicz, J. J.; Kenner, C.T. **Determination of Calcium and Magnesium in Limestones and Dolomites**, Anal. Chem., 1952, 24 (7), 1186–1187.
3. Ghorbani, H. R.; Mehr, F.P.; Pazoki, H.; Rahmani B. M. **Synthesis of ZnO Nanoparticles by Precipitation Method.** Orient J Chem 2015;31(2).
4. 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.

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

DISCIPLINE SPECIFIC ELECTIVE COURSE – 2 (DSE-2): Green Chemistry in Organic Synthesis

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		
Green Chemistry in Organic Synthesis (DSE-2)	04	03	--	01	Class 12^{th} with Physics, Chemistry	Basic knowledge of organic reactions

Learning objectives

The objectives of this course are as follows:

- To create awareness about the chemistry that is not harmful for human health and the environment.
- To provide thorough knowledge of the green chemistry principles that can be used to develop chemistry in greener way.
- To familiarize students with new remediation technologies for the cleaning up of hazardous substances.
- To use green chemistry for boosting profits, increase productivity and ensure sustainability with absolute zero waste.
- To learn about innovations and applications of green chemistry in education that helps companies to gain environmental benefits as well as to achieve economic and societal goals also
- The objective of the practical component is to develop basic skills to be able to design, develop and run chemical processes in a sustainable way.

Learning outcomes

By studying this course, students will be able to:

- List the twelve principles of green chemistry and 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
- State the uses of catalyst over stoichiometric reagents

- Debate and use green solvents, renewable feedstock, and renewable energy sources for carrying out safer chemistry
- Use green chemistry for problem solving, innovation and finding solutions to environmental problems.
- Design safer processes, chemicals, and products through understanding of inherently safer design (ISD)
- Discuss the success stories and use real-world cases to practice green chemistry

SYLLABUS OF DSE-2

UNIT – 1: Introduction **(1 Week)**

Introduction to Green Chemistry, some important environmental laws, pollution prevention Act of 1990, emergence of green chemistry, need for Green Chemistry. Goals of Green Chemistry. Limitations/ Obstacles in the pursuit of the goals of Green Chemistry. Green chemistry in sustainable development.

UNIT – 2: **Application of Green Chemistry Principles** **(12 Weeks)**

Principles of Green Chemistry and designing a chemical synthesis
Concept familiarization and application of green chemistry principles using specific examples

1. Prevention of waste/ by products; waste or pollution prevention hierarchy
2. Green metrics to assess greenness of a reaction: Calculation of atom economy of the rearrangement, addition, substitution, and elimination reactions; calculation of E-factor for industrial processes
3. Prevention/ minimization of hazardous/ toxic products
4. Safer Solvent and Auxiliaries: Problems associated with conventional reaction media Some Common Green solvents: Introduction, application, advantages, and disadvantages of green solvents in organic synthesis (taking suitable examples). Special emphasis on the following:
   i. Super Critical Fluids (with special reference to carbon dioxide)
   ii. Water: Concept of In-water, and on-water reactions (with special reference to synthesis of terpinol and linalool in water, Benzoin condensation, Heck reaction)
   iii. Ionic Liquids: Physical properties and classification of Ionic Liquids (with special reference to Diels Alder reaction and Coumarin synthesis in ionic liquids)
   iv. Biomass derived Solvents: Physicochemical properties, Use of glycerol and its derivatives (Mizoroki–Heck reaction) and 2-methyltetrahydrofuran (Suzuki–Miyaura reaction).
5. Design for energy efficiency: Phenomenon of accelerating organic reactions by using the following Green Chemistry tools (taking suitable examples) and its advantages:
   i. Mechanochemistry
   ii. Ultrasound assisted reactions: Taking examples like Simmons Smith reaction, Diels–Alder reaction,
   iii. Microwave assisted reactions: Special emphasis on solvent-free synthesis- copper phthalocyanine and aspirin, In-water reactions-Hofmann Elimination, methyl benzoate to benzoic acid and Decarboxylation reaction;
   iv. Electrocatalysis: Taking examples like adiponitrile synthesis, synthesis of 3-bromothiophene.

v. Visible light induced Reactions: with examples such as, syntheses of caprolactam and vitamin D_3, cis-trans isomerization of alkenes

6. Use of renewable starting materials: Illustrate with few examples such as biodiesel, bioethanol, polymers from renewable resources (PLA from corn), Synthesis and properties of 2-Methyltetrahydrofuran, furfural and 5-Aminolevulinic acid (DALA) from levulinic acid
7. Avoidance of unnecessary derivatization – careful use of blocking/protecting groups (taking specific examples like selective oxidation of aldehydic group and synthesis of 6-Aminopenicillanic Acid (6-APA) from penicillin G
8. Catalysis and green chemistry
   Introduction to Catalysis (including concept of selectivity, turnover frequency and turnover number), Types of Catalysts: Heterogeneous catalysis and homogeneous catalysis (H-beta and zeolites in organic synthesis), General catalytic cycle for heterogeneous catalysis; Asymmetric catalysis (Monsanto route to L-dopa via asymmetric hydrogenation, synthesis of carbapenhem via Asymmetric reduction); Photocatalysis (with special reference to TiO2); Biocatalysis (Synthesis of adipic acid/catechol using biocatalyst) and Nanocatalysis (oxazole synthesis using nanocatalyst)
9. Design for degradation: (Illustrate with the help of examples: soaps and detergents, pesticides, polymers)
10. Real Time monitoring of chemical processes using inline, offline, and online techniques
11. Inherently safer design/chemistry:
    Principle and subdivision of ISD, Bhopal Gas Tragedy (safer route to carbaryl) and Flixiborough accident (safer route to cyclohexanol, Asahi Process)

UNIT – 3: Industrial Applications and Success Stories (2 Weeks)

- Vitamin C Synthesis using enzymes (Hoffman La Roche)
- Zoloft -Presidential Chemistry Award Winning Innovation (Pfizer)
- Methyl Methacrylate syngas process (Eastman Chemicals)
- Synthesis of herbicide disodium iminodiacetate
- Rightfit pigments azo dyes synthesis and their applications
- Healthier Fats and oils by Green Chemistry: Enzymatic Interesterification for production of No Trans-Fats and Oils.
- Synthesis of anti-tuberculosis drug Paramycin from waste water stream

Practical component Credits:

01 (Laboratory periods:15 classes of 2 hours each)

Note: 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 CO2 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, ethylcyanoacetate 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.
10. Preparation of dibenzalacetone by cross aldol condensation reaction using base catalysed green method.

Essential/recommended readings

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:

1. Kirchoff, M.; Ryan, M.A. (2002), **Greener approaches to undergraduate chemistry experiment**, American Chemical Society, Washington DC.
2. Sharma, R.K.; Sidhwani, I.T.; Chaudhari, M.K. (2013), **Green Chemistry Experiments: A monograph**, I.K. International Publishing House Pvt Ltd. New Delhi.
3. 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.
4. Sidhwani 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.
5. Sidhwani, I.T; Sharma, R.K. (2020), **An Introductory Text on Green Chemistry**, Wiley India Pvt Ltd.
6. **Monograph on Green Chemistry Laboratory Experiments**, Green Chemistry Task Force Committee, Department of Science and Technology, Government of India.
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

DISCIPLINE SPECIFIC ELECTIVE COURSE -3(DSE-3): Solutions, Colligative properties, Phase Equilibria 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		
Solutions, Colligative properties, Phase Equilibria and adsorption (DSE-3)	**04**	**03**	**-**	**01**	Class 12th with Physics, Chemistry	

Learning Objectives

The Learning Objectives of this course are as follows:

- To make the students understand the various properties of dilute solutions.
- To make the students understand the thermodynamic basis of colligative properties.
- To explain the concept of phase, co-existence of phases, phase diagram for various types of system, CST and distribution law.
- To introduce the concept of adsorption, its dependence on various conditions and applications

Learning outcomes

By studying this course, students will be able to:

- Explain different types of phase equilibrium, draw a well labelled phase diagram.
- Predict the existence of a substance in a given phase under different conditions of temperature and pressure
- Apply the concepts of phase, solutions and distribution law while studying other chemistry courses and every-day life processes.
- Explain the type of adsorption that can take place in different systems and predict the conditions to get maximum adsorption.

SYLLABUS OF DSE-3

UNIT-1: Solutions and Colligative Properties **(4 Weeks)**

Dilute solutions; lowering of vapour pressure, Raoult's law, Henry's law. Thermodynamic basis of the colligative properties - lowering of vapour pressure, elevation of Boiling Point, Depression of Freezing point and Osmotic pressure and derivation of expressions for these using chemical potential. Application of colligative properties in calculating molar masses of normal, dissociated and associated solutes in solutions, van't Hoff factor and its applications. Concept of activity and activity coefficients.

UNIT-2: Phase Equilibria (8 Weeks)

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), with applications. A comparison between the phase diagram of CO_2 and H_2O. Phase diagrams for systems of solid-liquid equilibria involving eutectic, congruent and incongruent melting points, solid solutions (excluding partial miscibility). Binary solutions: Gibbs-Duhem-Margules equation, its derivation and applications to fractional distillation of binary miscible liquids (ideal and non-ideal), Konovalov's laws, azeotropes, lever rule, partial miscibility of liquids, CST, miscible pairs, steam distillation. Nernst distribution law: its derivation and applications.
Three component systems, water-chloroform-acetic acid system, triangular plots.

UNIT-3: Surface chemistry (3 Weeks)

Physical adsorption, chemisorption, adsorption isotherms (Langmuir and Freundlich). Nature of adsorbed state. Multilayer adsorption, BET equation derivation, thermodynamic treatment of adsorption-Gibbs equation.

Practical component Credit: 01

(Laboratory periods: 15 classes of 2 hours each)

Practical

Phase Equilibrium

1. Determination of critical solution temperature and composition at CST of the phenol water system
2. To study the effect of impurities of sodium chloride and succinic acid on the CST of phenol-water system.
3. To study the cooling curves for the following systems:
   (i) simple eutectic
   (ii) congruently melting systems.

Adsorption

Verify the Freundlich and Langmuir isotherms for adsorption of acetic acid on activated charcoal.

Essential/recommended readings

Theory:

1. Peter, A.; Paula, J. de. (2011), **Physical Chemistry**, 9th Edition, Oxford University Press.
2. Castellan, G. W. (2004), **Physical Chemistry**, 4th Edition, Narosa.
3. Kapoor, K.L. (2015), **A Textbook of Physical Chemistry**, Vol 3, 6th Edition, McGraw Hill Education.
4. Kapoor, K.L. (2015),**A Textbook of Physical Chemistry**, Vol 5, 6th Edition, McGraw Hill Education.
5. Ball, D. W. (2017), **Physical Chemistry,** 2nd Edition, Cengage Learning, India.

Practical:

1. Khosla, B.D.; Garg, V.C.; Gulati, A. (2015), **Senior Practical Physical Chemistry**, R. Chand & Co, New Delhi.
2. Garland, C. W.; Nibler, J. W.; Shoemaker, D. P. (2003), **Experiments in Physical Chemistry**, 8th Edition, McGraw-Hill, New York.

Suggestive readings

1. Levine, I.N. (2010), **Physical Chemistry**, Tata Mc Graw Hill.

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

DISCIPLINE SPECIFIC ELECTIVE COURSE -4 (DSE-4): Nuclear and Environmental 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		
Nuclear and Environmental Chemistry (DSE-4)	**04**	**03**	**--**	**01**	Class 12th with Physics, Chemistry	**--**

Learning Objectives

The Objectives of this course are as follows:

- To make students know more about nuclear chemistry
- To familiarise the students about environmental chemistry, especially with respect to air and water

Learning outcomes

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

- Gain knowledge about Nuclear chemistry, radioactive decay, nuclear disasters, and nuclear waste and their disposal.
- Describe the composition of air, various air pollutants, effects and control measures of air pollutants.
- List different sources of water, water quality parameters, impacts of water pollution, water treatment.
- Identify different industrial effluents and their treatment methods.

SYLLABUS OF DSE-4

Unit-1 : Nuclear Chemistry **(7 Weeks)**

The nucleus: subatomic particles, e liquid drop model; forces in nucleus-mesons; stability of nucleus-n/p ratio, binding energy; radioactive elements.
Radioactive decay- α-decay, β-decay, γ-decay; neutron emission, positron emission; unit of radioactivity (curie); half life period; radioactive displacement law, radioactive series.
Measurement of radioactivity: ionization chamber, Geiger Counters, Scintillation counters.
Nuclear reactions: Nuclear fission-theory of nuclear fission; chain reaction; nuclear fusion; nuclear reactors-fast breeder reactors, fuels used in nuclear reactors, separation of isotopes, moderators, coolants; nuclear reactors in India.
Applications: Dating of rocks and minerals, carbon dating, neutron activation analysis, isotopic labeling studies, nuclear medicine- ^{99m}Tc radio pharmaceuticals.
Nuclear disasters – Chernobyl disaster, Three Mile Island Disaster, Disposal of nuclear waste and its management.

UNIT – 2: Air Pollution (4 Weeks)

Major regions of atmosphere, chemical and photochemical reactions in atmosphere. Air pollutants: types, sources, particle size and chemical nature, Major sources of air pollution, Pollution by SO_2, CO_2, CO, NO_x, H_2S and other foul-smelling gases, methods of estimation of CO, NO_x, SO_x and control procedures.

Chemistry and environment impact of the following: Photochemical smog, Greenhouse effect, Ozone depletion

Air pollution control, Settling Chambers, Venturi Scrubbers, Electrostatic Precipitators (ESPs).

UNIT – 3 : Water Pollution: (4 Weeks)

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).

Sludge disposal. Industrial waste management, incineration of waste. Water treatment and purification (reverse osmosis, electro dialysis, ion-exchange). Water quality parameters for wastewater, industrial water and domestic water.

Practical component
Practical: Credits: 01
(Laboratory periods:15 classes of 2 hours each)
(At least four experiments to be performed)

1. Determination of dissolved oxygen in a given sample of water.
2. Determination of Chemical Oxygen Demand (COD) in a given sample of water.
3. Determination of Biological Oxygen Demand (BOD) in a given sample of water.

4. Measurement of chloride, sulphate and salinity of water samples by simple titration method ($AgNO_3$ and potassium chromate).
5. Estimation of total alkalinity of water samples (CO_3^{2-}, HCO_3^-) using double titration method.
6. Measurement of dissolved CO_2 in a given sample of water.
7. Determination of hexavalent Chromium Cr(VI) concentration in tannery wastes/ waste water sample using UV-Vis spectrophotometry technique.

Essential/recommended readings

Theory:

1. Stanley E. Manahan, 10th edition, **Environmental chemistry,** CRC Press, Taylor and Francis Group, US, 2017
2. Baird, C. and Cann, M., **Environmental Chemistry,**(2012), Fifth Edition, W. H. Freemann & Company, New York, US.
3. VanLoon, G.W. and Duffy, J.S.(2018) **Environmental Chemistry - A global perspective**, Fourth Edition, Oxford University Press
4. Brusseau, M.L.; Pepper,I.L. and Gerba, C., (2019) **Environmental and Pollution Science**, Third Edition, Academic Press.
5. Masters, G.M., (1974) **Introduction to Environmental Science and Technology**, John Wiley & Sons.
6. Masters, G.M., (2015) **Introduction to Environmental Engineering and Science.** JPrentice Hall India Learning Private Limited.
1. 7.Arnikar, H.J., (1987), Second Edition, **Essentials of Nuclear Chemistry,** Wiley Blackwell Publishers
7. Arnikar, H.J.; Rajurkar, N. S.,(2016) **Nuclear Chemistry through Problems,** New Age International Pvt. Ltd.
8. De, A.K.(2012), **Environmental Chemistry,** New Age International Pvt., Ltd.
9. Khopkar, S.M.(2010), **Environmental Pollution Analysis**, New Age International Publisher.
10. Das, A. K. (2010), ***Fundamentals of Inorganic Chemistry***, Volume 1, Second Edition, CBS Publishers & Distributors Pvt Ltd.
11. Das, A. K. (2012), ***Environment Chemistry with Green chemistry***, Books and Allied (P) Ltd.

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.

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

DISCIPLINE SPECIFIC ELECTIVE COURSE – 5 (DSE-5): Reactions, Reagents and Chemical Process

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		
Reactions, Reagents and Chemical Process (DSE-5)	04	03	--	01	Class 12th with Physics, Chemistry	Basic knowledge of organic reactions

Learning objectives

The objectives of this course are as follows:

- To study the important organic name and rearrangement reactions that are crucial for the synthesis of valuable organic compounds.
- To give the knowledge belonging to the role of reagents in organic reactions for the synthesis of chemo-, diastereo- and enantio-selective products.
- To impart the knowledge of process chemistry that is a key part of the large-scale synthesis of chemical products essential for day-to-day life

Learning outcomes

By studying this course, students will be able to:

- Explain the reaction mechanism of various name and rearrangement reactions
- Discuss the role of the reagents in organic synthesis and apply these reagents for the bulk chemical synthesis
- Debate and use oxidizing and reducing reagents for selective synthesis organic products
- Apply the learnt techniques to chemical processes
- Acquire skills for human resource building especially in the chemical industry.

SYLLABUS OF DSE-5

UNIT – 1: Name Reactions **(5 Weeks)**

Application, scope and mechanism of following reactions: Prevost Reaction, Chugaev Reaction, Maukaiyama Aldol Reaction, Mozingo Reaction, Ramberg Backlund Reaction, Shapiro Reaction, Barbier Reaction, Clark- Eschweiler Reaction, Darzen's Reaction, Julia-Olifination Reaction, Tiffeneaus Damjanov Reaction, Darkin West Reaction, Bischler-Napieralaski Reaction, Birch reduction of aromatic compounds, Appel Reaction, Mitsunobu

Reaction, Corey Kim Oxidation, Azide-alkyne 1,3-dipolar cycloaddition reaction, Olefin metathesis: Grubbs reaction, Heck Reaction, Suzuki coupling and Wittig reaction.

UNIT – 2: **Reducing Reagents** **(3 Weeks)**

Reactions, mechanism and applications of following reducing agents: Sodium borohydride, Lithium aluminium hydride, $NaBH_3CN$, DIBALH, lithium-tri-*tert*-butoxyaluminum hydride, Red-Al $Na[AlH_2(OCH_2OCH_2OCH_3)_2]$, Zinc borohydride, L and K selectrides, $LiBHEt_3$ and $KBHEt_3$, Luche Reagent $NaBH_4$-$CeCl_3$, $K[BH(OAc)_3]$, *bis*-Boric Acid (BBA), Catecholborane, DEMS (Diethoxymethylsilane), 3-Mercapto propionic acid, Polymethylhydrosiloxane (PMHS), Schwartz's Reagent (Zirconocene chloride hydride).

UNIT – 3: Oxidizing Reagents **(3 Weeks)**

Reactions, mechanism and applications of following oxidizing agents: Jones Reagent (CrO_3, H_2SO_4, H_2O), Swern Reagent (DMSO, oxalyl chloride), Dess Martin, TEMPO, TPAP (Tetrapropyl ammonium perruthenate), Fetizon's Reagent, Fenton's Reagent [H_2O_2 + Fe(II) ion], Sodium perborate NaH_2BO_4, Sodium Bismuthate $NaBiO_3$, ABNO (9-Azabicyclo[3.3.1]nonane N-oxyl), DEAP (Diethyl allyl phosphate, ), AZADO (2-Azaadamantane N-oxyl], Wacker oxidation.

UNIT – 4: Process Chemistry **(4 Weeks)**

1. Process chemistry a) Introduction, stages of scale up process: Bench, pilot, and large-scale process with at least two examples of scale up process of API. b) In-process control and validation of large-scale process.
2. Unit Processes: The following unit processes should be studied with mechanism and one example of each process Nitration: Nitrating agents, process equipment for technical nitration. Halogenation: Types of halogenations, catalytic halogenations. Reduction: Catalytic hydrogenation, hydrogen transfer reactions, metal hydrides. Oxidation: Types of oxidative reactions, and non-metallic oxidizing agents such as H, sodium hypochlorite, oxygen gas, ozonolysis.

Practical component **Credits:**

01 (Laboratory periods:15 classes of 2 hours each)

1. Oxidation of alcohols to acid using Jones reagent.
2. Reduction of acetophenone and its derivatives to 1-phenyl ethanol derivatives by $NaBH_4$.
3. Reduction of 4-tert-butyl-cyclohexanone to cis and trans 4-tert-butyl-cyclohexanol.
4. Synthesis of 2,5-dimethyl-2,5-hexanediol from tert-butanol using Fenton's reagents.
5. Wittig reaction of benzyltriphenylphosphonium chloride and 4-bromobenzaldehyde using potassium phosphate (tribasic).
6. Substitution (S_N2) reaction of 1-iodobutane and 2-naphthol.
7. Aldol condensation reaction: solventless synthesis of chalcones.
8. Borohydride reduction of a ketone: hydrobenzoin from benzil.
9. Visit to chemical industry of the demonstration of pilot scale.

Essential/recommended readings

Theory:

2. Clayden, J. Greeves, N., Warren, S. **Organic Chemistry**, South Asian Edition, Oxford University Press, USA
3. Gadamasetti K., **Process Chemistry in the Pharmaceutical Industry: Challenges in an Ever- Changing Climate-An Overview**, Vol-2, CRC Press, London.
4. Murphy R.M., **Introduction to Chemical Processes: Principles, Analysis, Synthesis**, McGraw-Hill Education, New York.
5. Harrington P. J., **Pharmaceutical Process Chemistry for Synthesis: Rethinking the Routes to Scale up**, John Wiley and Sons, Inc, New Jersey.
6. Parashar, R.K.; Ahluwalia, V.K. (2018), **Organic Reaction Mechanism,** 4th Edition, Narosa Publishing House.

Practical:

1. Mann F.G, Saunders, B.C., **Practical Organic Chemistry**, Dorling Kindersley (India) Pvt. Ltd. (Pearson Education Ltd.), Singapore.
2. Vogel A.I., **Elementary Practical Organic Chemistry**, Dorling Kindersley (India) Pvt. Ltd. (Pearson Education Ltd.), Singapore.

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

DISCIPLINE SPECIFIC ELECTIVE COURSE - 6 (DSE- 6): Polymers, Colloids, Surfaces and Interfaces

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		
Polymers, Colloids, Surfaces and Interfaces (DSE- 6)	**04**	**03**	**--**	**01**	Class 12th with Physics, Chemistry	**--**

Learning Objectives

The objectives of this course are as follows:

- To give students a comprehensive coverage of important physical aspects of polymers chemistry, colloids, emulsions, surfaces and interfaces.
- to study the applications of these aspects.

Learning outcomes

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

- Explain the types of polymers, kinetics of polymerization and polymer properties.
- Understand and apply the concepts of properties of polymer solutions and their thermodynamics.
- Comprehend the basic concepts of surface chemistry specifically in relation to colloids.
- Have a thorough understanding of applications of colloids in various areas.

SYLLABUS OF DSE-6

UNIT 1: Introduction to polymers **(Lectures: 6)**

Recapitulation of basic concepts of polymers. Types of polymerizations and their mechanism and kinetics: Free radical, ionic, step-growth, coordination, copolymerization. Polymerization techniques: Bulk, solution, suspension, and emulsion.

UNIT 2: Polymer solution **(Lectures: 9)**

Polymer solution – solubility parameter, properties of dilute solutions and their criteria, Thermodynamics of polymer solutions, entropy, enthalpy, and free energy change. Flory Huggins theory.

UNIT 3: Introduction to Colloid Chemistry (Lectures: 9)

Recapitulation of basic concepts of Adsorption, 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), preparation and properties of colloids - Tyndall effect, Brownian movement, electrophoresis, dialysis, coagulation and flocculation; Charge on Colloidal particles and Electrical double layer concept, Suspensions and their characteristics, Emulsions and their characteristics.

UNIT 4: Surface chemistry in relation to colloids (Lectures: 12)

Surface film on liquid surface, surface potential, monomolecular films, Langmuir Blodgett layers. Emulsions, foams and aerosols; electrical aspects of surface chemistry; Surface of solids, solid-liquid interface, stability of dispersions, stabilization of suspensions

UNIT 5: Application of colloids (Lectures: 9)

Characterization of colloidal particles, Role of colloid chemistry in Nanotechnology (wet colloid chemical approach, "bottom up" fabrication of nanoparticles and nanostructured materials), applications of colloid chemistry in petroleum recovery, coating and painting, food, pharmaceuticals and cosmetic industry, medicinal chemistry (use in drug formulations), Sewage disposal, Purification of water, cleansing action of soap, Formation of Delta, Smoke precipitation, Photography, Artificial rain

Practical component

Practicals: Credits: 01

(Laboratory periods:15 classes of 2 hours each)

1. Free radical solution polymerization of styrene (St) / Methyl Methacrylate (MMA)/MethylAcrylate (MA).
2. Preparation of nylon 6,6
3. Determination of molecular weight of polyvinyl propylidene in water by viscometry.
4. Determination of the viscosity-average molecular weight of poly(vinyl alcohol) (PVOH) and the fraction of head-to-head monomer linkages in the polymer.
5. Determination of molecular weight by end group analysis of polymethacrylic acid.
6. Estimation of the amount of HCHO in the given solution by sodium sulphite method.
7. Preparation of Colloidal Sols of following
    A. Arsenic sulphide,

B. Antimony sulphide

C. Ferric chloride

D. Aluminium hydroxide

8. To find out the precipitation values of arsenious sulphide sol by using monovalent, bivalent and trivalent cations.
9. To determine the nature of charge on particle in given colloidal solution and their electrophoretic velocity and zeta potential.
10. To prepare lyophilic sol of starch.

Essential/recommended readings

Theory:

1. Carraher,C. E. Jr. (2013), **Seymour's Polymer Chemistry**, Marcel Dekker, Inc.
2. Odian, G. (2004), **Principles of Polymerization**, John Wiley.
3. Billmeyer, F.W. (1984), **Text Book of Polymer Science**, John Wiley
4. Myers D.,Surface, interfaces and colloids Principles and Applications, 2nd Edition, Wiley-VCH
5. V.R. Gowarikar (2010), **Polymer Science**, New Age International Publishers Ltd.

Practical:

1. Sperling, L.H. (2005), **Introduction to Physical Polymer Science**, John Wiley & 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 -7 (DSE-7): Novel Inorganic Solids

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		
Novel Inorganic Solids (DSE-7)	**04**	**03**	**--**	**01**	**Class 12th with Physics, Chemistry**	**--**

Learning Objectives

The Objectives of this course are as follows:

- To familiarize the students with the characterization techniques of inorganic solids
- To familiarize the students with use and manifold applications of composites, carbon or high-tech ceramics

Learning Outcomes:

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

- Explain the mechanism of solid-state synthesis.
- Explain about the different characterization techniques and their principle.
- Explain the importance of composites and their applications.
- Discuss and explain the usage of solid materials in various instruments, batteries, etc. which would help them to appreciate the real-life importance of these materials

SYLLABUS OF DSE- 7

Unit 1: Synthesis of inorganic solids **(Lectures: 5)**

Conventional heat and beat method, Co-precipitation method, Sol-gel method, Hydrothermal method, Chemical vapor deposition (CVD), Ion-exchange and Intercalation method.

Unit 2: Characterization techniques of inorganic solids **(Lectures: 10)**

Powder X-ray Diffraction, UV-visible spectroscopy, Scanning Electron Microscopy (SEM), Transmission Electron Microscopy (TEM), Fourier-Transform Infrared (FTIR) spectroscopy, Brunauer–Emmett–Teller (BET) surface area analyser, Dynamic Light Scattering (DLS)

Unit 3: Pigments **(Lectures: 10)**

Cationic, anionic and mixed solid electrolytes and their applications. Inorganic pigments – coloured, white and black pigments.

One-dimensional metals, molecular magnets, inorganic liquid crystals.

Unit 4: Composite materials **(Lectures: 10)**

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 5: Speciality polymers **(Lectures: 10)**

Speciality polymers: Conducting polymers - Introduction, conduction mechanism, polyacetylene, polyparaphenylene, polyaniline. and polypyrrole, applications of conducting polymers, ion-exchange resins and their applications.

Ceramic & Refractory: Introduction, classification, properties, manufacturing and applications of ceramics, refractory and superalloys as examples.

Practicals **Credits: 01**

(Laboratory periods: 15 classes of 2 hours each)

1. Preparation of polyaniline and its characterization using UV-visible spectrophotometer.
2. Intercalation of hydrogen in tungsten trioxide and its conductivity measurement using conductometer.
3. Synthesis of the following inorganic pigments:

   (i) $PbCrO_4$ / chrome yellow

   (ii) Barium white

   (iii) Prussian Blue

   (iv) Malachite

. 4. Preparation of zeolite A and removal of Mg and Ca ions from water samples quantitatively using zeolite.

5. Determination of exchange capacity of cation exchange resins and anion exchange resins.

6. Determination of a mixture of cobalt and nickel (UV-visible spectroscopy).
7. Preparation of a disc of a ceramic compound using ball milling, pressing and sintering, and study its XRD.

Essential/recommended readings

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. Poole Jr.; Charles P.; Owens, Frank J. (2003), **Introduction to Nanotechnology**, John Wiley and Sons.

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.
3. Cheng, K.H.; Jacobson, A.J.; Whittingham, M.S. (1981),**Hexagonal Tungsten Trioxide and Its Intercalation Chemistry**, Solid State Ionics, 5, 1981, 355-358.
4. Ghorbani H.R.; Mehr, F.P; Pazoki, H; Rahmani, B.M.; **Synthesis of ZnO Nanoparticles by Precipitation Method**, Orient J Chem 2015, 31(2).

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

DISCIPLINE SPECIFIC ELECTIVE COURSE – 8 (DSE-8): Applied 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		
Applied Organic Chemistry (DSE-8)	04	03	--	01	Class 12th with Physics, Chemistry	--

Learning Objectives

The objectives of this course are as follows:

- To make students aware of the importance of organic compounds in daily life.
- To familiarize students with the chemistry and uses of dyes, polymers, terpenoids, alkaloids, steroids and pharmaceutical compounds and their direct or indirect effect on human life and health

Learning outcomes

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

- Discuss and demonstrate the chemistry and uses of commercially important and naturally occurring compounds like dyes, polymers, terpenoids, alkaloids, steroids and pharmaceuticals.
- Appreciate the chemistry of biodegradable and conducting polymers and their importance to human life and society.
- Comprehend the chemistry of dyeing and dyes. Explain why some dyes are better than others. Describe the applications of various types of dyes including those in foods and textiles.
- Comprehend the synthetic routes and mode of action of some selected pharmaceutical compounds
- Use the knowledge gained to solve real world problems

SYLLABUS OF DSE-8

Unit 1: Dyes **(Lectures: 7)**

Nomenclature of commercial dyes with at least one example. Suffixes - G, O, R, B, 6B, L, S; colour index and colour index number. Classification of dyes based on structure and application; Chemistry of dyeing.

Synthesis and applications of the following types of dyes: Azo dyes - Methyl orange, Congo red; Triphenyl methane dyes-Malachite green, Rosaniline and Crystal violet; Phthalein Dyes - Phenolphthalein; Natural dyes - Structure elucidation and synthesis of Alizarin and Indigotin; Edible Dyes (natural and synthetic) with examples and effect of synthetic food colours on health.

Unit 2: 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 (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 3: Natural Product Chemistry- An Introduction to Terpenoids, Alkaloids and Steroids (Lectures: 12)

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.

Steroids: Introduction, occurrence, structure, Diel's hydrocarbon, nomenclature of steroid hydrocarbons, structure and biological functions of the following steroids- Cholesterol, Sex Hormones (Estrogen, androgen and progesterone), Adrenocortical hormones (Cortisone and cortisol) and Ergosterol (antirachitic effect).

Unit 4: Pharmaceutical Compounds **(Lectures:14)**

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

Antipyretics -Paracetamol; Analgesics- Ibuprofen; Antimalarials - Chloroquine; Antitubercular drugs - Isoniazid.

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

Practical component

Practical: **Credits: 01**

(Laboratory periods:15 classes of 2 hours each)

(At least five experiments to be performed)

1. Synthesis of urea formaldehyde resin and test the solubility.
2. Preparation of Starch-PVA Film.
3. Preparation of Methyl orange.
4. Separation of a mixture of dyes by Thin Layer Chromatography (TLC).
5. Isolation and estimation of the content of aspirin in a commercial tablet.
6. Synthesis of 4-methyl-7-hydroxycoumarin by condensation of resorcinol with ethyl acetoacetate.
7. Synthesis of 3,5-dimethyl pyrazole by condensation of acetylacetone and hydrazine.
8. Synthesis of benzimidazole.
9. Synthesis of 2,3-diphenylquinoxaline.
10. Synthesis of paracetamol

Essential/recommended readings

Theory:

1. Finar, I.L. Fifth Edition **Organic Chemistry**, Volume 2, Pearson Education, 2008.
2. Saunders, K. J., (1988), **Organic Polymer Chemistry,** Second Edition Chapman & Hall, London.
3. Campbell, Ian M., (2000), **Introduction to Synthetic Polymers**, Second 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), Fourth Edition, Oxford University Press.
6. Beale J.M. Block J., (2010) **Wilson and Gisvold's Textbook of Organic Medicinal and Pharmaceutical Chemistry,** Twelfth Edition, Lippincott Williams and Wilkins.
7. Alagarsamy, V. (2010), **Textbook of Medicinal Chemistry**, Volume II, Second Edition, Reed Elsevier India Private Limited.

Practical:

1. Sciam, A.J. **TLC of mixture of dyes**; *J. Chem. Educ*., **1985**, 62(4), 361. https://pubs.acs.org/doi/10.1021/ed062p361.
2. McKone, H.T.; Nelson, G.J**. Separation, and identification of some FD &C dyes by TLC. An undergraduate laboratory experiment**, *J. Chem. Educ*., **1976**, *53*(11), 722. DOI: 10.1021/ed053p722.

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

DISCIPLINE SPECIFIC ELECTIVE COURSE- 9 (DSE-9): Applications of Computers 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		
Applications of Computers in Chemistry (DSE 9)	**04**	**03**	**-**	**01**	Class 12th with Physics, Chemistry	

Learning Objectives

The Objectives of this course are as follows:

- To familiarize the students with the fundamental building blocks and syntax of coding in Python with
- To apply python programming to solve simple Chemistry problems by thinking algorithmically and coding structurally

Learning outcomes

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

- Understand the importance of python programming in chemistry and its applications in the field of AI and ML
- Perform simple computations in python after learning the basic syntax, loop structure, string data manipulation etc.
- Solve chemistry problems such as finding pKa of a weak acid, solving Schrodinger's equation etc.
- Plot experimental data and perform regression analysis

SYLLABUS OF DSE-9

UNIT–1: Basic Computer system **(Lectures: 3)**

Hardware and Software; Input devices, Storage devices, Output devices, Central Processing Unit (Control Unit and Arithmetic Logic Unit); Number system (Binary, Octal and

Hexadecimal Operating System); Computer Codes (BCD and ASCII); Numeric/String constants and variables. Operating Systems (DOS, WINDOWS, and Linux); Software languages: Low level and High-Level languages (Machine language, Assembly language; QBASIC, C, C++, FORTRAN 90&95); Compiled versus interpreted languages. Debugging Software Products (Office, chemsketch, scilab, matlab, and hyperchem), internet application

UNIT-2: Introduction to Python **(Lectures: 3)**

Why Python? Python coding environment setup, Python as an interpreted language, Brief history of Python, Uses of Python (including artificial intelligence and machine learning), Applications of Python in Chemistry

UNIT-3: Coding in Python **(Lectures: 18)**

(i) Basic syntax including constants and variables, Operators, Data Types, Declaring and using Numeric data types: int, float, string etc. (ii) Program Flow Control Conditional blocks: if, else and else if, simple FOR loops, FOR loop using ranges, string, list and dictionaries. Use of while loops, Loop manipulation using pass, continue, break and else. (iii) Complex data types: String, List, Arrays, Tuples and Dictionary, String operations and manipulation methods, List operations including slicing, in-built Python Functions. (iv) Python packages - usage of numpy and scipy for mathematical computations.

UNIT-4: Plotting graphs **(Lectures: 9)**

Matplotlib for Plotting - Simple plots, formatting of plots, multiple plots, histograms, bar graphs, distributions, curve fitting – linear regression.

UNIT-5: Numerical Methods in Chemistry **(Lectures: 12)**

Solution of quadratic equation, polynomial equations (formula, iteration, Newton – Raphson methods and binary bisection) with examples of polynomial equations used in chemistry; Numerical differentiation – finite difference method (backward, central and forward), Numerical integration - Trapezoidal and Simpson's rule to calculate area under the curves for chemistry problems, e.g., entropy calculations, Simultaneous equations, Statistical analysis-mean, variance, standard deviation, error, Curve fitting – linear regression, Solving Schrödinger's equation using Python packages.

Practical component

Practicals: Python Programming for Chemists **Credits: 01**

4. **Writing simple programs using scipy and numpy**
    a. syntax, data types
    b. loop structure, conditional loops

c. To learn string data manipulation
d. Array and lists
e. Sorting, matrix manipulations

5. **Plotting graphs using matplotlib**
   a. Planck's distribution law
   b. Maxwell-Boltzmann distribution curves as a function of temperature and mass
   c. Radial distribution curves for hydrogenic orbitals
   d. Gas law Isotherms – Ideal and Real
   e. Data from phase equilibria studies
   f. Wavefunctions and Probabilities as multiplots
   g. Kinetics data with linear fitting

6. **Numerical Methods in Chemistry**
   a. Solving equations involved in chemical equilibria such as pH of a weak acid at a given concentration, cubic equation obtained from solving van der Waals equation of real gases using Iteration, Newton-Raphson, and Binary Bisection Method
   b. Numerical Differentiation – finding equivalence point given pH metric and potentiometric titrations data by finding the first and the second derivative using the finite difference method
   c. Numerical Integration – Trapezoidal and Simpson's 1/3 rule to calculate enthalpy and entropy of an ideal gas
   d. Statistical Analysis – Calculating Mean, Variance, Standard Deviation
   e. Solving Schrodinger's Equation

Essential/recommended readings

Theory:

7. Dr. M. Kanagasabapathy(2023), **Python for Chemistry: An introduction to Python algorithms, Simulations, and Programing for Chemistry** (English Edition), BPB Publications
8. Robert Johansson (2021), **Numerical Python: Scientific Computing and Data Science Applications with Numpy, SciPy and Matplotlib**, 2nd Edition, Apress

Practical

1. Urban M., Murach J., **Murach's Python programming,** 2nd Indian reprint 2018, Shroff publishers and distributors
2. Gaddis T., **Starting out with python plus My programming Lab** with Pearson e-text-Access card package, 3rd ed.

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

DISCIPLINE SPECIFIC ELECTIVE COURSE - 10(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		
Analytical Methods in Chemistry (DSE-10)	**04**	**03**	**--**	**01**	**Class 12th with Physics, Chemistry**	**-**

Learning Objectives

The Objectives of this course are as follows:

- To familiarize the students with concept of sampling, Accuracy, Precision, Statistical test data-F, Q and t test.
- To familiarize the students with the laws of spectroscopy and selection rules governing the possible transitions in the different regions of the electromagnetic spectra.
- To familiarize the students with important separation methods like solvent extraction and chromatography

Learning Outcomes:

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

- Perform experiment with accuracy and precision.
- Develop methods of analysis for different samples independently.
- Test contaminated water samples.
- Use basic principle of instrument like Flame Photometer, UV-Visible spectrophotometer learnt for practical applications.
- Apply knowledge of geometrical isomers and keto-enol tautomers to analysis.
- Determine composition of soil.
- Estimate macronutrients using Flame photometry.

SYLLABUS OF DSE-10

Unit 1: Qualitative and Quantitative Aspects of Analysis: (Lectures: 5)

Sampling, evaluation of analytical data, errors, accuracy and precision, methods of their expression.

Normal law of distribution of indeterminate errors, statistical test of data; F, Q and t test, rejection of data, and confidence intervals.

Unit 2: Optical Methods of Analysis (Lectures: 25)

Origin of spectra, interaction of radiation with matter, fundamental laws of spectroscopy and selection rules

UV-Visible Spectrometry: Basic principles of instrumentation (choice of source, monochromator and detector) for single and double beam instrument; Transmittance. Absorbance and Beer-Lambert law

Basic principles of quantitative analysis: estimation of metal ions from aqueous solution, geometrical isomers, keto-enol tautomers.

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

Unit 3: Thermal methods of analysis (Lectures: 5)

Theory of thermogravimetry (TG) and basic principle of instrumentation of thermal analyser. Techniques for quantitative estimation of Ca and Mg from their mixture.

Unit 4: Separation techniques (Lectures:10)

Solvent extraction: Classification, principle and efficiency of the technique.

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

Chromatography: Classification, principle and efficiency of the technique, Mechanism of separation: adsorption, partition & ion-exchange

Practicals Credits 01

(Laboratory periods: 15 classes of 2 hours each)

1. Separation of constituents of leaf pigments by Thin Layer Chromatography

2. Solvent Extractions

   (i) To separate a mixture of Ni^{2+} & Fe^{2+} by complexation with DMG and extracting the Ni^{2+} DMG complex in chloroform, and determine its concentration by spectrophotometry.

3. Analysis of soil:

   (i) Total soluble salt
   (ii) Estimation of exchangeable calcium and magnesium
   (iii) Estimation of carbonate and bicarbonate
   (iv) Qualitative detection of nitrate and phosphate

4. Separation of amino acids from organic acids by ion exchange chromatography.
5. Spectrophotometry

   (i) Verification of Lambert-Beer's law and determination of concentration of a coloured species ($CuSO_4$ / $KMnO_4$ /$CoCl_2$ / $CoSO_4$)
   (ii) Spectrophotometric analysis of caffeine and benzoic acid in a soft drink
   (iii) Determination of concentration of coloured species via following methods;
   (a) Graphical method, (b) Epsilon method, (c) Ratio method, (iv) Standard addition method

6. Flamephotomerty
   (i) Estimation of potassium, calcium and magnesium using flame photometry

Essential/recommended readings

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. Khopkar, S.M. (2008), **Basic Concepts of Analytical Chemistry,** New Age International Publisher.
5. Skoog, D.A.; Holler F.J.; Nieman, T.A. (2005), **Principles of Instrumental Analysis,** Thomson Asia Pvt. Ltd.

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 - 11 (DSE-11): Basic Principles of Food 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		
Basic Principles of Food Chemistry (DSE-11)	04	03	--	01	Class 12th with Physics, Chemistry	--

Learning Objectives

The objectives of this course are as follows:

- To make students understand the sources, importance, stability and transformations of food components during handling and processing.
- To make students aware about nature and importance of additives in food chemistry.

Learning outcomes

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

- Develop a strong understanding of basic fundamentals of food chemistry
- Discuss and demonstrate how alterations /transformations during processing and handling affect the quality and stability of food
- Develop an elementary idea on the nature and importance of additives in food chemistry.
- Apply the knowledge gained to real world problems

SYLLABUS OF DSE-11

Unit 1: Introduction **(Lectures:3)**

What is food chemistry; An overview of the following: alterations during handling or processing (texture, flavour, colour), chemical and biochemical reactions leading to alteration in food quality (browning, oxidation, hydrolysis, protein denaturation), cause and effect relationship pertaining to food handling; factors governing stability of food (chemical and environmental factors) and role of food chemists.

Unit 2: Water **(Lectures:3)**

Definition of water in food, structure of water and ice, types of water, sorption phenomenon, water activity and packaging, water activity and shelf-life.

Unit 3: Carbohydrates (Lectures:6)

Introduction, sources, functions, deficiencies, structure and importance of polysaccharides in food chemistry (Agar and Agarose, Pectin, Hemicellulose, Cyclodextrins, Gums, Alginate, Starches, modified starches), Non-enzymatic browning and its prevention, caramelisation, formation of acrylamide in food, role of carbohydrates as sweeteners and comparison with artificial sweeteners.

Unit 4: Proteins (Lectures:6)

Introduction, sources, classification, functions, deficiencies, physico-chemical & functional properties of proteins, nature of food proteins (plant and animal proteins).

Unit 5: Lipids (Lectures:6)

Introduction, sources, classification and physical properties, functions, deficiencies, effect of frying on fat, reaction of lipids: hydrogenation, interesterification, hydrolysis, auto-oxidation and its prevention; flavour reversion, fat replacers: fat mimetics and fat substitutes.

Unit 6: Vitamins and Minerals (Lectures:6)

Vitamins: Introduction, sources, classification: water soluble and water insoluble vitamins, essential vitamins, physiological function, deficiencies, causes of variation and loss in foods, vitamin like compounds, effect of food processing.

Minerals: Introduction, sources, classification: major minerals and trace elements, physiological function, deficiencies, factors affecting mineral content of food, fortification and enrichment of foods with minerals, effect of food processing.

Unit 7: Food Additives (Lectures:15)

Additives: Introduction, importance, classification, antioxidants, emulsifiers, stabilizers, gelling agents, gums, thickeners, sweeteners, acidulants, preservatives, humectants, food toxins

Colouring Agents and Pigments: Introduction, natural food colourants: anthocyanins, carotenoids, chlorophyll, caramel, betalains; examples of pigments in common food; Nature-identical colourants: β-Carotene, canthaxanthin and riboflavin; artificial colouring agents; artificial/synthetic colourants: Azo dyes (e.g. amaranth dye, tatrazine, citrous red, Allura red); quinoline (e.g. quinoline yellow); phthalein (e.g. erythrosine); triarylmethanes and indigoid (e.g. indigo carmine), FD&C Dyes and lakes; properties of certified dyes, colours exempt from certification.

Food Flavor: Sensation of taste and odour, chemical dimension of basic types of taste (Salty, Sweet, Bitter, Sour, Umami taste), other sensations like astringency, coolness, pungency/pungency); non-nutritive sweeteners (aspartame, saccharin, sucralose, cyclamate) and nutritive sweeteners, molecular mechanism of flavour perception, biogenesis of fruits and vegetable flavors, taste inhibition, modification and enhancement, common vegetable and spice flavors.

Practical component

Practical: **Credits: 01**

(Laboratory periods:15 classes of 2 hours each)

(At least four experiments to be performed)

1. Determination of moisture in food products by hot air oven-drying method.
2. Paper chromatography of synthetic food dyes.
3. Quantitative determination of food dyes in powdered drink mixes by spectrophotometric method.
4. Colorimetric determination of Iron in vitamin / dietary tablets.
5. Determination of rancidity of edible oils by Kriess Test.
6. Estimation of Vitamin C in a given solution/ lemon Juice/chillies by 2, 6-dichlorophenol by Indophenol Method.
7. Isolation of casein from milk.
8. Qualitative estimation of cholesterol by Liebermann-Burchard method.
9. Detecting the presence of Vanaspati and rancidity in the given Ghee sample through qualitative tests.

Essential/recommended readings

Theory:

1. DeMan, J.M., Finley, J.W., Hurst, W.J., Lee, C.Y. (2018), **Principles of Food Chemistry**, Fourth Edition, Springer.
2. Msagati, T.A.M. (2013), **Chemistry of Food Additives and Preservatives**, Wiley-Blackwell.
3. Fennema, O.R. (2017), **Food Chemistry**, Fifth Edition, CRC Press.
4. Attokaran, M. (2017), **Natural Food Flavors and Colorants**, Second Edition, Wiley-Blackwell.
5. Potter, N.N., Hotchkiss, J.H, (1995) **Food Science,** Fifth Edition, Chapman & Hall.
6. Brannen, D., Davidsin, P.M., Salminen, T. Thorngate III, J.H. (2002), **Food Additives**, Second Edition, CRC Press.
7. Coultate, T. (2016), **Food: The Chemistry of its Components**, Sixth Edition, Royal Society of Chemistry.
8. Belitz, H. D.; Grosch, W. (2009), **Food Chemistry**, Springer.
9. Course: Food Chemistry (iasri.res.in)

Practical:

1. Ranganna, S. (2017). **Handbook of analysis and quality control for fruits and vegetable products**, Second Edition, McGraw Hill Education
2. Sawhney, S.K., Singh, R. (2001), **Introductory Practical Biochemistry**, Narosa Publishing House

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

DISCIPLINE SPECIFIC ELECTIVE COURSE -12 (DSE-12): Computational Methods & Molecular Modelling

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 Methods & Molecular Modelling (DSE-12)	**04**	**03**	**--**	**01**	Class 12th with Physics, Chemistry and Mathematics	**--**

Learning Objectives

The Objectives of this course are as follows:

- To make students learn the theoretical background of computational techniques in molecular modelling.
- To give the different flavours of computational chemistry by the end of this course.
- To provide hands-on experience in molecular modelling on various software

Learning outcomes

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

- Explain the theoretical background of computational techniques and selective application to various molecular systems.
- 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 the use of software like Chem Sketch and Argus Lab in interesting hands-on exercises.
- Perform analysis of molecular properties using various software.

SYLLABUS OF DSE-12

UNIT-1 : Introduction **(Lectures: 6)**

Introduction to computational chemistry: Overview of Classical and Quantum Mechanical Methods (Ab initio, DFT, Semi-empirical, Molecular Mechanics, Molecular Dynamics, and Monte Carlo)

UNIT – 2: Potential Energy Surfaces **(Lectures: 6)**

Intrinsic Reaction Coordinates, Stationary points, Equilibrium points – Local and Global minima, Geometry optimization and energy minimization, the concept of transition state with examples, Hessian matrix

UNIT – 3 : Molecular Mechanics & Molecular Dynamics **(Lectures: 9)**

Molecular Mechanics

Force Fields (A brief explanation of all the terms of a basic force field), the basic idea of MM1, MM2, MM3, MM4, MM+, AMBER, BIO+, OPLS.

Molecular Dynamics

The concept of the periodic box, ensembles (microcanonical, canonical, isothermal – isobaric), steps in a typical MD simulation.

UNIT-4: Huckel Molecular Orbital Theory **(Lectures: 6)**

Huckel MO with examples: ethene and propenyl systems, Properties calculated – energy, charges, bond order, electronic energies, resonance energies.

UNIT- 5: Computational Methods **(Lectures: 18)**

Ab-initio methods

Antisymmetry principle, Slater determinants, SCF method, Hartree-Fock method.
Basis sets, Basis functions, STOs and GTOs, diffuse and polarization functions. Minimal basis sets, Basis set superposition error (BSSE) - Effective core potentials (ECP)
Advantages of ab initio calculations.

Density Functional Theory

A brief description of Density Functional Theory (DFT). Calculation of Electronic Properties in ground and Excited states

Semi-empirical methods

Basic idea about Zero differential overlap (ZDO) approximation

Some important concepts

Concepts of atomic charges, electrostatic potential maps, computation of thermodynamic properties and spectroscopic observables

Practical component

Practical: Credits: 01

(Laboratory periods:15 classes of 2 hours each)

1) Write the Z-Matrix of a given set of molecules.

2) Carry out geometry optimisation on H_2O, H_2S, H_2Se molecules compare the optimized bond angles and dipole moments from the results obtained. Obtain the ESP-mapped density surfaces and interpret the results obtained with reference to bonding in these molecules.

   Suggestive: A comparative analysis of results of the above exercise may be carried out using different quantum mechanical methods.

3) Calculate the energy of the following chemical species and arrange them in order of increasing stability.

   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.

4) Carry out geometry optimisation on the following chemical species and compare the shapes and dipole moments of the molecules.

   1-pentanol, 2-pentanol, 3-pentanol, 2-methylbutan-1-ol, 3-methylbutan-1-ol, 2-methylbutan-2-ol, 2-methylbutan-3-ol and 2,2-dimethylpropanol.

   Correlate the computationally obtained values of the dipole moments with the experimental values of the boiling points: (118 ºC, 100 ºC, 108 ºC, 82 ºC, of 1-butanol, 2-butanol, 2-methyl-1-propanol, and 2-methyl-2- propanol respectively).

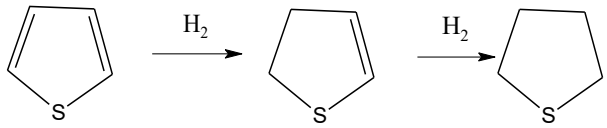
5) Based on the implicit electronic structure calculations, determine the heat of hydrogenation of Propylene.

6) Based on the calculations of enthanlies of the participating chemical species on optimized geometry of the molecules, calculate the reaction enthalpy at 298 K for the following, industrially important reactions:

   $$CH_4 + H_2O \rightarrow CO + 3H_2$$ (steam reforming of methane)

   ≡≡ (Haber-Bosch process)

7) Carry out geometry optimisation and determine the energy of the participating chemical species in the following reactions Using these results calculate the resonance energy of thiophene.



8) Carry out geometry optimisation & Energy calculations on the following species and obtain Frontier Molecular Orbitals. Visualize the Molecular Orbitals of these species and interpret the results for bonding in these molecules.
Benzene, Naphthalene, and Anthracene.

9) Compare the gas phase basicities of the methylamines by comparing the enthalpies of the following reactions:

$$BH^+ + NH_3 \rightarrow B + NH_4^+$$

Where B = CH_3NH_2, $(CH_3)_2NH$, $(CH_3)_3N$

10) On the basis of results of geometry optimization and energy calculations, determine the enthalpy of isomerization of cis and trans 2-butene.

11) Perform a conformational analysis of butane. Plot the graph between the angle of rotation and the energy of the conformers using spreadsheet software.

12) Compute the resonance energy of benzene by comparison of its enthalpy of hydrogenation with that of cyclohexene.

13) Calculate the electronic UV/Visible absorption spectrum of Benzene.

14) Calculate the electronic absorption spectra of formaldehyde.

15) Plot the electrostatic potential mapped on electron density for benzene and use it to predict the type of stacking in the crystal structure of benzene dimer.

16) On a given set of molecules methylamine (CH_3NH_2) carry out geometry optimization, single point energy and NBO calculations and interpret the output results treated at the ab initio RHF/3-21G level.

17) Study the mechanism of SN_2 reaction between Cl^- and CH_3Br involving a Walden inversion computationally.

18) Perform a geometry optimization followed by a frequency assessment (opt+freq keyword) using the B3LYP method and 6-31-G(d) basis set on a given set of small molecules i.e. BH_3, CH_4.
Suggestive: A greater number of molecules may be studied as per instructions received from the concerned teacher.

19) Based on the fundamentals of conceptual DFT calculate the ionization potential (IP), electron affinity (EA), electronegativity and electron chemical potential of a given set of molecules.

20) Perform molecular docking of Sulfonamide-type D-Glucose inhibitor into MurrD active site using Argus Lab.

21) Perform molecular dynamics (MD) simulation of a given alkali metal ion in aqueous function (RDF)

Essential/recommended readings

Theory:

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.
4. Leach, A.R. (2001), **Molecular Modelling**, Prentice-Hall.
5. House, J.E. (2004), **Fundamentals of Quantum Chemistry**, 2nd Edition, Elsevier.
6. McQuarrie, D.A. (2016), **Quantum Chemistry**, Viva Books.
7. Levine, I. N.; **Physical Chemistry**, 5th Edition, McGraw –Hill.

Practical:

1. https://www.afs.enea.it/software/orca/orca_manual_4_2_1.pdf
2. https://dasher.wustl.edu/chem430/software/avogadro/learning-avogadro.pdf
3. http://www.arguslab.com/arguslab.com/ArgusLab.html
4. https://barrett-group.mcgill.ca/tutorials/Gaussian%20tutorial.pdf
5. https://gaussian.com/techsupport/
6. https://gaussian.com/man/
7. https://gaussian.com/wp-content/uploads/dl/gv6.pdf
8. https://dasher.wustl.edu/chem478/software/spartan-manual.pdf
9. http://www.mdtutorials.com/gmx/
10. https://vina.scripps.edu/manual/

Important Instruction Note on working approach:

- A student is required to perform/investigate a minimum of 10 exercises from the given set of exercises.
- The students may use open source softwares; ArgusLab, Avogadro and ORCA. In case a licenced version softwares is available, if procured by the college, other licenced softwares may also be used.

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 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

Note:

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

- **The students are required to opt one paper each from DSEs 1-3 in Semester 3, DSEs 4-6 in Semester 4, DSEs 7-9 in Semester 5 and DSEs 10-13 in Semester 6.**

- **Research Methodology (DSE 13) shall be offered as one of the DSE courses in semester VI or VII. If a student wishes to pursue four years Honours Degree with Research, he/she shall compulsorily opt for a Research Methodology course in either Semester VI or VII.**

Details of Generic Elective (GE) Courses offered by Department of Chemistry

GE COURSES –21 (4 Credits each-3T+1P/2T+2P)		
COURSE CODE	**NAME OF THE COURSE**	**CREDITS** **T=Theory Credits** **P=Practical Credits**
CHEMISTRY-GE-1	Atomic Structure and Chemical Bonding	T=2 P=2
CHEMISTRY-GE-2	Coordination and Organometallic Compounds	T=2 P=2
CHEMISTRY-GE-3	Bioinorganic Chemistry	T=2 P=2
CHEMISTRY-GE-4	Basic Concepts of Organic Chemistry	T=2 P=2
CHEMISTRY-GE-5	Chemistry of Oxygen containing Functional Groups and their Application to Biology	T=2 P=2
CHEMISTRY-GE-6	Molecules of Life	T=2 P=2
CHEMISTRY-GE-7	States of Matter	T=2 P=2
CHEMISTRY-GE-8	Chemical Kinetics and Photochemistry	T=2 P=2
CHEMISTRY-GE-9	Conductance and Electrochemistry	T=2 P=2
CHEMISTRY-GE-10	Basics of Polymer Chemistry	T=2 P=2
CHEMISTRY-GE-11	Chemistry of Food Nutrients	T=2 P=2
CHEMISTRY-GE-12	Chemistry: Statistical Methods and Data Analysis	T=2 P=2
CHEMISTRY-GE-13	Medicines in Daily Life	T=2 P=2
CHEMISTRY-GE-14	Chemistry: Molecular Modelling, Artificial Intelligence and Machine Learning	T=2 P=2
CHEMISTRY-GE-15	Chemistry and Society	T=2 P=2

CHEMISTRY-GE-16	Role of Metals in Medicines	T=2 P=2
CHEMISTRY-GE-17	Energy and the Environment	T=3 P=1
CHEMISTRY-GE-18	Fragrances and Flavours: An Industry's Perspective	T=3 P=1
CHEMISTRY-GE-19	Radio-chemistry in Energy, Medicine and Environment	T=3 P=1
CHEMISTRY-GE-20	Green Chemistry	T=2 P=2
CHEMISTRY GE-21	Chemistry in Indology and Physical & Mental Well Being	T=3 P=1

GE Pool A: Semester I, III, V (ODD SEMESTERS)

1. GE-1: Atomic Structure and Chemical Bonding
2. GE-3: Bioinorganic Chemistry
3. GE-4: Basic Concepts of Organic Chemistry
4. GE-7: States of Matter
5. GE-9: Conductance and Electrochemistry
6. GE-11: Chemistry of Food Nutrients
7. GE-12: Chemistry: Statistical Methods and Data Analysis
8. GE-13: Medicines in Daily Life
9. GE-15: Chemistry and Society
10. GE-19 Radio-chemistry in Energy, Medicine and Environment
11. GE-21: Chemistry in Indology and Physical & Mental Well Being

GE Pool B: Semester II, IV, VI (EVEN SEMESTERS)

1. GE-2: Coordination and Organometallic Compounds
2. GE-5: Chemistry of Oxygen containing Functional Groups and their Application to Biology
3. GE-8: Chemical Kinetics and Photochemistry
4. GE-10: Basics of Polymer Chemistry
5. GE-14: Chemistry: Molecular Modelling, Artificial Intelligence and Machine Learning
6. GE-6: Molecules of Life
7. GE-16: Role of Metals in Medicines
8. GE-17: Energy and the Environment
9. GE-18: Fragrances and Flavours: An Industry's Perspective
10. GE-20: Green Chemistry

Course Code: CHEMISTRY- GE-1

Course Title: Atomic Structure and Chemical Bonding

Total Credits: 04 (Credits: Theory-02, Practical-02)

Total Lectures: Theory- 30, Practical-60

Objectives: The course reviews the structure of the atom, which is a necessary pre-requisite in understanding the nature of chemical bonding in compounds. It provides basic knowledge about ionic and covalent bonding. The constitution of the course strongly aids in the paramount learning of the fundamental concepts about atomic structure, chemical bonding and their applications.

Learning Outcomes:

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

- Solve the conceptual questions using the knowledge gained by studying the quantum mechanical model of the atom, quantum numbers, electronic configuration, radial and angular distribution curves, and shapes of s, p, and d orbitals
- Understand the concept of lattice energy and solvation energy.
- Draw the plausible structures and geometries of molecules using radius ratio rules, VSEPR theory and MO diagrams (homo- & hetero-nuclear diatomic molecules).

Theory:

Unit 1: Atomic Structure **Lectures: 14**

Review of: Bohr's theory and its limitations, Heisenberg uncertainty principle, Dual behaviour of matter and radiation, De-Broglie's relation, Hydrogen atom spectra, need of a new approach to atomic structure. Time independent Schrodinger equation and meaning of various terms in it. Significance of ψ and ψ2 , Schrödinger equation for hydrogen atom, radial and angular parts of the hydrogen wave functions (atomic orbitals) and their variations for 1s, 2s, 2p, 3s, 3p and 3d orbitals (Only graphical representation), radial and angular nodes and their significance, radial distribution functions and the concept of the most probable distance with special reference to 1s and 2s atomic orbitals. Significance of quantum numbers, orbital angular momentum and quantum numbers ml and ms. Shapes of s, p and d atomic orbitals, nodal planes, discovery of spin, spin quantum number (s) and magnetic spin quantum number (ms). Rules for filling electrons in various orbitals, electronic configurations of the atoms, stability of half-filled and completely filled orbitals, concept of exchange energy, relative energies of atomic orbitals, anomalous electronic configurations.

Unit 2: Chemical Bonding and Molecular Structure — Lectures: 16

Ionic Bonding: General characteristics of ionic bonding, energy considerations in ionic bonding, lattice energy and solvation energy and their importance in the context of stability and solubility of ionic compounds, statement of Born-Landé equation for calculation of lattice energy (no derivation), Born Haber cycle and its applications, covalent character in ionic compounds, polarizing power and polarizability, Fajan's rules. Ionic character in covalent compounds, bond moment, dipole moment and percentage ionic character. Covalent bonding: VB Approach: Shapes of some inorganic molecules and ions on the basis of VSEPR (H_2O, NH_3, PCl_5, SF_6, ClF_3, SF_4) and hybridization with suitable examples of linear, trigonal planar, square planar, tetrahedral, trigonal bipyramidal and octahedral arrangements. Concept of resonance and resonating structures in various inorganic and organic compounds. MO Approach: Rules for the LCAO method, bonding and antibonding MOs and their characteristics for ss, s-p and p-p combinations of atomic orbitals, nonbonding combination of orbitals, MO treatment of homonuclear diatomic molecules of 1st and 2nd periods (including idea of s-p mixing) and heteronuclear diatomic molecules such as CO, NO and NO^+.

Practicals: — Credits: 02

(Laboratory periods: 60)

1. Acid-Base Titrations: Principles of acid-base titrations to be discussed.

(i) Estimation of sodium carbonate using standardized HCl.

(ii) Estimation of carbonate and hydroxide present together in a mixture.

(iii) Estimation of carbonate and bicarbonate present together in a mixture.

(iv) Estimation of free alkali present in different soaps/detergents

2. Redox Titrations: Principles of oxidation-reduction titrations (electrode potentials) to be discussed.

(i) Estimation of oxalic acid by titrating it with $KMnO_4$.

(ii) Estimation of Mohr's salt by titrating it with $KMnO_4$.

(iii) Estimation of oxalic acid and sodium oxalate in a given mixture.

(iv) Estimation of Fe (II) ions by titrating it with $K_2Cr_2O_7$ using internal indicator (diphenylamine/ N-phenylanthranilic acid).

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.

Practicals:

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

Additional Resources:

1. Wulfsberg, G (2002), **Inorganic Chemistry**, Viva Books Private Limited.
2. Miessler, G.L.; Fischer P.J.; Tarr, D. A. (2014), **Inorganic Chemistry**, 5th Edition, Pearson.

Teaching Learning Process:

- Conventional chalk and board teaching,
- Class interactions and discussions
- Power point presentation on important topics.

Assessment Methods:

- Presentations by Individual Student/ Group of Students
- Class Tests at Periodic Intervals.
- Written assignment(s)
- End semester University Theory and Practical Examination

Keywords: Atomic Structure, Wave function, Quantum Numbers, Electronegativity, Ionic Bonding, Dipole Moment, VSEPR Theory, Covalent Bonding, Multiple Bonding, Molecular Orbitals, Bonding MO, Antibonding MO, Homonuclear, Heteronuclear.

Course Code: CHEMISTRY- GE-2

Course Title: Coordination and Organometallic Compounds

Total Credits: 04 (Credits: Theory-02, Practical-02)

Total Lectures: Theory- 30, Practical-60

Objectives: The purpose of the course is to introduce students to some important d-block metals and their compounds which they are likely to come across. Students learn about organometallic compounds, a frontier area of chemistry providing an interface between organic and inorganic chemistry. It familiarizes them with coordination compounds which find manifold applications in diverse fields.

Learning Outcomes:

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

- Familiarize with different types of organometallic compounds, their structures and bonding involved.
- Understand the nature of Zeise's salt and compare its synergic effect with that of carbonyls.
- Identify important structural features of tetrameric methyl lithium and understand the concept of multicenter bonding in these compounds
- Apply 18-electron rule to rationalize the stability of metal carbonyls and related species
- Use IR data to explain the extent of back bonding in carbonyl complexes
- Understand the terms, ligand, denticity of ligands, chelate, coordination number and use standard rules to name 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
- Understand the properties of coordination compounds and VBT and CFT for bonding in coordination compounds
- Explain the meaning of the terms Δ_o, Δt, pairing energy, CFSE, high spin and low spin and how
- CFSE affects thermodynamic properties like lattice enthalpy and hydration enthalpy

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Theory:

Unit 1: Coordination Chemistry **Lectures: 4**

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.

Unit 2:Bonding in coordination compounds **Lectures: 14**

Valence Bond Theory (VBT): Salient features of theory, concept of inner and outer orbital complexes of Cr, Fe, Co and Ni. 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_o.

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, square planar coordination.

Unit 3: Organometallic Compounds **Lectures: 12**

Definition and classification with appropriate examples based on nature of metal-carbon bond (ionic, s, p and multicentre bonds). Structure and bonding of methyl lithium and Zeise's salt. Structure and physical properties of ferrocene. 18-electron rule as applied to carbonyls. Preparation, structure, bonding and properties of mononuclear and polynuclear carbonyls of 3d metals. 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.

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

1. Gravimetry

Discuss basic principles of gravimetry (precipitation, co- precipitation and post precipitation, digestion, washing etc)

(i) Estimation of Ni(II) using dimethylglyoxime (DMG).

(ii) Estimation of copper as CuSCN.

(iii) Estimation of Al(III) by precipitating with oxine and weighing as Al(oxine)3 (aluminium oxinate).

2. Inorganic Preparations

(i) Schiff's base involving ethylenediamine and salicylaldehyde (or any other amine and aldehyde/ketone) and to check its purity using TLC.
(ii) Nickel/ Copper complex of the above prepared Schiff's base and its characterisation using UV/Vis spectrophotometer. The IR spectra also to be interpreted
(iii) tetraamminecopper (II) sulphate
(iv) potassium trioxalatoferrate (III) trihydrate.
(v) tetraamminecarbonatocobalt(III) nitrate

References:

Theory:

1. Atkins, P.W.; Overton, T.L.; Rourke, J.P.; Weller, M.T.; Armstrong, F.A. (2010), **Shriver and Atkins Inorganic Chemistry**, W. H. Freeman and Company.
2. Miessler, G. L.; Fischer P.J.; Tarr, D.A. (2014), **Inorganic Chemistry**, Pearson.
3. Huheey, J.E.; Keiter, E.A., Keiter; R.L., Medhi, O.K. (2009), **Inorganic Chemistry-Principles of Structure and Reactivity**, Pearson Education.
4. Pfennig, B. W. (2015), **Principles of Inorganic Chemistry.** John Wiley & Sons.
5. Cotton, F.A.; Wilkinson, G. (1999), **Advanced Inorganic Chemistry** Wiley-VCH.

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. Schiff Base Complex of Cu (II) with Antibacterial and Electrochemical Study, Arjun C. Bhowmick, Majharul I. Moim, Miththira Balasingam **, American Journal of Chemistry** 2020, 10(2): 33-37, DOI: 10.5923/j.chemistry.20201002.03

Teaching Learning Process:

- Conventional chalk and board teaching,
- Class interactions and discussions
- Power point presentation on important topics.

Assessment Methods:

- Presentations by Individual Student/ Group of Students
- Class Tests at Periodic Intervals.
- Written assignment(s)
- End semester University Theory and Practical Examination

Keywords: Organometallic compounds, metal carbonyls, synergistic effect, Coordination compounds, VBT, Crystal field theory, Splitting of d levels, Dq

Course Code: CHEMISTRY- GE-3

Course Title: Bioinorganic chemistry

Total Credits: 04 (Credits: Theory-02, Practical-02)

Total Lectures: Theory- 30, Practical-60

Objectives: The purpose of the course is to introduce students to bioinorganic chemistry, currently a frontier area of chemistry providing an interface between organic chemistry, inorganic chemistry and biology. The student would learn about the importance of inorganic chemical species, especially metals, in biological systems, through discussions on topics such as the sodium-potassium pump, the applications of iron in physiology, including iron transport and storage system, role of magnesium in energy production and chlorophyll, toxicity of heavy metal ions and their antidotes.

Learning Outcomes:

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

- Classify metal ions in biological systems as essential, non-essential, trace & toxic.
- Diagrammatically explain the working of the sodium-potassium pump in organisms and the factors affecting it
- Understand the role of metal ions such as Mg, Ca and Fe in biological systems.
- Understand the toxicity of heavy metal ions (Hg, Pb, Cd and As) in the physiological system
- Explain the use of chelating agents in medicine

Theory:

Unit 1: Introduction **Lectures: 6**

A brief introduction to bio-inorganic chemistry. Metal ions present in biological systems and their classification on the basis of action (essential, non-essential, trace & toxic). Classification of metallobiomolecules (enzymes, transport and storage proteins and non-proteins). Brief idea about membrane transport, channels, pumps.

Unit 2:Role of s-block Elements in Biological System **Lectures: 8**

Role of metal ions present in biological systems with special reference to Na^+, K^+ and Mg^{2+} and Ca^{2+} ions: Na/K pump; Ca pump, role of Mg^{2+} ions in energy production and chlorophyll. Role of calcium in bone formation.

Unit 3:Role of iron in Biological System **Lectures: 8**

Role of iron in oxygen transport and storage (haemoglobin and myoglobin), Perutz mechanism,

Cooperative effect, Bohr effect, comparison of oxygen saturation curves of haemoglobin and myoglobin, carbon monoxide. Storage and transport of iron in humans (ferritin and transferrin).

Unit 4: Toxicity of Heavy Metal Ions **Lectures: 8**

Toxicity of heavy metal ions (Hg, Pb, Cd and As), reasons for toxicity and their antidotes

Practicals: **Credits: 02**

(Laboratory periods: 60)

1. **Spectrophotometric estimation:**

(i) Verify Lambert-Beer's law and determine the concentration of $CuSO_4/KMnO_4/K_2Cr_2O_7/CoSO_4$ in a solution of unknown concentration

(ii) Spectrophotometric estimation of Fe^{2+} ions by using 1, 10- phenanthroline

(iii) Determination of the composition of the Fe^{3+} - salicylic acid complex in solution by Job's method.

2. **Complexometric titrations using disodium salt of EDTA:**

1. Estimation of Zn^{2+} using EBT / Xylenol orange as indicator
2. Estimation of Mg^{2+}
3. Estimation of Ca^{2+} by substitution method
4. To estimate the concentration of Ca in commercially available medicines.
5. To estimate the Mg present in multivitamins.

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. Cotton, F.A.; Wilkinson, G.; Gaus, P.L. **Basic Inorganic Chemistry**, 3rd Edition,Wiley India.
4. Crichton, R.R. (2008), **Biological Inorganic Chemistry: An Introduction**. Amsterdam, Elsevier.
5. Kaim, W., B. Schwederski and A. Klein. (2014), **Bioinorganic Chemistry: Inorganic Elements in the Chemistry of Life: An Introduction and Guide.** 2nd Edition, Wiley.

Practical:

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

Additional Resources:

1. Lippard, S.J.; Berg, J.M. (1994), **Principles of Bioinorganic Chemistry**, Panima Publishing Company.
2. Greenwood, N.N.; Earnshaw, A. (1997), **Chemistry of the Elements**, 2nd Edition, Elsevier

Teaching Learning Process:

- Conventional chalk and board teaching,
- Class interactions and discussions
- Power point presentation on important topics.

Assessment Methods:

- Presentations by Individual Student/ Group of Students
- Class Tests at Periodic Intervals.
- Written assignment(s)
- End semester University Theory and Practical Examination

Keywords: Bioinorganic chemistry; Sodium potassium pump; chlorophyll, ATP, Haemoglobin, myoglobin, ferritin, transferrin, toxicity, heavy metal ions, antidotes

Course Code: CHEMISTRY- GE-4

Course Title: Basic Concepts of Organic Chemistry

Total Credits: 04 (Credits: Theory-02, Practical-02)

Total Lectures: Theory- 30, Practical-60

Objectives: This course is designed to teach the fundamentals of organic chemistry and the introduction of a new concept of visualizing the organic molecules in a three- dimensional space. To establish the applications of these concepts, different types of organic reactions are introduced. The constitution of the course strongly aids in the paramount learning of the 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.
- Formulate the mechanism of organic reactions by recalling and correlating the fundamental properties of the reactants involved.

- Learn and identify many organic reaction mechanisms including free radical substitution, electrophilic addition and electrophilic aromatic substitution.
- Differentiate between various types of organic reactions possible on the basis of reaction conditions

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Theory:

Unit 1: Basic Concepts **Lectures: 6**

Electronic displacements and their applications: Inductive, electromeric, resonance and mesomeric effects and hyperconjugation. Dipole moment, acidity and basicity.
Homolytic and heterolytic fissions with suitable examples. Types, shape and relative stability of carbocations, carbanions and free radicals. Electrophiles and nucleophiles
Concept of Aromaticity: Huckel's rule

Unit 2: Stereochemistry **Lectures: 10**

Stereoisomerism: Optical activity and optical isomerism, asymmetry, chirality, enantiomers, diastereomers. specific rotation; Configuration and projection formulae: Newmann, Sawhorse, Fischer and their interconversion. Chirality in molecules with one and two stereocentres; meso configuration.
CIP rules: Erythro/Threo, D/L and R/S designations.
Geometrical isomerism: *cis-trans, syn-anti* and *E/Z* notations.

Unit 3: Types of organic reactions **Lectures: 14**

Introduction to substitution, addition, elimination, isomerization, rearrangement, oxidation and reduction reactions.
Free radical substitutions (Halogenation), concept of relative reactivity v/s selectivity. Free radical reactions in the biological reactions
Mechanisms of E1, E2, Saytzeff, Hoffmann eliminations and Cope elimination. Biological dehydration reactions
Electrophilic Additions reactions of alkenes and alkynes: mechanism with suitable examples, (Markownikoff/Antimarkownikoff addition), syn and anti-addition; addition of H_2, X_2, hydroboration-oxidation, ozonolysis, hydroxylation.
Nucleophilic substitution reactions – S_N1 and S_N2 mechanisms with stereochemical aspects and effect of solvent; nucleophilic substitution vs. elimination. Biological methylating agents
Electrophilic aromatic substitution: halogenation, nitration, sulphonation, Friedel Crafts alkylation/ acylation with their mechanism. Directing effects of groups in electrophilic substitution.

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

1. Calibration of a thermometer and determination of the melting points of the organic compounds (Kjeldahl method, electrically heated melting point apparatus and BODMEL)
2. Purification of the organic compounds by crystallization using the following solvents:
   a. Water b. Alcohol c. Alcohol-Water

3. Determination of boiling point of liquid compounds. (Boiling point lower than and more than 100 °C by distillation, capillary method and BODMEL)
4. Acetylation of one of the following compounds: amines (aniline, *o*-, *m*-, *p*- toluidines and *o*-, *m*-, *p*-anisidine) and phenols (*β*-naphthol, salicylic acid) either by conventional or green method.
5. Bromination of acetanilide/aniline/phenol either by conventional or green method.
6. Nitration of chlorobenzene/nitrobenzene.

References:

Theory:

1. Sykes, P. (2005), **A Guide Book to Mechanism in Organic Chemistry**, Orient Longman.
2. Eliel, E. L. (2000), **Stereochemistry of Carbon Compounds**, Tata McGraw Hill.
3. Morrison, R. N.; Boyd, R. N., Bhattacharjee, S.K. (2010), **Organic Chemistry**, 7th Edition, Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
4. Mehta B.; Mehta M. (2015), **Organic Chemistry**, PHI Learning Private Limited
5. Bahl, A; Bahl, B. S. (2012), **Advanced Organic Chemistry**, S. Chand.

Practicals:

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.

Teaching Learning Process:

- Lectures in class rooms
- PowerPoint presentations/videos
- Hands-on learning using 3-D models

Assessment Methods:

- Presentation/assignment by students
- Class Test at Periodic Intervals
- Written Assignment
- Continuous evaluation in practicals
- End Semester University Theory and Practical Exams

Keywords: Electronic effects, Huckel rule, Stereochemistry, Free radical substitutions, eliminations reactions, electrophilic additions, ozonolysis, nucleophilic substitution reactions, electrophilic aromatic substitution

Course Code: CHEMISTRY- GE-5

Course Title: Chemistry of Oxygen containing Functional Groups and their Applications to Biology

Total Credits: 04 (Credits: Theory-02, Practical-02)

Total Lectures: Theory- 30, Practical-60

Objectives: This course is designed to teach the fundamental chemistry of oxygen containing functional groups. To establish these concepts typical reactions of alcohols, phenols, aldehydes, ketones, carboxylic acids and their derivatives are discussed. Relevance of oxygen containing functional groups to biology is taken up to help students appreciate the importance of these compounds in real world.

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 reaction chemistry.
- Formulate the mechanism of organic reactions by recalling and correlating the fundamental properties of the reactants involved.
- Understand the applications of functional group chemistry to biology.

Theory:

Unit 1: Alcohols (upto 5 Carbon) **Lectures: 5**

Structure and classification of alcohols as 1º, 2º & 3º, Reactions: Acidic character of alcohols and reaction with sodium, with HX (Lucas Test), esterification, oxidation (with PCC, alkaline $KMnO_4$, acidic $K_2Cr_2O_7$ and conc. HNO_3), Oppeneauer Oxidation, Biological oxidation Reactions

Unit 2: Phenols **Lectures: 4**

Acidity of phenols and factors affecting their acidity, Reactions: Electrophilic substitution reactions, *viz.* nitration, halogenation, sulphonation, Reimer-Tiemann reaction, Gattermann–Koch reaction, Houben-Hoesch condensation; Reaction due to OH group: Schotten-Baumann reaction

Unit 3: Aldehydes and Ketones (Aliphatic and Aromatic) **Lectures: 12**

Reactions: Nucleophilic addition, nucleophilic addition-elimination reaction including reaction with HCN, ROH, $NaHSO_3$, NH_2-G derivatives. Iodoform test, Aldol condensation and its biological application, Cannizzaro's reaction, Wittig reaction, Benzoin condensation,

Clemmensen reduction, Wolff Kishner reduction, Meerwein-Pondorff Verley reduction, enzyme-catalyzed additions to α,β-unsaturated carbonyl compounds.

Unit 4: Carboxylic acids and their derivatives (Aliphatic and Aromatic) Lectures: 9

Reactions: Hell-Volhard Zelinsky reaction, acidity of carboxylic acids, effect of substitution on acid strength, Claisen condensation and its biological applications, decarboxylation in biological systems, relative reactivities of acid derivatives towards nucleophiles, activation of carboxylate ions for nucleophilic acyl substitution reactions in biological systems, Reformatsky reaction, Perkin condensation.

Practicals: Credits: 02
(Laboratory periods: 60)

Preparations: (Mechanism of various reactions involved to be discussed) (Recrystallization, determination of melting point and calculation of quantitative yields to be done in all cases)

1. Oxime of aldehydes and ketones

2. 2,4-Dinitrophenylhydrazone of aldehydes and ketones

3. Aldol condensation using green method.

4. Benzoin condensation using Thiamine Hydrochloride as a catalyst.

5. Alkaline hydrolysis of amide/ester.

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

7. Identification of functional group for monofunctional organic compounds (Alcohols, phenols, aldehydes, ketones, carboxylic acids).

References:

Theory:

1. Sykes, P. (2005), **A Guide Book to Mechanism in Organic Chemistry**, Orient Longman.
2. Eliel, E. L. (2000), **Stereochemistry of Carbon Compounds**, Tata McGraw Hill.
3. Morrison, R. N.; Boyd, R. N., Bhattacharjee, S.K. (2010), **Organic Chemistry**, 7th Edition, Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
4. Mehta B.; Mehta M. (2015), **Organic Chemistry**, PHI Learning Private Limited Bahl,
5. Bahl, A., Bahl, B. S. (2012), **Advanced Organic Chemistry**, S. Chand.
6. Bruice, Paula Y. (2020), **Organic Chemistry**, 8th Edition, Pearson.

Practicals:

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.

Teaching Learning Process:

- Lectures in class rooms
- Power point presentations/videos
- Hands-on learning using 3-D models

Assessment Methods:

- Presentation/assignment by students
- Class Test at Periodic Intervals
- Written Assignment
- Continuous evaluation in practicals
- End Semester University Theory and Practical Exams

Keywords: Alcohols, Lucas Test, Phenol, Aldehydes, Ketones, Nucleophilic addition, nucleophilic addition – elimination, Cannizzaro's reaction, Wittig reaction, Benzoin condensation, Enzyme-catalysed reaction, Carboxylic acid, Claisen condensation

Course Code: CHEMISTRY- GE-6

Course Title: Molecules of Life

Total Credits: 04 (Credits: Theory-02, Practical-02)

Total Lectures: Theory- 30, Practical-60

Objectives: This course is designed to deliver information about the chemistry of carbohydrates, proteins & enzymes and its relevance in the biological system using suitable examples. Key emphasis is placed on understanding the structural principles that govern reactivity/physical /biological properties of biomolecules as opposed to learning structural details.

Learning Outcomes:

By the end of the course, the 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.

Theory:

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 and correlation with drug action **Lectures: 8**

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 stereospecificity), enzyme inhibitors and their importance, 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.

Practicals: **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.
4. Estimation of proteins by Lowry's method.
5. Study of the action of salivary amylase on starch under optimum conditions.
6. Qualitative tests for amino acids, proteins and carbohydrates.
7. Separation and identification of mixture of sugars by paper chromatography.

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).
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.
2. **Manual of Biochemistry Workshop**, 2012, Department of Chemistry, University of Delhi.

Teaching Learning Process:

- Chalk and black board method. Along with pedagogy of flipped classroom
- Certain topics like mechanism of enzyme action and enzyme inhibition can be taught through audio-visual aids.
- Students should be encouraged to participate actively in the classroom through regular presentations on curriculum-based topics, peer assessment, designing games based on specific topics etc.
- As the best way to learn something is to do it yourself, practicals are planned in such a way so as to reinforce the topics covered in theory.

Assessment Methods:

- Graded assignments
- Class tests and Quizzes
- Class seminars by students on course topics with a view to strengthening the content through width and depth
- Continuous evaluation for the practicals
- End semester university theory and practical examination.

Keywords: Carbohydrates, point, Amino acids, Enzymes, SAR, Drug Receptor Theory

Course Code: CHEMISTRY- GE-7

Course Title: States of Matter

Total Credits: 04 (Credits: Theory-02, Practical-02)

Total Lectures: Theory- 30, Practical-60

Objectives: The students will learn about the properties of ideal and real gases deviation from ideal behaviour, properties of liquid, types of solids with details about crystal structure. The student will also learn about the reaction rate, order, activation energy and theories of reaction rates.

Learning Outcomes:

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

- Derive ideal gas law from kinetic theory of gases and explain why the real gases deviate from ideal
- behaviour.
- Explain Maxwell-Boltzmann distribution, critical constants and viscosity of gases.
- Explain the properties of liquids especially surface tension and viscosity.
- Explain symmetry elements, crystal structure specially NaCl, KCl and CsCl
- Define rate of reactions and the factors that affect the rates of reaction.
- Understand the concept of rate laws e.g., order, molecularity, half-life and their determination
- Learn about various theories of reaction rates and how these account for experimental observations.

Theory:

Unit 1: Kinetic Theory of Gases **Lectures: 13**

Postulates of kinetic theory of gases and derivation of the kinetic gas equation, deviation of real gases from ideal behaviour, compressibility factor, causes of deviation, van der Waals equation of state for real gases. Boyle temperature (derivation not required), critical phenomena, critical constants and their calculation from van der Waals equation, Andrews isotherms of CO_2, Maxwell Boltzmann distribution laws of molecular velocities and molecular energies (graphic representation – derivation not required) and their importance. Temperature dependence of these distributions, most probable, average and root mean square velocities (no derivation), collision cross section, collision number, collision frequency, collision diameter and mean free path of molecules, viscosity of gases and effect of temperature and pressure on coefficient of viscosity (qualitative treatment only).

Unit 2: Liquids State **Lectures: 5**

Surface tension and its determination using stalagmometer, Viscosity of a liquid and determination of coefficient of viscosity using Ostwald viscometer, effect of temperature on surface tension and

coefficient of viscosity of a liquid (qualitative treatment only). Effect of addition of various solutes on surface tension and viscosity. Explanation of cleansing action of detergents.

Unit 3: Solid State **Lectures: 12**

Forms of solids, symmetry elements, unit cells, crystal systems, Bravais lattice types and identification of lattice planes. Laws of crystallography - law of constancy of interfacial angles. Law of rational indices, Miller indices. X–ray diffraction by crystals, Bragg's law and powder XRD. Powder diffraction patterns of NaCl, CsCl and KCl (qualitative treatment only), defects in crystals. Glasses and liquid crystals.

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

1. Surface tension measurement (use of organic solvents excluded): Determination of the surface tension of a liquid or a dilute solution using a stalagmometer.

2. Viscosity measurement (use of organic solvents excluded):
a) Determination of the relative and absolute viscosity of a liquid or dilute solution using an Ostwald viscometer.
b) Study of the variation of viscosity of an aqueous solution with concentration of solute.

3. Solis State: Powder XRD
a) Differentiate and classify the given set of the diffraction pattern as crystalline materials or amorphous (Glass) substance.
b) Carry out analysis of a given set of powder XRD and determine the type of the cubic crystal structure
c) Determination of approximate crystal size from a given set of powder XRD

References:

Theory:

1. Atkins, P.W.; Overton, T.L.; Rourke, J.P.; Weller, M.T.; Armstrong, F.A. (2010), **Shriver and Atkin's Inorganic Chemistry**, Oxford.
3. Miessler, G. L.; Tarr, D.A. (2014), **Inorganic Chemistry**, Pearson.
4. Castellan, G. W. (2004), **Physical Chemistry**, Narosa.
5. Kapoor, K.L. (2015), **A Textbook of Physical Chemistry**, Vol.1, 6th Edition, McGraw Hill Education.
6. Kapoor, K.L. (2015), **A Textbook of Physical Chemistry**, Vol.5, 3rd Edition, McGraw Hill Education.

Practicals:

1. Khosla, B.D.; Garg, V.C.;Gulati, A.(2015),**Senior Practical Physical Chemistry**, R. Chand & Co.

Teaching Learning Process:

- Teaching Learning Process for the course is visualized as largely student-focused.
- Transaction through an intelligent mix of conventional and modern methods.
- Engaging students in cooperative learning.
- Learning through quiz design.
- Problem solving to enhance comprehension.

Assessment Methods: Assessment will be done on the basis of regular class test, presentations and assignments as a part of internal assessment during the course as per the curriculum. End semester university examination will be held for both theory and practical. In practical, assessment will be done based on continuous evaluation, performance in the experiment on the date of examination and viva voce.

Keywords: Ideal/real gases, Surface tension, Viscosity, Crystal systems, Powder-XRD.

Course Code: CHEMISTRY- GE-8

Course Title: Chemical Kinetics and Photochemistry

Total Credits: 04 (Credits: Theory-02, Practical-02)

Total Lectures: Theory- 30, Practical-60

Objectives: The students will learn about fundamentals of chemical kinetics, rates of chemical reactions, complex reactions, theories of reaction rate and the laws of photochemistry aimed at understanding electronic transitions upon irradiation of electromagnetic radiation in UV-Vis region.

Learning Outcomes:

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

- Understand the concept of rate of a reaction, order and molecularity of a reaction, various factors affecting the rate and theories of reaction rates.
- Students will be able to apply the learnt concepts in studying the reaction kinetics of various reactions.
- Understand the basic concepts of photochemistry, photochemical and photosensitized reactions and their role in biochemical systems.

Theory:

Unit 1: Chemical Kinetics **Lectures: 20**

The concept of reaction rates, effect of temperature, pressure, catalyst and other factors on reaction rates. Order and molecularity of a reaction, derivation of integrated rate equations for zero, first and second order reactions (both for equal and unequal concentrations of reactants), half–life of a reaction, general methods for determination of order of a reaction. kinetics of complex reactions (integrated rate expressions up to first order only): (i) Opposing reactions (ii) parallel reactions and (iii) consecutive reactions and their differential rate equations (steady-state approximation in reaction mechanisms). Concept of activation energy and its calculation from Arrhenius equation. Theories of reaction rates: Collision theory and activated complex theory of bi-molecular reactions. Comparison of the two theories (qualitative treatment only)

Unit 2: Photochemistry **Lectures: 10**

Characteristics of electromagnetic radiation, Jablonski Diagram. Lambert-Beer's law and its limitations, physical significance of absorption coefficients. Laws of photochemistry, quantum yield, actinometry, examples of low and high quantum yields, photochemical equilibrium and the differential rate of photochemical reactions, photosensitized reactions, quenching. Role of photochemical reactions in biochemical processes.

Practicals: **Credits: 02**

(Laboratory periods: 60)

Chemical Kinetics

Study the kinetics of the following reactions by integrated rate method:

a) Acid hydrolysis of methyl acetate with hydrochloric acid.

b) Compare the strength of HCl and H2SO4 by studying the kinetics of hydrolysis methyl acetate.

c) Initial rate method: Iodide-persulphate reaction

d) Integrated rate method: Saponification of ethyl acetate.

e) Study the reactiob kinetics of Iodination of acetone.

References:

Theory:

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

2. Kapoor, K.L. (2015), **A Textbook of Physical Chemistry**, Vol 5, 6th Edition, McGraw Hill Education.

3. Kapoor, K.L. (2013), **A Textbook of Physical Chemistry**, Vol 6, 3rd Edition, McGraw Hill Education.

Practicals:

1. Khosla, B.D.; Garg, V.C.;Gulati, A.(2015), **Senior Practical Physical Chemistry**, R. Chand & Co.

Teaching Learning Process:

- Teaching Learning Process for the course is visualized as largely student-focused

- Transaction through an intelligent mix of conventional and modern methods
- Engaging students in cooperative learning.
- Learning through quiz design.
- Problem solving to enhance comprehension.

Assessment Methods: Assessment will be done on the basis of regular class test, presentations and assignments as a part of internal assessment during the course as per the curriculum. End semester university examination will be held for both theory and practical. In practical, assessment will be done based on continuous evaluation, performance in the experiment on the date of examination and viva voce.

Keywords: Rate Law, Rate constant. Arrhenius Equation, Lambert-Beer's law, Jablonski Diagram

Course Code: CHEMISTRY- GE-9

Course Title: Conductance and Electrochemistry

Total Credits: 04 (Credits: Theory-02, Practical-02)

Total Lectures: Theory- 30, Practical-60

Objectives: The students will learn about conductance, its measurement and applications. Students will also learn principles of electrochemical cells: Electrolytic and Galvanic cell, measurement of, measurement of emf and its applications.

Learning Outcomes:

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

- Explain the factors that affect conductance, migration of ions and application of conductance measurement.
- Understand different types of galvanic cells, their Nernst equations, measurement of emf, calculations of thermodynamic properties and other parameters from the emf measurements.
- Understand applications of Emf measurements in relation to determination of activity coefficients, pH of a solution and Potentiometric titrations.

Theory:

Unit 1: Conductance **Lectures: 10**

Quantitative aspects of Faraday's laws of electrolysis. Arrhenius theory of electrolytic dissociation. Conductivity: equivalent and molar conductivity and their variation with dilution for weak and strong electrolytes, Kohlrausch Law of independent migration of ions. Wein Effect and Debye–Falkanhegan Effect.

Transference number and its experimental determination using Hittorf and moving boundary methods, Ionic mobility, applications of conductance measurements: determination of degree of ionization of weak electrolytes, solubility and solubility products of sparingly soluble salts, ionic product of water, hydrolysis constant of a salt. Conductometric titrations (only acid-base).

Unit 2: Electrochemistry **Lectures: 20**

Reversible and irreversible cells with Examples, concept of EMF of a cell, measurement of EMF of a cell, Nernst equation and its importance, types of electrodes, standard electrode potential (reduction Potential) and its application to Gas–ion half-cell. 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. Concentration cells with transference and without transference, liquid junction potential; determination of activity coefficients and salt bridge, pH determination using hydrogen electrode. Potentiometric titrations-qualitative treatment (acid-base and oxidation-reduction only).

Practicals: **Credits: 02**

(Laboratory periods: 60)

Conductance

1. Determination of cell constant.
2. Determination of equivalent conductance, degree of dissociation and dissociation constant of a weak acid.
3. Perform the following conductometric titrations:

a) Strong acid vs strong base

b) Weak acid vs strong base.

Potentiometry

Perform the potentiometric titrations of (i) Strong acid vs strong base, (ii) Weak acid vs strong base and (iii) Mohr's salt vs $KMnO_4$.

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. (2013), **A Textbook of Physical Chemistry**,Vol 3, 3rd Edition, McGraw Hill Education.

Practicals:

1. Khosla, B.D.; Garg, V.C.;Gulati, A.(2015), **Senior Practical Physical Chemistry**, R. Chand & Co.

Teaching Learning Process:

- Teaching Learning Process for the course is visualized as largely student-focused.
- Transaction through an intelligent mix of conventional and modern methods.

- Engaging students in cooperative learning.
- Learning through quiz design.
- Problem solving to enhance comprehension.

Assessment Methods: Assessment will be done on the basis of regular class test, presentations and assignments as a part of internal assessment during the course as per the curriculum. End semester university examination will be held for both theory and practical. In practical, assessment will be done based on continuous evaluation, performance in the experiment on the date of examination and viva voce.

Keywords: Conductance, Ionic mobility, EMF, Nernst Equation, transference number.

Course Code: CHEMISTRY- GE-10

Course Title: Basics of Polymer Chemistry

Total Credits: 04 (Credits: Theory-02, Practical-02)

Total Lectures: Theory- 30, Practical-60

Objectives: The objective of this course is to help the student to know about the synthesis, properties and applications of polymers.

Learning Outcomes:

By the end of the course, the students will:

- Know about classification of polymeric material.
- Learn about different mechanisms of polymerization and polymerization techniques
- Evaluate kinetic chain length of polymers based on their mechanism
- Differentiate between polymers and copolymers
- Learn about different methods of finding out average molecular weight of polymer.
- Differentiate between glass transition temperature (Tg) and crystalline melting point (Tm)
- Learn properties and applications of various useful polymers in our daily life

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Theory:

Unit 1: Introduction to polymers **Lectures:10**

Different schemes of classification of polymers, Polymer nomenclature, configuration and conformation of polymers, Molecular forces and chemical bonding in polymers, Texture of Polymers

Functionality and its importance:

Criteria for synthetic polymer formation, basic methods of polymerization processes and their mechanism: addition, condensation, Relationships between functionality, extent of reaction and degree of polymerization.

Unit 2: Properties of Polymers **Lectures: 10**

Glass transition temperature (Tg) and determination of Tg, Free volume theory, WLF equation, Factors affecting glass transition temperature (Tg).
Crystallization and crystallinity: Determination of crystalline melting point and degree of crystallinity,
Morphology of crystalline polymers, Factors affecting crystalline melting point.
Molecular weight distribution and determination of molecular weight of polymers (Mn, Mw, etc.) by end group analysis, viscometry and osmotic pressure methods. Molecular weight distribution and its significance.

Unit 3: Preparation, properties and applications **Lectures: 10**

Brief introduction to preparation, structure, properties and application of the following polymers: polyolefins, polystyrene and styrene copolymers, poly(vinyl chloride), poly(vinyl acetate), acrylic polymers, fluoro polymers, polyamides and related polymers. Phenol formaldehyde resins (Bakelite, Novolac), polyurethanes, silicone polymers, polydienes, Polycarbonates, Conducting Polymers: polyacetylene, polyaniline, poly(p-phenylene sulphide, polypyrrole, polythiophene

Practicals: **Credits: 02**

(Laboratory periods: 60)

Polymer Synthesis

1. Free radical solution polymerization of styrene (St) / Methyl Methacrylate (MMA)/MethylAcrylate (MA).
2. Preparation of nylon 6,6
3. Redox polymerization of acrylamide
4. Precipitation polymerization of acrylonitrile
5. Preparation of urea-formaldehyde resin
6. Preparations of novalac resin/resole resin.
7. Microscale Emulsion Polymerization of Poly(methylacrylate).

Polymer characterization

1. Determination of molecular weight of polyvinyl propylidene in water by viscometry.
2. Determination of the viscosity-average molecular weight of poly(vinyl alcohol) (PVOH) and the fraction of head-to-head monomer linkages in the polymer.
3. Determination of molecular weight by end group analysis of polymethacrylic acid.

Polymer analysis

1. Estimation of the amount of HCHO in the given solution by sodium sulphite method.
2. Determine the melting point of crystalline polymer.
3. Measurement of glass transition temperature, T_g.s

References:

Theory:

1. Carraher,C. E. Jr. (2013), **Seymour's Polymer Chemistry**, Marcel Dekker, Inc.
2. Odian, G. (2004), **Principles of Polymerization**, John Wiley.
3. Billmeyer, F.W. (1984), **Text Book of Polymer Science**, John Wiley.
4. Ghosh, P. (2001), **Polymer Science & Technology**, Tata Mcgraw-Hill.
5. Lenz, R.W. (1967), **Organic Chemistry of Synthetic High Polymers**, Intersecience (Wiley).

Practical:

1. Allcock, H.R.; Lampe, F. W.; Mark, J. E. (2003), **Contemporary Polymer Chemistry**, Prentice-Hall.
2. Fried, J.R. (2003), **Polymer Science and Technology**, Prentice-Hall.
3. Munk, P.; Aminabhavi, T. M. (2002), **Introduction to Macromolecular Science,** John Wiley & Sons.
4. Sperling, L.H. (2005), **Introduction to Physical Polymer Science**, John Wiley & Sons.

Teaching Learning Process:

- Student centred teaching Learning process.
- Blend of conventional blackboard teaching and modern teaching learning tools
- Focus on real life applications of concepts
- Problem solving and quizzes for enhanced understanding of the concepts
- Engaging students in collaborative learning.
- Pre-lab learning of theoretical concept of the experiment.
- Performing the experiment, recording the data, calculating the result.
- Interpreting the result.
- Comparing the results of the class.
- Discussing the sources of error.

Assessment Methods:

- Class Tests at Periodic Intervals.
- Written assignment(s)
- Continuous evaluation of laboratory work and record file.
- Oral assessment, quizzes.
- Mock practical examination.
- Semester end University examination.

Keywords: Bonding, Texture, Polymerization, Crystallization, Properties, Applications.

Course Code: CHEMISTRY- GE-11

Course Title: Chemistry of Food Nutrients

Total Credits: 04 (Credits: Theory-02, Practical-02)

Total Lectures: Theory- 30, Practical-60

Objectives: This introductory course on food chemistry is designed in such a manner that the students develop a basic understanding of the components of food, their source, properties and interactions as well as changes that occur during processing, storage, and utilization.

Learning Objectives:

On completion of the course, the student will be able to:

- Build a strong understanding of chemistry of food: composition of food, role of each component.
- Understand some of the reactions and changes in individual food components which occur during processing, handling and storage

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Theory:

Unit 1: Carbohydrates **Lectures: 6**

Introduction, sources, functions, classification: monosaccharide, oligosaccharide and polysaccharide, structure and importance of polysaccharides in food chemistry (pectin, cellulose, starch, gums), chemical reactions of sugar: mutarotation, caramelisation; non enzymic browning and its prevention, role of carbohydrates as sweeteners in food.

Unit 2: Lipids **Lectures:8**

Introduction, sources, classification (fatty acids, phospholipids, fats & oils, waxes), common fatty acids present in oils and fats, Omega- 3&6 fatty acids, trans fats, chemical properties-Reichert Meissel value, Polenski value, iodine value, peroxide value, saponification value, effect of frying on fats, changes in fats and oils- rancidity, lipolysis, flavor reversion, auto-oxidation and its prevention.

Unit 3: Proteins **Lectures:8**

Introduction, sources, classification (simple, conjugated, derived), structure of protein (primary, secondary and tertiary), physico-chemical & functional properties of proteins, protein denaturation.

Unit 4: Vitamins & Minerals **Lectures:8**

Vitamins: Introduction, classification: fat-soluble vitamins & water-soluble vitamins.

Minerals: Introduction, classification: macrominerals (Ca, P, Mg) & microminerals (Se, Fe, I, Co, Zn, Cu, Se, Cr).

Physiological importance of vitamins and minerals, effect of food processing on vitamins and minerals.

Practicals: **Credits: 02**

(Laboratory periods: 60)

1. Determination of moisture in food products by hot air oven-drying method.
2. Colorimetric determination of Iron in vitamin / dietary tablets.
3. 2, 6-Dichlorophenol indophenol method for estimation of vitamin C in a given solution/ lemon Juice/chillies.
4. Estimation of total soluble sugar content by ferricyanide method (volumetric analysis).
5. Determination of saponification value of the given fat/oil.
6. Determination of iodine value of the given fat/oil.
7. Qualitative tests for proteins and carbohydrates.
8. Qualitative estimation of cholesterol by Liebermann Burchard method.

References:

Theory:

1. deMan, J.M., Finley, J.W., Hurst, W.J., Lee, C.Y. (2018), **Principles of Food Chemistry**, 4th Edition, Springer.
2. Msagati, T.A.M. (2013), **Chemistry of Food Additives and Preservatives**, Wiley-Blackwell.
3. Fennema, O.R. (2017), **Food Chemistry**, 5th Edition, CRC Press.
4. Attokaran, M. (2017), **Natural Food Flavors and Colorants**, 2nd Ed., Wiley-Blackwell.
5. Potter, N.N., Hotchkiss, J.H, (1995) **Food Science,** 5th Ed., Chapman & Hall.
6. Brannen, D., Davidsin, P.M., Salminen, T. Thorngate III, J.H. (2002), **Food Additives**, 2nd Edition, CRC Press.
7. Coultate, T. (2016), **Food: The Chemistry of its Components**, 6th Edn., Royal Society of Chemistry.
8. Belitz, H. D.; Grosch, W. (2009), **Food Chemistry**, Springer.
9. Course: FOOD CHEMISTRY (iasri.res.in)

Practical:

1. Ranganna, S. (2017). **Handbook of analysis and quality control for fruits and vegetable products**, 2nd Edn., McGraw Hill Education
2. Sawhney, S.K., Singh, R. (2001), **Introductory Practical Biochemistry**, Narosa Publishing House

Teaching Learning Process:

- Student centred teaching Learning process.
- Blend of conventional blackboard teaching and modern teaching learning tools
- Focus on real life applications of concepts
- Problem solving and quizzes for enhanced understanding of the concepts
- Engaging students in collaborative learning.
- Pre-lab learning of theoretical concept of the experiment.

Assessment Methods:

- Class Tests at Periodic Intervals.
- Written assignment(s)
- Continuous evaluation of laboratory work and record file.
- Oral assessment, quizzes.
- Mock practical examination.
- Semester end University examination.

Keywords: Food nutrients, Carbohydrates, Proteins, Lipids, Vitamins, Minerals, Browning reaction.

Course Code: CHEMISTRY- GE-12

Course Title: Chemistry: Statistical Methods and Data Analysis

Total Credits: 04 (Credits: Theory-02, Practical-02)

Total Lectures: Theory- 30, Practical-60

Objective: In this course the students will be given insight about the statistical treatment on the chemical analysis data along with illustration about the analysis of collected analytical data to take up a job of technician, scientist and laboratory manager. The presentation of data in different form such as "Table, Graph, Bar Diagram, Pie Chart, Venn diagram" are explained along with their reliability and validity.

Learning outcomes:

At the end of this course student will be:

- Familiar with interpretation and use of analytical data collected by different techniques,

- Significance of different analytical techniques and their applications,
- Reliability and presentation of data for reporting to different forum.

Theory:

Unit 1: Basics of Chemical Analysis **Lectures: 6**

Analytical Chemistry, Qualitative and quantitative analysis, Analytical methodology. Calibration of glass wares, recording laboratory data.

Unit 2: Different Methods of Chemical Analysis **Lectures: 8**

Titrimetric method: volumetric titremetry, standard solution, titrimetric curve, calculation; Gravimetric method: precipitation gravimetry, calculation and applications of gravimetry; and Spectrometric methods: introduction, principle and instrument, working quantitative aspects absorbance, applications in chemical analysis

Unit 3: Statistical Method of Chemical Analysis **Lectures: 8**

Accuracy and Precision, Comparison of precision, Errors, Distribution of random errors, propagation of errors, measurement of errors, significant figure, inter laboratory error, methods of least square analysis of variance, Q test, Z test, T test, statistical treatment of finite sample, recommendations for treating outliers. Minimising errors in analytical procedure.

Unit 4: Data Analysis and Validation **Lectures: 5**

Confidence interval, Testing of hypothesis, plotting of data, least square method, Figures of merit: sensitivity, detection limit, linear dynamic range, control test, upper control limit and lower control limit, Validation, reporting analytical results and significant figures

Unit 5: Sampling, Standardisation, Labelling and Calibration **Lectures: 7**

Analytical samples, sample size, constituent sample, real samples, sample, sample handling, preparing laboratory samples, automated sample handling, lab on chip and General laboratory principles, recording laboratory data, standards, comparison of standards, internal standard, external standards calibration, least square method, and multivariant calibration.

Practicals: **Credits: 02**

(Laboratory periods: 60)

1. Calibrate the volume of laboratory glass wares i.e. volumetric flask, beaker, burette and calibration constant.
2. Demonstrate the good laboratory practices like effect of dilution, temperature, taking observation, personal and apparatus safety.
3. Determine the quantitative presence of heavy metals like copper, chromium and iron in natural and laboratory samples using volumetric and gravimetric titration.

4. Determine the presence of magnesium ion in heavy water by EDTA method and prepare calibration curve.
5. Evaluate the absolute and method errors in a set of data collected during determination of nitrogen in an organic compound.
6. Calculate the standard deviation and predict precision of analytical results.
7. Determine the concentration of pollutant in natural sample after using external standards methods.
8. Compare the inter laboratory error of a spectroscopic results.
9. Evaluate the limit of detection for colorimetric analysis of dyes and coloured metals in wastes water samples.
10. Demonstrate the control of interference by masking by complexation.
11. Report the ten analytic results in significant numbers along with standard deviation.
12. Determine the confidence limit and interval for a laboratory instrument like breath alcohol analyser
13. Demonstrate the internal standard method for calibration of metal estimation.
14. Estimate the comparative effectiveness of different types of graphs like line, pi chart and bar graph.
15. Demonstrate the working of lab on chip like glucose sensor.

References:

1. Dey, R. A. and Underwood, A. L., **Quantitative Analysis**, 6th Edition, Pearson.
2. Skoog, D. A., West, D. M., Holler, F. J., Crouch, S. R., **Fundamental analytical chemistry**, Thomson Asia Ltd.
3. Encyclopaedia of analytical chemistry: Applications, Theory, and Instrumentation, R A Meyor (Eds) Wiley and Sons (2000).

Teaching Learning Process:

- Student centred teaching Learning process.
- Blend of conventional blackboard teaching and modern teaching learning tools
- Focus on real life applications of concepts
- Problem solving and quizzes for enhanced understanding of the concepts
- Engaging students in collaborative learning.
- Pre-lab learning of theoretical concept of the experiment.
- Performing the experiment, recording the data, calculating the result.
- Interpreting the result.
- Comparing the results of the class.
- Discussing the sources of error.

Assessment Methods:

- Class Tests at Periodic Intervals.
- Written assignment(s)
- Continuous evaluation of laboratory work and record file.
- Oral assessment, quizzes.

- Mock practical examination.
- Semester end University examination.

Keywords: chemical analysis, Statistical method, Sampling, Standardisation, labelling and calibration.

Course Code: CHEMISTRY- GE-13

Course Title: Medicines in Daily Life

Total Credits: 04 (Credits: Theory-02, Practical-02)

Total Lectures: Theory- 30, Practical-60

Objectives: The course is designed to study the basic details about various medicines of general uses, which are crucial for the various diseases. This course also gives the knowledge of active pharmaceutical ingredient in some medicines, their synthesis; therapeutic effect and side effects on human physiology. Medicines are essential for a healthy day-to-day life and therefore this course will aware the students about its positive and negative effects.

Learning Outcomes:

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

- Understand the role of different medicines on human physiology.
- Gain the knowledge of active pharmaceutical ingredient and their roles in different disease.
- Learn the proper use of different medicines and their effect and side effects.
- Learn the techniques of administering blood group, pulse rate, blood pressure and may other general diagnostic applications.

Theory:

Unit 1: General Introduction **Lectures: 8**

Introduction-Health, disease, drugs, chemotherapy, approaches in drug designing, classification of drugs and their origin.

Unit 2: Different class of medicines **Lectures: 22**

Structure of active ingredients, uses, dosage, side effects and their natural remedies:

Analgesics and antipyretics- Aspirin, paracetamol, ibuprofen, morphine, codeine

Antibiotics- Amoxicillin, norfloxacin, ciprofloxacin

Antihistamines or antiallergics- Cetrizine and Levocetrizine (role of stereoisomers)

Antiparasitic- Albendazole

Antidiabetics- Insulin, Glipizide and metformin

Antihypertensive – Amlodipine and its natural remedies- Rauwolfia.

Diuretic- Lasix

Antidepressant-Zoloft and its natural treatment

Antifungal – fluconazole, Itraconazole

Antacids- Ideal properties of antacids, combinations of antacids, Sodium 40 Bicarbonate, rantidine, milk of magnesia, aluminium hydroxide gel

Anticoagulants/antiplatelet drugs- Warfarin, heparin and Ecosprin

Anaesthetics- Atracurium, Desflurane

Poison and Antidote: Sodium thiosulphate, Activated charcoal, Sodium nitrite

Astringents: Zinc Sulphate, Potash Alum

Supplements- zinc and calcium, vitamins

Synthesis of small molecule drugs like aspirin and paracetamol

Practicals: **Credits: 02**

(Laboratory periods: 60)

1. Determination of heart rate and pulse rate, blood pressure and discussion on medicines affecting them.
2. Identification test- Magnesium hydroxide, Sodium bicarbonate, Calcium gluconate.
3. Preparation of inorganic pharmaceuticals- Boric acid Potash alum
4. Determination of sugar content in the given solution.
5. Estimation of zinc and calcium in a given solution.
6. Qualitative analysis of carbohydrates (Glucose, Fructose, Lactose, Maltose, Sucrose).
7. Qualitative tests for Proteins
8. Qualitative analysis of vitamin C.
9. Isolation of paracetamol (API) from a commercial tablet
10. Isolation of aspirin (API) from tablet and recording of melting point (synthesis needs discussion)

References:

Theory:

1. Patrick, G. L. (2001) **Introduction to Medicinal Chemistry**, Oxford University Press.
2. Lemke, T. L. & William, D. A. (2002), **Foye's Principles of Medicinal Chemistry**, 5th Ed., USA,

3. Singh H.; Kapoor V.K. (1996), **Medicinal and Pharmaceutical Chemistry**, Vallabh Prakashan.
4. Chatwal, G.R. (2010), **Pharmaceutical chemistry**, inorganic (vol. 1), Himalayan publishing house
5. https://go.drugbank.com./

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. Ahluwalia, V.K., Dhingra, S. (2004), **Comprehensive Practical Organic Chemistry: Qualitative Analysis**, University Press.
3. Munwar, S., Ammaji, S.(2019), **Comprehensive Practical Manual of Pharmaceutical Chemistry,** Educreation Publishing.
4. Mondal, P., Mondal, S.(2019), **Handbook of Practical Pharmaceutical Organic, Inorganic and Medicinal chemistry**, Educreation Publishing.

Teaching Learning Process:

- Lecture in class rooms
- Peer learning
- Technology driven learning
- Learning through experiment in the practical classes

Assessment Methods:

- Presentations by Individual Student/ Group of Students
- Class Tests at Periodic Intervals.
- Written assignment(s)
- End semester University Theory and practical Examination

Keywords: Medicines, Active pharmaceutical ingredient, drug

Course Code: CHEMISTRY- GE-14

Course Title: Chemistry: Molecular Modelling, Artificial Intelligence and Machine Learning in Chemistry

Total Credits: 04 (Credits: Theory-02, Practical-02)

Total Lectures: Theory- 30, Practical-60

Objectives: The course is aimed at familiarization of students to modern scientific machine (programming) language i.e., Python, artificial intelligence (AI) & machine learning (ML) and their potential applications in chemistry. Further the aim of the course is to provide elementary ideas of the techniques prevailing in the field of artificial intelligence (AI) and machine learning (ML) and their applications to research problems especially related to research and development of new materials and pharmaceutical compounds with desired properties.

Learning Outcomes:

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

- Conversant with the Python Programming Language.
- Familiar with Elementary techniques of Artificial intelligence (AI) & Machine learning (ML)
- Able to apply techniques of AI & ML in basic problems of research in some important areas of research in Chemistry.

Theory:

Part A: Molecular Modelling

Introduction to computational chemistry: **Lectures: 7**

Overview of Computational Methods in Chemistry (Ab initio, DFT, Semi- empirical, Molecular Mechanics

Potential Energy Surfaces **Lectures: 4**

The concept of Potential energy surface, Intrinsic Reaction Coordinates, Stationary points, Equilibrium points – Local and Global minima, Geometry optimization and energy minimization.

Molecular Mechanics **Lectures: 4**

Force Fields (A brief idea of a basic force field), Elementary idea of MM1, MM2, MM3, MM4, MM+, AMBER etc. A brief Idea of Molecular Docking

Part B: Artificial Intelligence & Machine learning in Chemistry **Lectures: 15**

An overview of computationally readable and processible representation of molecules, e.g., SMILES, mol files. Chemical space and access to chemical databases. Statistical treatment of data: regression analysis andtypes of regression. Elementary Idea of Quantitative structure-activity relationship (QSAR).

An insight into Artificial Intelligence & Machine learning and potentialareas of applications in chemistry. Dimensional reduction; Principal Component Analysis (PCA) and the importance and necessity of nonlinearity in Artificial Intelligence.

Genetic algorithm, basics of random mutation hill climbing (RMHC) and simulated annealing.

Practicals/Hands-on Training: **Credits: 02**

(Laboratory periods: 60)

Molecular Modeling based Exercise

1) Write the Z-Matrix of a given set of molecules.

2) Carry out geometry optimisation on H_2O, H_2S, H_2Se molecules and compare the optimized bond angles and dipole moments from the results obtained. Obtain the ESP-mapped density surfaces and interpret the results obtained with reference to bonding in these molecules.

Suggestive: A comparative analysis of results of the above exercise may be carried out using different quantum mechanicalmethods.

3) Calculate the energy of the following chemical species andarrange them in order of increasing stability.

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.

4) Carry out the geometry optimisation on the following chemical species and compare the shapes and dipole moments of the molecules.

1-butanol, 2-butanol, 2-methyl-1-propanol, and 2-methyl-2- propanol.

Correlate the computationally obtained values of the dipolemoments with the experimental values of the boiling points: (118ºC, 100 ºC, 108 ºC, 82 ºC, of 1-butanol, 2-butanol, 2-methyl-1- propanol, and 2-methyl-2- propanol respectively).

5) Based on the implicit electronic structure calculations, determinethe heat of hydrogenation of Ethene.

6) Based on the calculations of enthalpies of the participatingchemical species on optimized geometry of the molecules, calculate the reaction enthalpy at 298 K for the following, industrially important reactions:

$$CH_4 + H_2O \rightarrow CO + 3H_2$$ (steam reforming of methane)

$N_2 + 3\,H_2 \rightarrow 2NH_3$ (Haber-Bosch process)

7) Carry out geometry optimisation and determine the energy of theparticipating chemical species in the following reactions Using these results calculate the resonance energy of thiophene.

8) Carry out geometry optimization & energy calculations on the following species and obtain Frontier Molecular Orbitals. Visualize the Molecular Orbitals of these species and interpret the results for bonding in these molecules.

   Benzene, Naphthalene, and Anthracene.

9) Compare the gas phase basicities of the methylamines by comparing the enthalpies of the following reactions:

10) On the basis of results of geometry optimization and energy calculations, determine the enthalpy of isomerization of cis andtrans 2-butene.

11) QSAR based exercise on problems of interest to chemist.

12) Perform a conformational analysis of butane. Plot the graph between the angle of rotation and the energy of the conformers using spreadsheet software.

13) Compute the resonance energy of benzene by comparison of itsenthalpy of hydrogenation with that of cyclohexene.

14) Perform a geometry optimization followed by a frequency assessment (opt+freq keyword) using the B3LYP method and 6-31-G(d) basis set on a given set of small molecules i.e. BH_3, CH_4.

Suggestive: A greater number of molecules may be studied as per instructions received from the concerned teacher.

15) Based on the fundamentals of conceptual DFT calculate the ionization potential (IP), electron affinity (EA), electronegativity and electron chemical potential of a given set of molecules.
16) Perform molecular docking of Sulfonamide-type D-Glu inhibitor into MurD active site using Argus lab.

Artificial Intelligence (AI) and Machine Learning (ML) based exercise on problems of interest to chemist

17. Travelling salesman problem and electrical circuit design (minimization of path-length).
18. Genetic algorithm, in solving matrix form of linear equations
19. Non-linear least-square fitting problem.
20. Particle Swarm Optimization on the sphere function.

Important Instruction Note on working approach:

- A student is required to perform/investigate a minimum of 10 exercises in total.
- The exercises mentioned above will be performed by the studentstrictly in accordance with the instructions received and only under the supervision of the teacher concerned.
- Any other exercise may be carried out with prior permission, input, discussion and instructions received from the teacher concerned.

References:

1. Lewars, E. (2003), **Computational Chemistry**, Kluwer academicPublisher.
2. Cramer, C.J. (2004), **Essentials of Computational Chemistry**, John Wiley & Sons.
3. Cartwright C.; Kharma N., (2008), **Using artificial intelligence in chemistry and biology**, First Edition, CRC Press Taylor & Francis Group
4. Hippe; Z., **Artificial Intelligence in Chemistry: Structure Elucidation and Simulation of Organic Reactions**, (1991) Academic Press, Elsevier
5. Soft Computing in Chemical and Physical Sciences A Shift in Computing Paradigm (Kanchan Sarkar, Sankar Prasad Bhattacharyya) (z-lib.org)
6. Understanding Properties of Atoms, Molecules and Materials (PRANAB. SARKAR, Sankar Prasad Bhattacharyya) (z-lib.org)

Web Resources:

1. https://www.afs.enea.it/software/orca/orca_manual_4_2_1.pdf
2. https://dasher.wustl.edu/chem430/software/avogadro/learning-avogadro.pdf
3. http://www.arguslab.com/arguslab.com/ArgusLab.html
4. https://barrett- group.mcgill.ca/tutorials/Gaussian%20tutorial.pdf
5. https://gaussian.com/techsupport/
6. https://gaussian.com/man/
7. https://gaussian.com/wp-content/uploads/dl/gv6.pdf
8. https://dasher.wustl.edu/chem478/software/spartan-manual.pdf
9. http://www.mdtutorials.com/gmx/
10. https://vina.scripps.edu/manual/

Teaching Learning Process: Hands-on laboratory exercises Conventional teaching learning method. Engaging students in collaborative learning

Assessment Methods:

- Continuous evaluation of laboratory work and record file.Oral assessment, quizzes.
- Presentation on lab practices.Semester end examination.

Keywords: Molecular Modeling, Potential Energy Surface (PES), Geometry Optimization, Frequency calculation, Artificial Intelligence, Machine Learning, Nural Networks, Genetic

Algorithm.

Course Code: CHEMISTRY- GE-15

Course Title: Chemistry and Society

Total Credits: 04 (Credits: Theory-02, Practical-02)

Total Lectures: Theory- 30, Practical-60

Objective: The course is designed to expand the literacy of chemistry among the non-chemistry student even arts as well as commerce with objective increase general awareness, background of chemistry and its importance. This paper will be helpful for a common student to understand the importance and role of chemistry in development of civilization, societal issues related to chemistry and their expected solutions.

Learning Outcomes:

At the end of this course the student will be able to:

- Increase the literacy of chemistry even in non-science students
- Understand the basic concept, principle and importance of chemistry
- Realize the importance of chemistry in daily life and future requirement

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Theory:

Unit 1: Basics of chemistry **Lectures: 4**

Periodic table, Atom and molecules, chemical bonding, properties and chemical reactions with simple examples and illustration.

Unit 2: Chemistry in Heritage **Lectures: 8**

Extraction and uses of metals like iron and stone in ancient times, metals in ornaments, medicines, weapons and chemistry for preservatives, basics of preservation and few examples of preservatives.

Unit 3: Chemistry in Life **Lectures: 8**

Edible and non- edible molecules, biochemistry of foods and medicine with examples: Aspirin, Paracetamol. Ibuprofen and Penicillin, Cephalosporin, Chemistry for industry: Artificial sweeteners, Soaps and detergents and cosmetics, Polymer and Plastics: Uses and environmental issues.

Unit 4: Chemical pollution and Toxicity **Lectures: 4**

Chemical source of water, air and soil pollution, biomagnification and metal toxicity with example and illustrations. monitoring of air pollution.

Unit 5: Testing of chemicals **Lectures: 4**

Flame test, solubility test, qualitative and quantitative identification of ions in natural samples like metal copper, iron and chromium ores and adulterant in foods.

Unit 6: Future of chemistry **Lectures: 2**

Basics of green chemistry, Reuse and recycling of by-products, zero waste chemistry and Alternate fuel and energy providing chemicals: biodiesel, natural gas and hydrogen.

Practicals/Hands-on Training: **Credits: 02**

(Laboratory periods: 60)

1. Determine the calcium and magnesium contents in water samples using EDTA methods.
2. Determine the organic contents and pH of soil sample.
3. Estimate the food adulterants in edible items
4. Quantify the presence metals by flame test method
5. Demonstrate the conversion of PET into bottle into value added products.
6. Determine the quantitative presence of heavy metals like copper and chromium in natural sample like ore.
7. Demonstrate the exothermic and endothermic reaction in laboratory
8. Preparation aspirin and paracetamol as well as identify.
9. Compare the fuel efficiency of biodiesel and petrol.
10. Preparation of representative compound using microwave
11. Demonstrate the biodegradability of natural and synthetic plastics.
12. Demonstrate the protection of rusting of iron after surface spray coating.
13. Estimate the protein contents in edible samples using chemical methods.
14. Small working project on heritage chemistry like bio compatibility of metals and medicinal importance of metals like iron, gold and silver.

References:

1. Lee, J. D., **Concise Inorganic Chemistry**, Wiley India Pvt. Ltd.
2. Sharma, B. K., **Industrial chemistry**, Goel Publishing House, India
3. Christian, Gary D., Dasgupta, Purnendu K., Schug, Kevin A., **Analytical chemistry**, Wiley
4. V. Subramanian, **A text book of Environmental chemistry**, Wiley

Teaching Learning Process:

- Hands-on laboratory exercises

- Conventional teaching learning method. Engaging students in collaborative learning

Assessment Methods:

- Continuous evaluation of laboratory work and record file. Oral assessment, quizzes.
- Presentation on lab practices.
- Semester end examination.

Key words: Fundamental of chemistry, Chemistry for advancement in society, Chemistry and industry, Sustainable future of chemistry.

Course Code: CHEMISTRY- GE -16

Course Title: Role of Metals in Medicines

Total Credits: 04 (Credits: Theory-02, Practical-02)

Total Lectures: Theory- 30, Practical-60

Objective: To make the learners familiar about role of metal ions in some commercially available medicines.

Learning Outcomes:

By the end of this course student will be able to learn:

- Role of metal ions in various biomolecules and their functions.
- Role of metals in commercially available medicines and their functions

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Theory:

Unit 1: Bio role of Metals **Lectures: 4**

Brief introduction of following metals in biological system
Fe, Cu, Zn, Mn, Cr(III), V, Mo, W, Co, Ni, Na, K, Mg and Ca
Chemical structure, Commercial name, Name of the disease it is made for and its brief mechanism of action shall be taught for all the mentioned metals below.

Unit 2: Diagnostic and therapeutic agents **Lectures: 8**

Diagnostic and therapeutic agents with Pt (Cisplatin) and Ga for cancer, Au (auranofin) for arthritis and V for diabetes.

Unit 3: Metals in drugs **Lectures:6**

Li_2CO_3 (Camcolit) for manic-depressive illness, $NaHCO_3$ (Alka-seltzer) for heartburn, $Al(OH)_3$ (Gaviscon) for heartburn, As (melarsoprol) for sleeping sickness, Bi subsalicylate (pepto-Bismol) for heartburn and diarrhea, Bi subcitrate (De-nol) peptic ulcer, Zinc oxide with Fe_2O_3 (Calamine lotion) as antimicrobial agent.

Unit 4: Metals in Multivitamins **Lectures:6**

Cyanocobalamin (Co), Ferrous fumerate (Fe), Magnesium oxide (Mg), Zinc Sulfate (Zn), Manganese sesulphate (Mn), Copper Sulfate (Cu), Sodium selenite (Se) and Chromium trichloride (Cr).

Unit 5: Radiopharmaceuticals and MRI contrast agents **Lectures:6**

^{99m}Tc for heart, brain and bone imaging, ^{123}I radiopharmaceuticals, $BaSO_4$for X-ray contrast agent, Gd (III) for MRI contrast agents.

Practicals: **Credits: 02**

(Laboratory periods: 60)

Volumetric titrations:

1. To estimate the acidity of commercially available antacids.
2. To estimate the concentration of Fe in commercially available medicines.
3. To estimate the concentration of Ca in commercially available medicinces.
4. To estimate the strength of carbonate in tablets containing Li_2CO_3
5. To estimate the sodium bicarbonate in synthetic/commercially available drug.
6. To estimate the zinc and iron present in Calamine lotion.
7. To estimate the Mg present in multivitamins.

References:

1. **Metals in Medicine**, John Wiley & Sons Ltd, Nov 2009
2. Chapter-9, **Metals in Medicine**, Stephen J. Lippard
3. Jones, Chris and Thornback, John, **Medicinal applications of coordination chemistry**, Cambridge, UK: Royal Society of Chemistry, 2007

Teaching Learning Process:

- Hands-on laboratory exercises
- Conventional teaching learning method. Engaging students in collaborative learning

Assessment Methods:

- Continuous evaluation of laboratory work and record file. Oral assessment, quizzes.

- Presentation on lab practices.
- Semester end examination.

Key words: Diagnostic, therapeutic agents, multivitamins, radiopharmaceuticals and MRI contrast agents.

Course Code: CHEMISTRY- GE- 17

Course Title: Energy and the Environment

Total Credits: 04 (Credits: Theory-03, Practical-01)

Total Lectures: Theory- 45, Practical-30

Objectives: The objective of this paper is to develop basic understanding of energy, issues related to energy, importance of energy in terms of economy, health and the environment. To understand different sources of energies, renewable and non-renewable sources of energy. To understand the importance of green fuels. This course will help the students to understand the adverse effect of pollution, and possible remediations.

Learning Outcomes:

By the end of this course student will be able to learn:

- Describe basic energy concepts
- Account for conventional and renewable energy technologies and their application
- Reflect and evaluate the environmental impact of energy production and the relationship between energy production, consumption and climate change
- Reflect on energy costs, analyse the consequences of today's energy consumption
- Efficient use of energy, water and other resources, Use of renewable energy, such as solar energy
- Pollution and waste reduction measures, and the enabling of re-use and recycling
- Good indoor environmental air quality, Use of materials that are non-toxic, ethical and sustainable
- Consideration of the environment in design, construction and operation

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Theory:

Unit 1: **Lectures: 13**

Introduction, chemistry and energy, conversion of chemical energy to electrical energy, Carbon cycle, Greenhouse gases, Global warming and climate change, Carbon footprint, zero-carbon or low-carbon energy. Electrical energy and steam energy, Energy Alternatives, Hidden Costs of Energy.

Unit 2: **Lectures: 10**

Production methods for electric power: Non-Renewable (conventional) sources of energy: Fossil fuels: Coal, petroleum and Natural gas. Energy transformation. Renewable energy sources: solar, hydropower, wind, geothermal, wave, ocean thermal, tidal, ocean currents, nuclear energy, biomass.

Unit 3: **Lectures: 12**

Production methods for electric power: Renewable (green) energy, conversion and storage systems. Nuclear fusion, Hydrogen fuels, photovoltaic solar cells, hydroelectric. Sustainable energy, biomass, Biofuels, production of biofuels, advantages, blending of biofuels with conventional fuels, Carbon Capture and Reuse, Waste to Energy Technologies.

Unit 4: Lectures: 10

Air Pollution, Urban and Indoor Air Pollution, Pollution and waste reduction measures, chemical remediation of air pollution. Effect of pollution on health and economy.

Practicals: **Credits: 01**

(Laboratory periods: 30)

Tutorials

1. Conversion of biomass to biofuels (2-3 different biofuels)
2. Working on solar cell model.
3. Working on wind turbine model.
4. Working on geothermal energy model.
5. Working on hydroelectric plant model.
6. Presentations by students

References:

Theory

1. Rao, C S., **Environment pollution control Engineering**, New Age International reprint 2015, 2nd edition
2. Bharucha, E., **Textbook of Environmental Studies**, Universities Press (2005)
3. Wright, R.T., **Environmental Science-Towards a sustainable Future**, Prentice Hall (2008) 9th edition.
4. Ahluwalia, V. K., **Energy and Environment**, The Energy and Resources Institute (TERI) (2019).

References:

Practicals

- Challapalli Narayan Rao, **Practical approach to implementation of Renewable Energy Systems,** Evincepub Publishing, 2022

Teaching Learning Process: To accomplish a goal, it is very important to learn in a strategic manner. There are different components of learning and the capacity of each learner varies. It is expected to have a student centric teaching. Questions and answers, both should come from students. 'How' to teach and 'What' to teach in the defined curriculum not only depends on the content and the knowledge of the teacher but critically more so on designing, i.e. how to introduce the concept to the students in a very effective way. Different ways of teaching include classical board teaching method, visual conceptual method, application based practical demonstration of the concept etc. are required in this course. In fact, the pedagogy is to make a class interesting and thus learning becomes enjoyable.

Assessment Methods: The effectiveness of learning can be judged by assessing the students. Various types of assessment methods can be followed depending on the branch of student opting the course. Assessment can be in form of Graded assignments, conventional class tests, class seminars and presentations by students on course topics with a view to strengthening the content through width and depth, end semester university examination for theory and practical.

Keywords: Energy, Renewable and non-renewable energy resources, Synthetic fuels, Biofuels, Carbon footprint, air pollution, remediation, pollution related health and economy.

Course Code: CHEMISTRY- GE -18

Course Title: Fragrances and Flavours: An Industry's Perspective

Total Credits: 04 (Credits: Theory-03, Practical-01)

Total Lectures: Theory- 45, Practical-30

Objectives: The use of fragrance is ubiquitous and is a global human phenomenon. Over the course of time, countless numbers of flavors and fragrances have found their way into everyday life, notably into foods, beverages and confectionery items; into personal care products (soaps, toothpastes, mouthwashes, deodorants, bath lotions and shampoos), perfumes, and other cosmetics as well as pharmaceutical formulations. Indeed, flavors and aromas are added to make such products more attractive or to mask the taste or smell of less pleasant ones. There is need to understand the applications of chemistry in the world of flavours and fragrances.

Learning Outcomes:

By the end of this course student will be able to learn:

- Synthesis of various fragrance and flavour ingredients
- Formulation methods, how different factors affects the formulation process in Fragrance and Flavour industry
- Uphold safety regulation and execute quality processes
- Quality control in manufacturing process, legal aspects, classification of odour and odorants.
- Different methods used for separation, purification and isolation of perfumes and flavours like distillation, extraction, crystallization, etc.

Theory:

Unit 1: Fragrances **Lectures: 18**

- Introduction to fragrances, types of fragrances (Fragrance families and classification)
- History of perfumes, Perfumery raw materials, classification of odour, odour type and odorants
- India in the context of Fragrance Industry
- ABCs of perfumery, odour aspects of perfumes, fragrance pyramid, fragrance families
- Some basic chemical knowledge to provide a better understanding of the structure of molecules possessing a sensory power, The volatility and solubility of sensory molecules
- Chemistry of aromatic compounds in perfume making, Composition of fragrances
- Current trends in fragrances, sensory analysis of different products
- Study of the raw materials used in perfumery (origin, extraction method, and olfaction)
- Key chemical reactions for conversion of raw materials to fragrances
- Extraction of essential oils used in perfumery
- Difference between alcohol and oil-based perfumes
- Outline of health, safety and sustainability parameters in perfumer

Unit 2: Sustainable Fragrance by Design **Lectures: 4**

- The challenges of sustainability and how it impacts the industry
- Sustainability charter
- Green chemistry principles
- Commitment to Biodiversity

Unit 3: Flavours **Lectures: 18**

- Introduction to flavours, types of flavours, flavour raw materials
- Understanding of terms like, Flavour and Flavouring agents. Attributes of flavour, taste, odour, odour stimulation, basic tastes and the human olfactory system.
- Stability of flavour in food, sensory evaluation of flavours in foods, Various flavour formulation
- Systematic approach to understanding flavour formation during food processing, food matrix, interaction of added flavours
- Flavour enhancers, modifiers, precursors, suppressors, solvents.
- Key chemical reactions for conversion of raw materials to flavours

- Forms of flavour and the manufacturing processes involving all types of flavours. Aroma recovery during processing.
- Biogenesis of flavours in fruits and vegetables, reaction flavours, off flavours.
- Stability of flavor in food, sensory evaluation of flavours in foods
- Selection and application of flavours in foods and beverages
- Legal aspects (natural flavours and natural flavouring substances, nature identical flavouring substances, artificial flavouring substances), and the FSSA act.

Unit 4: Extraction, Isolation and Purification of Perfumes and Flavour Compounds

Lectures: 5

- Extraction techniques for the separation of volatile oils from natural source- including. Distillation, Evaporation, Crystallization and Adsorption, supercritical fluid extraction methods of isolation of important ingredients

Practicals: **Credits: 01**

(Laboratory periods: 30)

1. Extraction of D-limonene from orange peel using liquid CO_2.
2. Extraction of caffeine from coffee beans using liquid CO_2.
3. Extraction of essential oils from lemon using steam distillation
4. Extraction of essential oils from lemon using liquid CO_2.
5. Extraction of essential oils from fragrant flowers.
6. Determination of esters by Thin Layer Chromatography
7. Memorisation of different raw materials used in perfumery, perfume language, Memorisation of perfumes
8. Testing up of different flavours
9. Analysis of spectra of perfume formulations.

References:

1. Arctander, S. (2008), **Perfume and flavour materials of Natural origin,** Allured Publishing Corporation, USA
2. Arctander, S. (2017), Volume I and II, **Perfume and Flavour Chemicals**, (Aroma Chemicals), Allured Publishing Corporation, USA
3. Curtis,T.; Williams, D. C.(2001) 2nd Edition, **An Introduction to Perfumery**, Micelle Press, USA.
4. Sell,C. (2008), **Understanding Fragrance Chemistry,** Allured Publishing Corporation, USA
5. Calkin,R.R., Jellinek, J.S., **Perfumery: Practice and Principles,** John Wiley & Sons Inc.
6. Gimelli, S.P. (2001), **Aroma Science,** Micelle Press, USA
7. Arctander, S. (2019), **Perfume and Flavour Materials of Natural Origin,** Orchard Innovations
8. https://www.beyondbenign.org/lessons/essential-oil-extraction-using-liquid-co2/

Teaching Learning Process: Blackboard, Power point presentations, Assignments, Field Trips to Flavour and perfumery Industry, Different working models, ICT enabled classes, Interactive sessions, recent literature using internet and research articles.

Assessment Methods: Students' evaluation will be done on the basis of regular class test, presentations and assignments as a part of internal assessment during the course as per the curriculum. End semester university examination will be held for both theory and practical. In practical, assessment will be done based on continuous evaluation, performance in the experiment on the date of examination and viva voce.

Keywords: Fragrances, Flavours, pharmaceutical formulation, distillation, extraction techniques

Course Code: CHEMISTRY- GE-19

Course Title: Radio-chemistry in Energy, Medicine and Environment

Total Credit: 04 (Credits: Theory-03, Practical-01)

Total Lectures: Theory- 45, Practical-30

Objectives: The objective of this course is to give an introduction to nuclear and radiochemical concepts. It will also help the student to gain fundamental knowledge about the radioisotopes and their real-world applications in medicine, diagnostic techniques, energy, research and environment.

Learning Outcomes:

By the end of the course, the students will:

- Learn about radioisotopes, radioactive decay
- Use of radiochemistry in various fields
- Effect of radiations on health
- Learn about nuclear energy and nuclear pollution

Theory:

Unit 1: Introduction **Lectures: 10**

Atoms, composition of nucleus, mass number, isotopes, nuclear stability, radioactive decay, radioactivity in nature: natural and artificial radioisotopes, elementary particles, radioactive decay (α, β and γ decay), half-life period, types of nuclear reactions: nuclear fission and nuclear fusion.

Unit 2: Nuclear power generation **Lectures: 5**

Nuclear Power generation from uranium ore (energy production and nuclear waste), introduction to nuclear reactors for energy and nuclear weapons

Unit 3: Applications of radiochemistry **Lectures: 15**

C 14 decay and radioactive dating, irradiation of food, radiotracers for studying chemical reactions (photosynthesis, metabolic studies of drugs, metabolism of organisms, fundamental properties of genetic material), medicinal application of radio chemicals in radiotherapy (use in cancer, hyperthyroidism, blood disorders), radio-pharmaceuticals, diagnostic procedures: CT, PET

Unit 4: Environment radioactivity **Lectures: 7**

Natural radioactivity, natural process that release radioactive material in environment, man-made events like Chernobyl disaster, bomb test, use of radiotracers in environmental studies.

Unit 5: Nuclear pollution and safety management **Lecture: 8**

Radiation protection standards, basics of radiation hazards, international guidelines on radiation protection, disposal of nuclear waste, nuclear disaster and it's managements, Effect of radiation on health: Biological effects of radiation, radiation monitors, dose limits for workers and public,

Practicals: **Credits: 01**

(Laboratory periods: 30)

1. Study the background radiation in different places and identify the probable source. (Data to be provided).
2. Survey the diagnostic procedures involving radio-chemistry in different diagnostic laboratories.
3. Write a report on the radio isotopes used in various diagnostic procedures.
4. Write a report on safety measures taken in diagnostic labs.
5. Write a report on any two nuclear and radiation accidents focusing on their impact on human life, environment and economy.

References:

1. Nuclear and radiochemistry, Konya J., Nagy N. 2nd Edition, Elsevier
2. Radiochemistry and Nuclear Chemistry, 4th Edition, Choppin G., Lilijenzin J-O, Rydberg J., Ekberg C. Elsevier.

Teaching Learning Process:

- Student centered teaching Learning process.
- Blend of conventional blackboard teaching and modern teaching learning tools
- Focus on real life applications of concepts
- Problem solving and quizzes
- Engaging students in collaborative learning.

Assessment Methods:

- Class Tests at Periodic Intervals.

- Written assignment(s)
- Oral assessment, quizzes.
- Semester end University examination.

Keywords: Radioisotopes, Radio-analysis, Radiopharmaceuticals, Nuclear reactor, Nuclear pollution.

Course Code: CHEMISTRY- GE-20

Course Title: Green Chemistry

Total Credits: 04 (Credits: Theory-02, Practical-02)

Total Lectures: Theory- 30, Practical-60

Objectives:

Huge rise in environmental pollution, depleting resources, climate change, ozone depletion, heaps and heaps of landfills piling up has forced the society to become more and more environmentally conscious. Future chemists and innovators are compelled to work towards sustainable practices. Green chemistry has arisen from these concerns. It is not a new branch of chemistry but helps to improve the creative and innovative thinking in undergraduate students. Green chemistry is a way to boost profits, increase productivity and ensure sustainability with absolute zero waste. Innovations and applications of green chemistry in education have helped companies to gain environmental benefits as well as to achieve economic and societal goals also. Undergraduate students are the ultimate scientific community of tomorrow. Training them to practice chemistry in the safest way possible is key towards safe working conditions in the laboratories as well as the chemical industry and extends to society in a sustainable future for the planet.

Learning Outcomes:

By the end of 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 to practice green chemistry

Unit 1: Introduction Lectures:08

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).

Unit 2: Twelve Principles of Green Chemistry Lectures: 12

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

• Prevention of waste / byproducts, 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, inherent safer design, principle of ISD "What you don't have cannot harm you", greener alternative to Bhopal Gas Tragedy (safer route to carcarbaryl) and Flixiborough accident (safer route to cyclohexanol) subdivision of ISD, minimization, simplification, substitution, moderation and limitation

Unit 3: Lectures: 10

The following Real-world Cases in green chemistry should be discussed: 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. Rightfit 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: **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, ethylcyanoacetate 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.

Practical:

1. Kirchoff, M.; Ryan, M.A. (2002), **Greener approaches to undergraduate chemistry experiment**, American Chemical Society, Washington DC.
2. Sharma, R.K.; Sidhwani, I.T.; Chaudhari, M.K. (2013), **Green Chemistry Experiments: A monograph**, I.K. International Publishing House Pvt Ltd. New Delhi.
3. 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.
4. Sidhwani 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.
5. Sidhwani, I.T; Sharma, R.K. (2020), **An Introductory Text on Green Chemistry**, Wiley India Pvt Ltd.
6. **Monograph on Green Chemistry Laboratory Experiments**, Green Chemistry Task Force Committee, Department of Science and Technology, Government of India.

Teaching Learning Process:

- **Conventional chalk and board teaching**
- Power point presentations
- Interactive sessions on recent green chemistry presidential awards
- Visit a chemical industry and ask the students to think critically for improving the conditions there.
- Screening of documentaries based on chemical accidents/ and then ask them to think about the solutions

Assessment Methods:

- Presentation/assignment by students
- Class Test at Periodic Intervals
- Written Assignment
- Continuous evaluation in practicals
- End Semester University Theory and Practical Exams

Keywords: Green chemistry, Twelve principles of green chemistry, Atom economy, Waste minimization, green metric, green solvents, Solvent free, Catalyst, Bio-catalyst, Renewable energy sources, Hazardous, Renewable feedstock, Ionic liquids, Supercritical fluids, Inherent safer design, green synthesis, combinatorial, Sustainable development, Presidential green chemistry awards.

Course Code: CHEMISTRY- GE-21

Course Title: Chemistry in Indology and Physical & Mental Well Being

Total Credit: 04 (Credits: Theory-03, Practical-01)

Total Lectures: Theory- 45, Practical-30

Objective: This course is being designed:

- To illuminate the students about the scientific basis and approaches related to the practices that promote physical and mental health/balance, that includes meditation, sports, Yoga and nutrition. The chemical/biochemical mechanisms that underscore the various states of the mind and body, which drives the general homeostasis or anomalies thereof, shall also be illustrated.
- To make students aware about role of metals in ancient and medieval India
- To make students aware of how Alchemists used metals, chemicals, compounds and ores in medicines
- To make students aware of the different types of instruments used in the ancient and medieval India
- To make students aware of the life and work of ancient and medieval scientists/chemists.

Learning Outcome:

By the end of the course, the students will:

- Understand about the scientific basis and approaches that promote physical and mental health.
- Know about the chemical/biochemical mechanisms that underline the states of the mind and body
- Understand the role of metals in ancient and medieval India
- Understand how alchemists used metals and chemical compounds in medicines
- Know about the life and contributions of ancient scientists and chemists

Unit 1: Physical Health Practices **Lectures: 08**

Principles of Physical Education, Body composition with respect to health and fitness and different methods of body composition analysis, Calculation of energy expenditure (at rest and during exercise), VO_2 and calculation of VO_2 max, respiratory exchange ratio, blood pressure, Means of fitness development- aerobic and anaerobic exercises, yoga and physical fitness, Exercises and their intensities related to heart rate zone, Different fitness levels for different age groups and gender, Kinesiology, Physiology of Exercise

Unit 2: Mind-body Practices **Lectures: 10**

States of mind and types of brain waves, mindfulness meditation in clinical psychology and psychiatry, Desbordes' recent studies on brain activities (Harvard's studies), MRI & functional MRI studies.

Types of meditations- focused attention meditation (FA), open monitoring meditation (OM), transcendental meditation (TM), loving–kindness meditation (LKM), mindfulness meditation (MM) and body–mind meditation (B-M).

Biochemical alterations, such as changes in activity/production of hormones, cytokines, chemokines, interferons, etc., oxygen saturation/desaturation, redox-condition and oxidative balance, progression/regression of certain diseases/health conditions, in response to various states of physical and mental well-being.

Unit 3: Nutrition for Mind/body Homeostasis **Lectures: 06**

Role of nutrition in physical and mental health. Nutrients: carbohydrates, Protein, Fat, Vitamins, Minerals, Water-their functions, role of hydration (water balance) during exercise, daily caloric requirement and expenditure.
Metabolism: An overview of ATP release in glycolysis, TCA cycle, electron transport chain. basic concept of balanced diet vs. fad diet (Atkins, ketogenic etc.), Concept of BMI (Body mass index) and BMR (Basal metabolic rate), Obesity and its hazard, Dieting versus exercise for weight control.

Unit 4: Concepts of Atoms, Molecules and Laws of Motion **Lectures: 02**

Concepts of atoms and molecules, properties and categories of atoms and molecules, Laws of motion.

Unit 5: **Metallurgy** **Lectures: 05**

Gold, Silver, Copper, Bronze and other alloys; Copper smelting blast furnace and copper extraction; Tron and Steel; Iron smelting blast furnaces from Southern India; Ironworks in Ancient and medieval India; Delhi Iron Pillar; Dhar and Kodachadri Iron pillars; Wootz steel; Zinc and its extraction.

Unit 6: **Chemicals** **Lectures: 04**

Drugs, dyes, pigments, glass, cosmetics and perfumes, etc.

Unit 7: **Drugs** **Lectures: 05**

Eight categories of Gandhasara; Compounds of mercury (Hg) made and used by the Indian Alchemists for medicinal purposes; Use of chemical, compounds and ores in medicines.

Unit 8: Life and work of Ancient Indian Scientists/Chemists **Lectures:05**

(i) Maharshi Kanada (Ancient text and manuscripts), (ii) Nagarjuna (Ras Ratnakar, Kakshaputtantra, Arogya Manjari, Yog Saar, Yoasthak), (iii) Vaagbhatt (Rasratna Samuchchay), (iv) Govindacharya (Rasarnava), (v) Yashodhar (Ras Prakash Sudhakar), (vi) Ramachandra (Rasendra Chintamani), (vii) Somdev (Rasendra Chudamani)

References:

1. Baer cites Kabat-Zinn, J. (1994): **Wherever you go, there you are: Mindfulness meditation in everyday life.** New York: Hyperion, p.4.
4. Buchholz L (October 2015). "**Exploring the Promise of Mindfulness as Medicine**". JAMA. 314 (13): 1327–1329. doi:10.1001/jama.2015.7023. PMID 26441167.
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11. Hofmann SG, Sawyer AT, Witt AA, Oh D (April 2010). "**The effect of mindfulness-based therapy on anxiety and depression: A meta-analytic review**". Journal of Consulting and Clinical Psychology. 78 (2): 169–183. doi:10.1037/a0018555. PMC 2848393. PMID 20350028.
12. Chiesa A, Serretti A (April 2014). "**Are mindfulness-based interventions effective for substance use disorders? A systematic review of the evidence**". Substance Use &

Misuse. 49 (5): 492–512. doi:10.3109/10826084.2013.770027. PMID 23461667. S2CID 34990668.
13. Garland EL, Froeliger B, Howard MO (January 2014). "**Mindfulness training targets neurocognitive mechanisms of addiction at the attention-appraisal emotion interface**". Frontiers in Psychiatry. 4: 173. doi:10.3389/fpsyt.2013.00173. PMC 3887509. PMID 24454293.
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16. Dunning DL, Griffiths K, Kuyken W, Crane C, Foulkes L, Parker J, Dalgleish T (March 2019). "**Research Review: The effects of mindfulness-based interventions on cognition and mental health in children and adolescents - a metaanalysis of randomized controlled trials**". Journal of Child Psychology and Psychiatry, and Allied Disciplines. 60 (3): 244–258. doi:10.1111/jcpp.12980. PMC 6546608. PMID 30345511.
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25. Ray, P. C., **A History of Hindu Chemistry: from the Earliest Times to the Middle of the Sixteenth Century A.D.**, Volume 1 – 1902, Volume 2 – 1908, The Bengal Chemical and Pharmaceutical Works Ltd
26. "**History of Chemistry in Ancient and Mideaval India**" (Edited volume of Acharya Ray's "History of Hindu Chemistry"), Indian Chemical Society, Calcutta, 1956.
27. Harsha, N. M., Nagaraja, T. N., **The History of Hindu Chemistry**, Ancient Science of Life, 2010, 30, 58 – 61.
28. Ray, P. C., **Life and experiences of a Bengali chemist,** Two Volume Set. Calcutta: Chuckervertty, Chatterjee & Co. 1932 and 1935.
29. Ray, P. R., **Chemistry in Ancient India**, Journal of Chemical Education, 1948, 25 (6), 327.
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Practicals: **Credits: 01**

(Laboratory periods: 30)

1. Extraction of essential oil from rose petal.
2. Extraction of casein from milk.
3. Determination of pulse rate/blood pressure/oxygen saturation before and after exercise.
4. Determination of acid value of given oil sample.
5. Isolation of piperine from black pepper.
6. Determination of Copper in a brass turnings.
7. Extraction of Butea monosperma (Palash) dye for its use in coloration of cloth.
8. Determination of mass loss in mild steel in acidic/basic media.
9. **Project on (Do any one):**
   Ayurveda as alternate medicine system,
   Homeopathy in India,
   Yogic Practices for mental wellness
   Ancient Chemists of India
   Other titles can also be suggested by the teacher.
10. **Visit to**
    Iron Pillar, the metallurgical marvel and prepare a brief report.
    Industries like Dabur India Ltd.

KEYWORDS: Metallurgy, Mental/Physical well-being, Drugs, Dyes, Yogic Exercises, Alternate Medicines System

INDEX

Skill Enhancement Courses (SEC)

UNIVERSITY OF DELHI

CNC-II/093/1(26)/2023-24/200
Dated: 21.09.2023

N O T I F I C A T I O N

Sub: Amendment to Ordinance V

[E.C Resolution No. 14-1/ (14-1-12) and 27-1 (27-1-14) dated 09.06.2023 and 25.08.2023]

Following addition be made to Appendix-II-A to the Ordinance V (2-A) of the Ordinances of the University;

Add the following:

Skill Enhancement Courses (SECs)
Under UGCF-2022
Listed under Appendix-II-A to the Ordinance V (2-A) of the Ordinances of the University
(with effect from Academic Year 2022-23)

A student who pursues any undergraduate programme in the University and its Colleges is offered a pool of Skill Enhancement Courses. A list of such courses as passed by the Executive Council in its meeting dated 09.06.2023 and 25.08.2023 is as below:

1) Plant Tissue Culture
2) Application of Plant Tissue Culture
3) Exploring medicinal plants: from cultivations to applications
4) DNA barcoding of medicinal/ commercially important plants
5) Cultivation of Lac: an eco-friendly multiuse wonder product of nature
6) Lac Characterization and Processing
7) Drosophila and Zebrafish model organism in biological studies
8) Isolation and characterization of Plasmid DNA
9) Isolation, characterization and quality check of Genome DNA
10) Polymerase chain reaction (PCR) and its applications
11) CAD (Computer aided Jewellery Design-I)
12) CAD (Computer aided Jewellery Design-II)
13) CAD (Computer aided Jewellery Design-III)
14) CAD (Computer aided Jewellery Design-IV)
15) Harmonium -II- Study of Harmonium
16) Reading & Writing skills in Brahmi Scripts

17) Acting Skills in Sanskrit Dramaturgy
18) Script writing skills in Sanskrit Dramaturgy
19) Fundamentals of Indian Manuscriptology
20) Traditional Indian Gastronomy
21) E-Learning Tools and Techniques for Sanskrit
22) Practices in Horoscopes -I
23) Basics of Food Science and Nutrition
24) Basic Forensic science
25) Basic Laboratory Techniques
26) Public health, hygiene and nutrition
27) LaTeX Typesetting for Beginners
28) Mathematical Modeling with Excel
29) Financial Modeling with Excel
30) Network Flows
31) R-Shiny: Powerful Web Apps for Everyone
32) Spoken Persian: Elementary level

SEC- : Basics of Food Science and Nutrition

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		
Basics of Food Science and Nutrition	**2**			**2**	XIIth pass	NIL

Learning Objectives

1. The primary objective of this course is to provide an understanding to the students of the types and biological importance of macro and micronutrients found in the dietary sources.
2. The students will get an opportunity to understand the integrated learning between the areas of Food science and Nutrition.
3. The course will also provide hands-on experience of different methods used to estimate different types of nutrients that will help the students learn the concept nutrition and health.

Learning Outcomes

Learners will be able to:

1. Analyse and evaluate concepts in human nutrition and its relation with food and health
2. Understand the concept of food exchange and meal planning
3. Understand the essentiality of macro and micronutrients in food items
4. Assess the quality and nutritive value of food.

Skill development and job opportunities:

Students will be able to take up jobs in public and community health schemes where food assessment is done. They can also as serve as assistants in program where meal planning is done like home care facilities, schools, hostels, old age homes. It will provide them the training to apply for jobs in any business establishments concerning food processing, packaging and production. After completion of the entire series, students will be able to take up job opportunities in any business involved with advanced food processing. They would also be eligible to get placements in food and drug assessment centres. The course will also enable student to apply to advance food science and tech courses.

SYLLABUS OF SEC- :

Unit I **4 weeks**

Introduction to nutrition and food science: Defining nutrition, nutrients and role of nutrients. Food groups- Grouping of foods based on composition. Classification of nutrients: Macronutrients and Micronutrients. Food Energy and the concept of Energy Balance. Principals of meal planning, food exchanges and Balanced diet.

Practical Exercises:

- Determination of calorie content and nutritive value of different food items.
- Estimation of Total moisture and ash content in the food items.
- Meal planning for healthy individuals depending on adult men and women.

Unit II: Macronutrients in food **5 weeks**

Introduction to Dietary Carbohydrates, Proteins and Fats and their roles in body functions, dietary sources and RDA

Practical Exercises:

- Estimation of Total Carbohydrate content in food by Molisch's test, Hanes method or Folin and Wu
- Estimation of Total lipid content in food by Soxhlet extraction or Bligh and Dyer method
- Estimation of Total protein content in food by modified Lowry's method.

Unit III: Micronutrients **6 weeks**

Introduction to water- and fat-soluble vitamins, brief overview of functions, dietary sources and RDA. Introduction to minerals, brief overview of functions, dietary sources and RDA

Practical Exercises:

- Quantitative estimation of Vitamin C in foods by titration
- Quantitative estimation of Vitamin A/E in oils by spectrophotometric methods
- Quantitative of Estimation of mineral content in food. (Ca, P/ Na/K and Fe)

Essential Reading

- Plummer, D. T. (1998) *An Introduction to Practical Biochemistry* (3rd ed.), Tata McGraw Hill Education Pvt. Ltd. (New Delhi); ISBN: 13: 978-0-07-099487-4 / ISBN:10: 0-07-099487-0.
- Cooper, T. G. (2011) *The Tools of Biochemistry* (2nd ed.), Wiley-Interscience Publication (New Delhi); ISBN: 13:9788126530168.
- Raymond, J. L., & Morrow, K. (2020). *Krause's food & the nutrition care process* (15th ed.). Saunders.

- Vasudevan, D. M., & Das, K. S. (2020). *Practical textbook of biochemistry for medical students* (3rd ed.). Jaypee Brothers Medical.
- Manay, N. S. O. (2001). Food: facts and principles. New Age International.

Suggested Readings

- Practical Biochemistry, Damodaran Geetha K, Jaypee Brothers Medical Publishers Private Limited; 1st edition (1 January 2011), ISBN: 9789350251416
- Mahan, L. K., & Raymond, J. L. (2016). Krause's food & the nutrition care process. Elsevier Health Sciences.
- Malik, D., Narayanasamy, N., Vavilala, P., Takur, J., Sinha, N., (2022). Textbook of Nutritional Biochemistry. Springer Singapore, ISBN978-981-19-4149-8.

Examination scheme and mode:

Total Marks: 50
Internal Assessment (Practical): 25 marks
End Semester Practical Exam*: 25 marks

The Internal Assessment for the course may include Class participation, Assignments, Class tests, Projects, Field Work, Presentations, amongst others as decided by the faculty.

SEC- : Basic Forensic science: crime scene investigation and evidence collection

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		
Basic Forensic science	2			2	Class XII	-

Learning Objectives

Forensic science is an essential part of the criminal and civil justice system. Forensic scientists collect and analyze evidences from crime scene and elsewhere. The objective of this analysis is to provide data that can assist in criminal or civil investigation, so that prosecution of suspects of the crime is done or an innocent person is cleared off the crime beyond any reasonable doubt. The specific objectives of this course are as follows:

- To provide an understanding of the sanctity of crime scene
- To understand collection and preservation of forensic evidence.

Learning outcomes

The Learning Outcomes of this course are as follows:

- Comprehend the developments in the field of forensic sciences; learn to observe a crime scene for identification of relevant evidences and samples for forensic analysis.
- Understand the importance of collection, packaging and preservation of samples to ensure reliability of data generated.

Skill development and job opportunities

- After completion of this course students would obtain the training in collection, documentation, and analysis of physical evidences. They will be encouraged to do short internships in police station, forensic laboratories and research institutes.
- The students will also able to take a job in a forensic laboratories or police station even after completing a one-year course as they are able to collection, preservation and documentation of evidence, drawing a crime scene and doing preliminary analysis at crime scene.

SYLLABUS OF SEC-

Unit 1: Basic Forensic **1 week**

Introduction, need, scope and Significance of forensic science, History, laws and basic principles of forensic science. Branches of forensic science. Organizational set up of forensic science laboratories.

Practical Exercise

- Understanding a crime using case studies.

Unit 2: Crime scene investigation **6 weeks**

Definition, Identification, Mapping, and preservation of a crime scene, Classification in a crime scene.Precautions to ensure credibility of a crime scene. Investigative strategies and eye witness report.

Practical exercises:

- Drawing a crime scene.
- Drawing and mapping a crime scene of an unusual case (fire, blast, water)
- Case studies in different indoor and outdoor primary and secondary crime scenes
- Documenting and reconstructing a crime scene.
- Virtual exercise / field trip to a crime scene

Unit 3: Forensic evidences **8 weeks**

Definition of a forensic evidence. Classification based on legal and forensic value Understanding chain of custody. Collection, Preservation, Packaging, and Labeling of chemical, physical evidence and biological evidence (blood, semen and other biological fluids, hair, fibers and fabrics, pollen) for forensic investigation.

Practical exercises:

- Collection and preservation of a fresh and dried body fluid sample
- Collection of tissues post mortem.
- Collection of a trace evidence like hair, fiber and pollenfrom crime scene and during autopsy
- Collection and preservation of a soil sample from crime scene and during autopsy
- Collection of a hand or foot print, tyre-print, fingerprint
- Collection and preservation of evidence for chemical/ballistic analysis.

Essential/ recommended readings

- James, S.H., Nordby, J.J. & Bell, S. (2014). *Forensic Science: An Introduction to Scientific and Investigative Techniques, Fourth Edition*: Taylor & Francis. ISBN 9781439853832
- Jones, P., & Williams, R.E. (2009). *Crime Scene Processing and Laboratory Workbook First Edition*: CRC Press. ISBN 9780429249976

- Saferstein, R. (2018). *Criminalistics: An Introduction to Forensic Science, Twelfth edition*: Pearson Education. ISBN 10:0134477596, ISBN 13: 9780134477596
- Lee, H., Palmbach, T. & Miller, M. (2001). *Henry Lee's crime scene handbook, First Edition*: Academic Press ISBN 9780080507989
- Parikh, C.K. (2016). *Parikh's textbook of medical jurisprudence, forensic medicine and toxicology: for classrooms and courtrooms*, *Seventh Edition*: CBS Publishers and Distributors. ISBN 9788123926469

Note: Learners are advised to use the latest edition of readings.

Examination scheme and mode:

Total Marks: 50

Internal Assessment: 25 marks

Practical Exam (Internal): 25 marks

The Internal Assessment for the course may include Class participation, Assignments, Class tests, Projects, Field Work, Presentations, amongst others as decided by the faculty.

SEC : Basic Laboratory Techniques

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		
Basic Laboratory Techniques	**2**			**2**	XII pass	

Learning Objectives

This course will help students understand skills required for working in Laboratories. To comprehend the standard operating procedures for laboratory chemicals, autoclave and water wash applications. The specific objectives of the course are:

- To be familiar with laboratory safety manual and GLPs and regulatory requirements.
- To learn about use and working of lab instruments such as pH meters, auto clave, laminar flow, microscopes, spectrophotometers, centrifuges and incubators.
- knowledge of preparation and testing of reagent water in the laboratory Learn how to make solutions and buffers
- Learn about microbiological techniques

Learning outcomes

At the end of the course the students will be

- Trained in best lab practices
- Able to use lab instruments such as pH meters, auto clave, laminar flow, microscopes, spectrophotometers, centrifuges and incubators
- Able to prepare solutions and buffers
- Able to prepare media and grow microbial culture in aseptic conditions

Job opportunities:

Students trained in lab skills will be employable in research labs, R & D labs in Pharma and Biotechnology industry and Diagnostic labs

SYLLABUS OF SEC-

Unit 1 – Laboratory safety and standards **2 weeks**

- Precision, accuracy and sensitivity

Unit 2– Preparation of solutions/ media **2 weeks**

- Preparation of solution (w/w, w/v, Molar, Normal, Stock, standard and serial dilutions)
- Preparation of buffer solution, pH scale, pH meter, Henderson-Hasselbalch equation, pK, (acetate/ phosphate buffer)

Unit 3– Microbial Techniques **6 weeks**

Instrumentation (Microscopy, Laminar Hood, autoclave, shaker incubator, BOD incubator hot air oven)

- Sterilization methods
- Types of Microbial media: Microbial growth media: Minimal Media, Defined media, Complex media, Enriched media, Selective media, and Differential media.
- Staining techniques for microbes
- Isolation of pure cultures of bacteria by streaking method.
- Enumeration of colony forming units (CFU) count by spread plate method
- Growth curve of bacteria
- Culture transfer Techniques: Streaking, Serial dilution and Plating methods. Phases of bacterial growth

Unit 4 – Bioinstrumentation for Separation techniques **5 weeks**

Chromatography

- Separate biomolecules/dyes using paper/thin layer and column chromatography to illustrate the principle and application of chromatography. Calculate the Rf value of each component.

Centrifugation

- Principle of centrifugation, Basics of sedimentation, Sedimentation coefficient, Factors affecting sedimentation.
- Types of centrifuges and rotors. Microfuges
- Separation plasma and blood cells/ cell fractionation

Spectroscopy:

- Principle of UV-visible absorption spectrophotometry, Lambert's Law, Beer's Law, Working of a spectrophotometer.
- Determination of absorption maxima (λmax).

- Verification of Lambert's and Beer's law

Gel Electrophoresis

- Principle, instrumentation, application and maintenance of horizontal and vertical electrophoresis.
- Separation of protein sample in denaturing condition and calculation of its molecular weight and mobility.
- Demonstration of separation of nucleic acids using agarose gel electrophoresis.

Essential/Recommended readings

- Biochemistry Laboratory: Modern Theory and Techniques, (6th edition), Boston, Mass: Prentice Hall; ISBN-13:978-0136043027Boyer, R.F. (2012).
- An Introduction to Practical Biochemistry (1998) 3rd ed., Plummer D. T., Tata McGraw Hill Education Pvt. Ltd. (New Delhi), ISBN:13: 978-0-07-099487-4/ ISBN:10: 0-07-099487-0.
- Cappucino, J. and Sherman, N. (2013). Microbiology: A Laboratory Manual. (10th ed.) Pearson Education Limited; ISBN 13: 9780321840226 Additional Resources: 1. Madigan, M.T., Martinko, J.M., Dunlap, P.V. and Clark, D.P. (2010).

Examination scheme and mode:

Total Marks: 50
Internal Assessment: 25
Practical: 25
Exam (Internal): NIL
End Semester University Exam: NO End Term Exam
The Internal Assessment for the course may include Class participation, Assignments, Class tests, Projects, Field Work, Presentations, amongst others as decided by the faculty.

SEC : Public health, hygiene and nutrition

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Creditdistributionofthecourse			Eligibilitycriteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
SEC-	2	0	NIL	2	Class XII	NIL

Learning Objectives

In the post covid scenario, the students have experienced live the various area where public health is of primary importance. The present course attempts to provide an interdisciplinary understanding of public health issues in India. Learning about processes of proper waste disposal and management of water will have great impact on human health as unsafe drinking water and sanitation was the second leading risk responsible for disease burden in India, mainly through diarrhea and other infections. The specific objectives of the course are:

- To provide a basic understanding of the scope of public health issues, particularly related to collection of primary data in the area of public health nutrition, infectious biology and sanitation, social and preventive medicine, and the environmental issues that affect public health.
- To generate a discussion platform that would encourage a healthy inter- and multidisciplinary interaction amongst the students to get a holistic view of public health issues in India.
- A mini research project on any relevant topic related to public health will be taken up after completing the course.
- After completing the course, the students can also apply for some higher-level courses in different areas of public health as the course helps in building a basic understanding on different aspects related to public health

Eligibility: Being interdisciplinary in its nature and scope, the course will be equally engaging and beneficial for students of all subject streams.

Learning Outcomes

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

- get a holistic overview of the inter disciplinary nature of Public health. They will be able to understand and address behavioral, social and cultural factors that impact individual and population health disparities.
- understand public health issues in India particularly related to Malnutrition,

sanitation issues and related burden of infectious disease, and the role of pollution as a public health concern.

- gets hands-on training on preparation of questionnaire and collection of primary and secondary data relevant to public health issues. They will be trained to use epidemiological methods to analyze patterns of disease progression in a population and describe applications and programs that can help address or mitigate the issue.
- To study various factors deteriorating quality of water by collecting samples from various parts of cities. Check TDS, pH, colour, odour, and transparency of water sample.
- Study of probable causes of stress and mental health problems. Design of some remedial strategies to overcome these problems.
- They will also learn to present the relevant data after subjecting it to statistical analysis. They will be able to identify and apply the appropriate statistical method needed to analyze and describe a public health problem.

Skill development and job opportunities:

Public health professionals are involved in everything from identifying diseases to creating public policy to helping refugees integrate into new communities. Now more than ever most of the world has witnessed first-hand a public health crisis and there will be no shortage or demand for well-trained public health professionals.

- After completion the course, students will be able to have career opportunities that include Medical and Health Services Manager, Biostatistician, Health care consultant, Epidemiologist, Occupational Health and Safety Specialist, Social and Community Service Manager, Health Education Special

SYLLABUS OF SEC

Unit I: Introduction to public health and hygiene **3 weeks**

Significance of public health, and hygiene to prevent spread of diseases (e.g. TB, leprosy, cholera, food poisoning etc.). Introduction to health care and **WASH** (Water, Sanitation and Hygiene)

Practical exercises:

1. To study various hygiene practices like personal, menstrual, oral and hand hygiene etc.

2. Field visit for understanding the health programs and hygiene like Asha worker interviews/Sulabh international museum of toilets/Water Treatment Plant (any one)

Unit II: Public health Biology **7 weeks**

What is public health nutrition? Application of nutrition concepts to design programs of public health concern, What are communicable diseases?

Understanding the biology, socioeconomic factors and other environmental conditions that influence the transmission and infection by pathogenic (disease-causing) bacteria, viruses, parasites, and fungi.

Practical exercises

Assessment of nutritional status using anthropometric indices like BMI, WHR.
Assessment of Nutritional status by a survey of clinical and non-invasive biochemical parameters.

- To study the following medically important organisms like mosquito, house fly cockroach and rats as transmission vectors for infectious disease
- Measuring blood pressure and correlating it with lifestyle.
- Case study of a disease (Nutritional, infectious and lifestyle) along with the public health data with analysis and discussion

Unit III: Environmental determinants of Public Health 5 weeks

Determinants of Environmental Health: factors that affect environmental health; Occupational environment and health concerns; Understanding effect of air, water and soil Pollution on health.

Practical exercises:

- To determine the portability of water using, pH, BOD, COD and MPN of the water sample from different sources.
- Collecting secondary data on AQI from different areas and correlate with health indices in that area.
- Field visits to nearby health care center to collect some data on the rate of a particular disease over past few months or years.

Essential/Recommended readings

1. Aschengrau A, Seage G.R., (2013) Essentials Of Epidemiology In Public Health Jones and Bartlett Publishers, Inc; 3rd edition
2. Bamji MS, Rao NP, Reddy V.(2017).Textbook of human nutrition. (4thed). Delhi: Oxford and IBH Publishing co. (P) Ltd.
3. Environmental Microbiology edited by I.L. Pepper, C.P. Gerba, T.J. Gentry. 3rd edition. Academic Press, USA. 2014.

Suggested readings:

1. Gibney et al.(2004). Public health nutrition. Hoboken, NJ: Blackwell Publishing
2. N. Okafor. (2011) Environmental Microbiology of Aquatic and Waste Systems by Springer, USA.
3. Waste Water Microbiology by D.H. Bergey. 2nd Edition. Medtech, India. 2019.
4. Park, K. (2017), Preventive and Social Medicine, B.B. Publishers.

5. Engelkirk P.G. and Duben-Engelkirk J. (2015) Burton's Microbiology for the HealthSciences, 10th Edn. Wolters Kluwer Health.
6. Shanmugavel, G. and George, B. Textbook of public health and hygiene. Darshan Publishers, 25-Jan-2021

Examination scheme and mode:

Total Marks: 50
Internal Assessment (Practical): 25 marks
End Semester Practical Exam*: 25 marks

The Internal Assessment for the course may include Class participation, Assignments, Class tests, Projects, Field Work, Presentations, amongst others as decided by the faculty.
For End Semester Practical Exam External to be appointed by the parent Department.

RADIATION SAFETY

Course Title and Code	Credits	Credit distribution of the course			Eligibility Criteria	Pre-requisite of the course
		Lecture	Tutorial	Practical		
Radiation Safety	**2**	**1**	**0**	**1**	Class XII pass with Physics and Mathematics as main subjects	Physics and Mathematics syllabus of class XII

Learning Objectives:

- This course focuses on the applications of nuclear techniques and radiation protection.
- It will not only enhance the skills towards the basic understanding of the radiation but will also provide the knowledge about the protective measures against radiation exposure.
- It imparts all the skills required by a radiation safety officer or any job dealing with radiation such as X-ray operators, jobs dealing with nuclear medicine: chemotherapists, operators of PET, MRI, CT scan, gamma camera etc.

Learning Outcomes:

This course will help students in the following ways.

- Awareness and understanding the hazards of radiation and the safety measures to guard against these hazards.
- Having a comprehensive knowledge about the nature of interaction of matter with radiations like gamma, beta, alpha rays, neutrons etc. and radiation shielding by appropriate materials.
- Knowing about the units of radiations and their safety limits, the devices to detect and measure radiation.
- Learning radiation safety management, biological effects of ionizing radiation, operational limits and basics of radiation hazards evaluation and control, radiation protection standards,
- Learning about the devices which apply radiations in medical sciences, such as X-ray, MRI, PET, CT-scan

SYLLABUS

THEORY COMPONENT

Unit 1: **(6 Weeks)**

Radiation and its interaction with matter: Basic idea of different types of radiation electromagnetic (X-ray, gamma rays, cosmic rays etc.), nuclear radiation and their origin.
Nuclear Radiation: Basic idea of Alpha, Beta, Gamma neutron radiation and their sources (sealed and unsealed sources).
Interaction of Charged Particles (including alpha particles): Heavy charged particles (e.g. accelerated ions) - Beth-Bloch Formula, Scaling laws, Mass Stopping Power, Range, Straggling.
Interaction of Beta Particles: Collision and Radiation loss (Bremsstrahlung).
Interaction of Photons: Linear and Mass Attenuation Coefficients.
Interaction of Neutrons: Collision, slowing down and Moderation.

Unit 2: **(4 Weeks)**

Radiation detection and monitoring devices: Basic concepts and working principle of gas detectors, Scintillation Detectors, Solid State Detectors and Neutron Detectors, Thermo-luminescent Dosimetry.
Radiation Quantities and Units: Basic idea of different units of activity, KERMA, exposure, absorbed dose, equivalent dose, effective dose, collective equivalent dose, annual limit of intake (ALI) and derived air concentration (DAC).

Unit 3: (2 Weeks)

Radiation Units, dosage and safety management: Basic idea of different units of activity, KERMA, exposure, absorbed dose, equivalent dose, effective dose, collective equivalent dose, annual limit of intake (ALI) and Derived air concentration (DAC).

Radiation safety management: Biological effects of ionizing radiation, Operational limits and basics of radiation hazards, its evaluation and control: radiation protection standards.

Unit 4: (3 Weeks)

Application of radiation as a technique: Application in medical science (e.g., basic principles of X-rays, MRI, PET, CT scan, Projection Imaging Gamma Camera, Radiation therapy), Archaeology, Art, Crime detection, Mining and oil. Industrial Uses: Tracing, Gauging, Material Modification, Sterilization, Food preservation.

PRACTICAL COMPONENT

Minimum five experiments need to be performed from the following, graphs to be plotted using any graphical plotting software

1) Estimate the energy loss of different projectiles/ions in Water and carbon, using SRIM/TRIM etc. simulation software, (different projectiles/ions to be used by different students).
2) Simulation study (using SRIM/TRIM or any other software) of radiation depth in materials (Carbon, Silver, Gold, Lead) using H as projectile/ion.
3) Comparison of interaction of projectiles with Z_P = 1 to 92 (where Z_P is atomic number of projectile/ion) in a given medium (Mylar, Carbon, Water) using simulation software (SRIM etc).
4) SRIM/TRIM based experiments to study ion-matter interaction of heavy projectiles on heavy atoms. The range of investigations will be Z_P = 6 to 92 on Z_A = 16 to 92 (where Z_P and Z_A are atomic numbers of projectile and atoms respectively). Draw and infer appropriate Bragg Curves.
5) Calculation of absorption/transmission of X-rays, γ-rays through Mylar, Be, C, Al, Fe and Z_A = 47 to 92 (where Z_A is atomic number of atoms to be investigated as targets) using XCOM, NIST (https://physics.nist.gov/PhysRefData/Xcom/html/xcom1.html).
6) Study the background radiation in different places and identify the source material from gamma ray energy spectrum. (Gamma ray energies are available in the website http://www.nndc.bnl.gov/nudat2/).
7) Study the background radiation levels using Radiation meter.
8) Study of characteristics of GM tube and determination of operating voltage and plateau length using background radiation as source (without commercial source).
9) Study of counting statistics using background radiation using GM counter.
10) Study of radiation in various materials (e.g. KSO_4 etc.). Investigation of possible radiation in different routine materials by operating GM counter at operating voltage.
11) Study of absorption of beta particles in Aluminum using GM counter.
12) Measurement of gamma ray attenuation co-efficient of aluminium using GM counter.
13) Estimation of half thickness for aluminium using GM Counter.

References:

Essential Readings:

1) Basic ideas and concepts in Nuclear Physics: An introductory approach by K Heyde, third edition, IOP Publication, 1999.
2) Nuclear Physics by S N Ghoshal, First edition, S. Chand Publication, 2010.
3) Nuclear Physics: Principles and Applications by J Lilley, Wiley Publication, 2006.
4) Fundamental Physics of Radiology by W J Meredith and B Massey, John Wright and Sons, UK, 1989.
5) An Introduction to Radiation Protection by A Martin and S A Harbisor , John Willey and Sons, Inc. NewYork, 1981.

Additional Readings:

1) Radiation detection and measurement by G F Knoll, 4th Edition, Wiley Publications, 2010.
2) Techniques for Nuclear and Particle Physics experiments by W R Leo, Springer, 1994.
3) Thermoluminescence dosimetry by A F Mcknlay, Bristol, Adam Hilger (Medical Physics Hand book 5
4) Medical Radiation Physics by W R Hendee, Year book Medical Publishers, Inc., London, 1981.
5) Physics and Engineering of Radiation Detection by S N Ahmed, Academic Press Elsevier, 2007.
6) IAEA Publications: (a) General safety requirements Part 1, No. GSR Part 1 (2010), Part 3 No. GSR Part 3 (Interium) (2010); (b) Safety Standards Series No. RS-G-1.5 (2002), Rs-G-1.9 (2005), Safety Series No. 120 (1996); (c) Safety Guide GS-G-2.1 (2007).

References (for Laboratory Work):

1) Schaum's Outline of Modern Physics, McGraw-Hill, 1999.
2) Schaum's Outline of College Physics, by E. Hecht, 11^{th} edition, McGraw Hill, 2009.
3) Modern Physics by K Sivaprasath and R Murugeshan, S Chand Publication, 2010.
4) AERB Safety Guide (Guide No. AERB/RF-RS/SG-1), Security of radioactive sources in radiation facilities, 2011

AERB Safety Standard No. AERB/SS/3 (Rev. 1), Testing and Classification of sealed Radioactivity Sources., 2007.

Chemistry Lab Standard Operations and Safety Measures

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisiteofthecourse (ifany)
		Lecture	Tutorial	Practical/ Practice		
Chemistry Lab Operations and Safety Measures	**2**	**0**		**2**	XIIth Pass with Science	NA

Learning Objectives

- To cultivate efficient working skills among the students to work in a chemistry laboratory
- To create a trained workforce which can responsibly learn imbibe and explore verticals on structured knowledge safely.
- To make students aware of different chemicals and their properties being used in the chemistry laboratory.

Learning outcomes

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

- Able to design and implement safe working practices in chemistry laboratory.
- Able to safely handle different glass apparatus
- Able to handle the chemicals and equipment safely and properly.
- Able to design working protocols related to various methods and instruments in chemistry laboratory.

SYLLABUS

Practicals/ Hands-on Training: **(15 WEEKS)**

Part A: Safety Measures

1) Design an illustrative chart exhibiting creativity at transaction of Do's and Don'ts instructions for working in a chemistry laboratory.
2) i. Carry out Classification and labeling of the given set of chemicals based upon Globally Harmonized System.
   ii. Carry out detailed survey of the Chemical Abstract Service (CAS) Registry Number and identify the given set of CAS RN and explain the different sections of CAS RN.
3) Carry out preparation of the indicative MSDS (Material Safety Data Sheet) of given set of chemicals as per Standard MSDS format.
4) Design an illustrative chart exhibiting creativity at transaction of Common Safety Symbols along with its description. Associate appropriate safety symbol with each of the given set of chemicals.
5) Draw and elucidate the National Fire Protection Association Hazard Labels.

6) i. Identify and enlist the Incompatible Chemicals from a given set of chemicals available in the laboratory.
   ii. Carry out investigations on Labeling and storage of Chemical in laboratory.

7) i. On the basis of MSDS analysis, identify the required storage conditions for the given set of chemicals.
   ii. Describe procedure for the storage, maintenance and handling of compressed gas cylinders.

   iii. Explore guidelines for the Storage of shelf chemicals and reagents.

8) i. Carry out a brief review of common pathways by which working Chemicals can enter the Body.
   ii. Carry out a detailed study of the Limits of Exposure of given Chemicals.

9) i. Classify the Hazard based on storage, handling, and disposal of chemicals.
   ii. Identification and describe handling protocols for Substances with Greater Hazardous Nature.

10) Carry out detailed investigations on procedural protocols for safe Disposal of Chemicals.
11) i. Carry out study on recommended Safety and Emergency Equipment essential for the safe practices in a Chemistry Laboratory.
   ii. Study the guidelines in the Event of a Chemical Accident or Spill.

12) i. Write detailed description on Fire Safety in the laboratory.
   ii. Carry out investigations of the data regarding Institute Safety Policies: Safety Audits / Inspections.

Part B: Chemistry Lab Standard Operations

1) Carry out exploration on Holding, Handling and use of Common Laboratory Apparatus as per given list of laboratory apparatus (Appendix A).
2) Carry out investigations of various types of apparatus in labs based on material they are made of such as Pyrex Glass (borosilicate Glass) Apparatus, Fused Silica Apparatus: Corning Vycor Glass, Porcelain apparatus, Plastic Apparatus, Metal Apparatus.
3) Understanding the protocol of Cleaning and drying and polishing of Glassware apparatus.
4) Carry out detailed investigations on Identification, diagrammatic representation, set up of Apparatus assemblies and details exploration on operational procedural protocols for glassware apparatus with Interchangeable ground glass joints: Typical Assemblies.
5) i. Carry out calibration of Volumetric/ Graduated Glassware Apparatus along with description on Temperature Standards.
   ii. Carry out Calibration of thermometers.

6) i. Carry out exploration and investigations of working protocol for various heating equipment in laboratory: Burners, Hot Plates, Electrical Heating Mantles, Electric Oven, Microwave Oven, Muffle Furnace, Infrared lamps, Crucible and Beaker Tongs and Emersion heaters.
   ii. Carry out exploration and investigations of working protocol for various Stirring apparatus in laboratory: Stirring rods; Policeman, Boiling rods, Use of Mechanical agitation-Magnetic Stirrer and Mechanical Shaker.

   iii. Carefully analyze the Glass, Cork and Rubber Stoppers and investigate their preparation and appropriate applications.

7) i. Carry out detailed investigations of Heating and Cooling Bath, and determine their working ranges and working protocols.
   ii. Explore and differentiate between different forms of water for Laboratory Use: Distilled (Grade I to III), De-ionized and tap water, and carry out conductance measurement /other analytical

investigations for the differentiation purpose.

8) i. Differentiate among Various types of Filter Paper and explore their applications.
ii. Preparation of a fluted filter paper and its advantages.

iii. Classification of reagents as AR/ GR grade.

9) i. Care and Use of Analytical Balance: Mass and Weight, Two-Pan Balance and Electronic Balance.
ii. Carry out Calibration of weighing balances and accuracy in measurement.

10) Introduction to Chromatographic adsorption: Paper and Thin Layer Chromatography.
Preparation of Thin Layer Chromatography (TLC) Plates.

11) i. Use of melting point apparatus. Experimental determination of the melting point using various methods.
ii. Experimental determination of the boiling point using various methods.

12) To Purify given organic solvents.
13) i. Hand on training for working with typical assemblies of apparatus for distillation and refluxing.
ii. Assessment of Fire hazards attending the distillation of inflammable solvents.

14) i. Purification of given solid organic compounds by crystallisation method.
ii. Recrystallization of given non-volatile organic solids and outline the Difficulties encountered in recrystallization process.

15) Removal of traces of colouring matter and use of decolourising carbon.
16) i. Carry out exploration and investigations of working and working protocol for Filtration Apparatus: Filtration with suction.
ii. Explore and imbibe knowledge about types of Vacuum Pump; Water and Oil Pump and their applications.

17) Investigate Conventions for Drying of the recrystallized material.
18) i. Introduction to Gas absorption traps and their importance.
ii. Recrystallization in an atmosphere of inert gas.

19) i. Performing Evaporation of the solvent in the laboratory.
ii. Preparation of anhydrous liquids or solutions of organic compounds in organic solvents.

20) i. Various procedures for the precipitation and washing of the precipitates.
ii. Application of various methods and instruments for drying of solid organic compounds.

21) i. Incineration of Filter paper with precipitate.
ii. Differentiate between various types of centrifugation methods, principle, uses and application of centrifugation method.

iii. Calculation of yields for different chemical processes.

22) In-depth Understanding and Preparation of Chemical Laboratory Reagents.
23) Explore methodologies of Preparation and Storage of Standard Solutions.

Important Instruction Note on working approach:

A minimum of 5 exercises from Part A and 10 exercises from Part B is required to be discussed/performed/investigate. Moreover, exercises related to MSDS, CASRN safety symbols identification is required to be performed mandatorily.

Mandatory exercises:

Part A Exercise No.: 2, 3, 4, 5 and 9

Part B Exercise No.: 1 to 10.

The exercises mentioned above will be performed by the student strictly in accordance with the instructions received and only under the supervision of the teacher concerned.

References:

1. Skoog D.A., West D.M., Holler F.J., Stanley R.C., **Fundamentals of analytical chemistry**, 9th Edition, Cengage Learning.
2. Mendham, J.; Denney, R.C.; Barnes, J.D.; Thomas, M.J.K. (2007), **Vogel's Quantitative Chemical Analysis**, 6th Edition, Prentice Hall.
3. Furniss, B. S; Hannaford, A. J.; Smith, Peter W. G.; Tatchell, A. R; **Vogel's Text Book of Practical Organic Chemistry**, 5th Edition, Longman Scientific and Technical, Longman Group Ltd.
4. Garland, C. W.; Nibler, J. W.; Shoemaker, D. P. (2003), **Experiments in Physical Chemistry**, 8th Edition, McGraw-Hill, New York.
5. https://iupac.org/
6. https://edu.rsc.org/resources/practical/experiments

Chemistry of Cosmetics and Hygiene 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		
Chemistry of Cosmetics and Hygiene Products	**2**	**0**		**2**	XIIth Pass with Science	

Learning Objectives

- To introduce the concept of cosmetics in terms of chemistry and their formulation.
- To make students understand the role of each ingredients in the preparation of the cosmetic products.
- To give an idea about the role of herbal ingredients in the making of any cosmetic product.

Learning Outcomes

By the end of the course, the students will:

- Be familiar with the basic principles of various cosmetic formulations
- Be aware of different ingredients and their roles in cosmetic products.
- Appreciate the role of herbal ingredients in various cosmetic products
- Use safe, economic and body-friendly cosmetics
- Prepare new innovative formulations to achieve the aimed efficacies and effects

SYLLABUS

Practicals/Hands-on-training (15 WEEKS)

1. Definition, History and Classification of cosmetic & cosmeceutical products.

Skin Care Products: Basic structure and function of skin. Principles of formulation of skin care products. Role of herbs in Skin Care: Aloe and turmeric. General Ingredients and preparation of

(a) Preparation of Talcum powder (chemical based and herbal)

(b) Face cream/ vanishing cream/ cold cream/ suntan cream/lather shaving cream (any two)

(c) Body lotion

2. **Hair Care Products**: Basic structure of hair and classification of hair. Principles of formulation of Hair care products. Types of shampoo and conditioners. Role of herbs in Hair care: Henna and amla. Role of primary and secondary surfactants in shampoo. General Ingredients and preparation of

(a) Shampoo (chemical based and herbal)

(b) Conditioners

3. **Hand Care and hygiene Products**: Principles of formulation of hand sanitizers and hand wash. General Ingredients and preparation of:

(a) Hand wash

(b) Hand sanitizer

4. **Nail preparation**: Structure of nail, Nail lacquers, Nail polish remover. General Ingredients and preparation of:

(a) Nail polish and nail polish remover

5. **Personal hygiene products**: Total fatty matter, alkali content and pH of soaps. Bathing soap and toilet soap. Antiperspirants and deodorants. General Ingredients and preparation of

(a) Soaps

(b) Cream Soaps

6. **Oral hygiene products**: **Common problem associated with teeth and gums.Role of herbs in oral care: Neem and clove.** Principles of formulation of Oral hygiene products. Flavours and essential oils. General Ingredients and preparation of

(a) Tooth powder (chemical based and herbal)

(b) Tooth paste

References

1. Barel, A.O.; Paye, M.; Maibach, H.I. (2014), **Handbook of Cosmetic Science and Technology,** CRC Press.
2. Garud, A.; Sharma, P.K.; Garud, N. (2012), **Text Book of Cosmetics**, Pragati Prakashan.
3. Gupta, P.K.; Gupta, S.K. (2011), **Pharmaceutics and Cosmetics**, Pragati Prakashan
4. Butler, H. (2000), **Poucher's Perfumes, Cosmetic and Soap**, Springer

Additional Resources:

1. Flick, E.W. (1990), **Cosmetic and toiletry formulations,** Noyes Publications / William Andrew Publishing.
2. Natural Ingredients for Cosmetics; EU Survey 2005
3. Formulation Guide for cosmetics; The Nisshin OilliO Group, Ltd.
4. Functional Ingredients & Formulated Products for Cosmetics & Pharmaceuticals; NOF Corporation

Basic Analytical Techniques

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		
Basic Analytical Techniques	**2**	**0**	**0**	**2**	XIIth Pass with Science	NA

Learning Objectives

- To make students aware of the importance and the concepts of chemical analysis of water and soil samples collected from different sources
- To make them learn few techniques like chromatography, analytical techniques and instrumentation techniques, for example: spectrophotometry and flame photometry.

Learning Outcomes

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

- Handle analytical data
- Determine the pH and conductance of soil samples, which can be useful in agriculture sector
- Do quantitative analysis of metal ions in water samples
- Separate ions using chromatographic techniques
- Estimate macronutrients using Flame photometry.

SYLLABUS

Practicals: (15 WEEKS)

1. Determination of pH of soil samples collected from college nursery, sports ground and the soil collected from Yamuna River Bank.
2. Determination of conductance of soil samples collected from college nursery and sports ground.
3. Determination of pH of different types of aerated drinks and fruit juices.
4. Estimation of Calcium and Magnesium ions as Calcium carbonate (total hardness) by complexometric titration.
5. Determination of pH, acidity, and alkalinity of water samples collected from different water body/supply sources like Yamuna water, MCD supply water, Groundwater, water samples collected from water sewage treatment plants (Delhi /NCR).
6. Determination of dissolved oxygen (DO) of a water sample collected from different sources (at least two sources).
7. Determination of BOD of water sample collected from different water sources.
8. Paper chromatographic separation (*ascending and circular both*) of the mixture of metal ion (Ni^{2+} and Co^{2+}) and (Cu^{2+} and Cd^{2+}).
9. To study the use of phenolphthalein in trap cases.
10. Estimation of macro-nutrients: Potassium, calcium and magnesium in soil samples by flame photometry.
11. Spectrophotometric determination of Iron in vitamin / dietary tablets / different solutions of iron.
12. Spectrophotometric identification and determination of caffeine and benzoic acid in soft drink.
13. Spectrophotometric determination of cadmium and chromium in the given water sample.
14. Determination of ion exchange capacity of anion / cation exchange resin (using batch procedure if use of column is not feasible).
15. Visit STP plants and different chemical industries.

References:

1. Svehla, G. (1996), **Vogel's Qualitative Inorganic Analysis**, Prentice Hall.
2. Mendham, J.; Denney, R.C.; Barnes, J.D.; Thomas, M.J.K. (2007), **Vogel's Quantitative Chemical Analysis**, 6th Edition, Prentice Hall.
3. De, A. K. (2021), **Environmental Chemistry**, 10th edition. New Age International Pvt. Ltd.

Note: Learners are advised to use the latest edition of readings.

Essential Food Nutrients

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		
Essential Food Nutrients	**2**	**1**	**0**	**1**	XIIth Pass with Science	NA

Learning Objectives

- To develop a basic understanding of the components of food, their source, properties and interactions as well as changes that occur during processing, storage, and utilization

Learning Outcomes

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

- Account for chemistry of foods: composition of food, role of each component
- Recognize some of the reactions and changes in individual food components which occur during processing, handling and storage

SYLLABUS

Theory:

Unit 1: Carbohydrates (3 WEEKS)

Introduction, sources, functions, deficiencies, Structures of monosaccharides and disaccharides: glucose,

fructose, galactose; lactose, maltose, sucrose, maltitol, concept of reducing and non-reducing sugars; role of carbohydrates as sweeteners in food; lactose intolerance, galactosemia, dental plaque, overview of carbohydrate metabolism.

Unit 2: Lipids (5 WEEKS)

Introduction, sources, functions, deficiencies, classification (fatty acids, phospholipids, fats & oils, waxes), common fatty acids present in oils and fats, Omega- 3,6,9 fatty acids, trans fats, chemical properties: iodine value, saponification value, effect of frying on fats, changes in fats and oils- rancidity, lipolysis, flavor reversion, auto-oxidation and its prevention.

Unit 3: Proteins (5 WEEKS)

Introduction, sources, functions, deficiencies, protein structure (primary, secondary and tertiary), physico-chemical & functional properties of proteins, food proteins: animal and plant proteins.

Unit 4: Vitamins & Minerals (2 WEEKS)

Vitamins: Introduction, classification: fat-soluble vitamins & water-soluble vitamins.
Minerals: Introduction, classification: macrominerals (Ca, P, Mg) & microminerals (Se, Fe, I, Co, Zn, Cu, Se, Cr).
Role of vitamins and minerals in food chemistry.

Practicals/Hands-on Training (15 WEEKS)

1. Determination of moisture in food products by hot air oven-drying method.
2. Colorimetric determination of iron in vitamin/dietary tablets.
3. Estimation of Vitamin C in a given solution/lemon juice/chillies by 2, 6 Dichlorophenol indophenol method.
4. Estimation of total soluble sugar content by ferricyanide method (volumetric analysis).
5. Determination of saponification value of the given fat/oil.
6. Determination of iodine value of the given fat/oil.
7. Qualitative tests for proteins and carbohydrates.
8. Qualitative Estimation of cholesterol by Liebermann Burchard method.

References:

Theory:

1. deMan, J.M., Finley, J.W., Hurst, W.J., Lee, C.Y. (2018), **Principles of Food Chemistry**, 4th Edition, Springer.
2. Msagati, T.A.M. (2013), **Chemistry of Food Additives and Preservatives**, Wiley-Blackwell.
3. Fennema, O.R. (2017), **Food Chemistry**, 5th Edition, CRC Press.
4. Attokaran, M. (2017), **Natural Food Flavors and Colorants**, 2nd Ed., Wiley-Blackwell.
5. Potter, N.N., Hotchkiss, J.H, (1995) **Food Science,** 5th Ed., Chapman & Hall.
6. Brannen, D., Davidsin, P.M., Salminen, T. Thorngate III, J.H. (2002), **Food Additives**, 2nd Edition, CRC Press.
7. Coultate, T. (2016), **Food: The Chemistry of its Components**, 6thEdn., Royal Society of Chemistry.
8. Belitz, H. D.; Grosch, W. (2009), **Food Chemistry**, Springer.
9. Course: FOOD CHEMISTRY (iasri.res.in)

Practicals:

1. Ranganna, S. (2017). **Handbook of analysis and quality control for fruits and vegetable products**, 2nd Edn., McGraw Hill Education
2. Sawhney, S.K., Singh, R. (2001), **Introductory Practical Biochemistry**, Narosa Publishing House

Forensic 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 (ifany)
		Lecture	Tutorial	Practical/ Practice		
Chemical Aspects of Forensic Science	**2**	**1**	0	**1**	XII th Pass with Science	NA

Learning Objectives

- To introduce students to this fascinating branch of science and familiarize them with important concepts like fingerprints, explosives/arson, drugs and their detection.

Learning outcomes

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

- Describe latent fingerprints, various methods of detection of latent fingerprints, explosive analysis in forensic science, collection and preservation of evidence from crime scene etc

SYLLABUS

Theory:

Unit 1: History of Development of Forensic Science in India (2 WEEKS)

Definitions, Scope and Need of forensic science, Ethics in forensic science, History of forensic science, Basic principles of forensic science, Organizational structure of forensic science laboratories, Different branches in forensic science

Unit 2: Fingerprints (5 WEEKS)

Definition, History of fingerprint identification, Fingerprint as forensic evidence, Visible Finger marks, Latent Finger marks, ten-digit classification, Methods of Development of latent fingerprints using

conventional methods–Powdering (Black and grey, fluorescent and magnetic), Methods of development of latent fingerprint using chemical method (iodine fuming, silver nitrate, Ninhydrin, Vacuum metal deposition), Automated Fingerprint identification system (AFIS), Poroscopy and Edgescopy

Unit 3: Forensic Chemistry (8 WEEKS)

Scope & significance of Forensic Chemistry, Types of cases/exhibits received for analysis. Trap Cases: Collection, and Preliminary analysis of evidence in trap cases.

Alcoholic Beverages: Types of alcohols, country made liquor, illicit liquor, denatured spirits, Indian made foreign alcoholic and non-alcoholic beverages.

Dyes: Scope & Significance of dyes in crime investigation, analysis of ink by TLC and UV visible spectrophotometry. Petroleum products and their adulterations: Chemical composition of various fractions of Petroleum Products, Analysis of petrol, kerosene, diesel.

Fire/Arson and Explosives Fire: Introduction to Fire & Arson, origin of fire, Chemistry of Fire, Fire tetrahedron,Firefighting operations, preservation of fire scene, collection of evidences, Seat of fire, cause of fire, motives, Analysis of fire debris, Case studies related to fire and Arson. Explosive and Explosion: Scope & significance of explosive analysis in forensic science, Types of explosives, deflagration and detonation, explosive trains, collection, preservation and forwarding of exhibits, preliminary analysis of explosives. Dos and Don'ts. Case studies related to explosives.

Drugs of abuse: Classification, including designer drugs. Ill effects of drugs of abuse, Preliminary and conformatory tests.

Practicals/ Hands-on Training (15 WEEKS)

1. Development of fingerprint through conventional powder method.
2. Development of fingerprint through chemical methods.
3. To check the alcohol presence in different liquor.
4. Phenolphthalein test for trap cases.
5. Identification of Handwriting Individual Characteristics.
6. Study of Disguise in handwriting.
7. TLC of amino acids

Essential/recommended readings

1. Saferstein, R. (1990) Criminalistics, Prentice Hall, New York.
2. Basic Principles of Forensic Chemistry by JaVed I. Khan • Thomas J. Kennedy Donnell R. Christian, Jr.
3. Fundamentals of FINGERPRINT ANALYSIS Hillary Moses Daluz
4. Clarke's Analysis of Drugs and Poisons 3rd Ed.

Green 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 (ifany)
		Lecture	Tutorial	Practical/ Practice		
Green Methods in Chemistry	**2**	**0**		**2**	XIIth Pass with Science	Basic understanding of Chemistry

Learning Objectives:

The learning objectives of this course are as follows:

- To create awareness about the chemistry that is good for human health and the environment.
- To provide thorough knowledge of the green chemistry principles, and new remediation technologies for the cleaning up of hazardous substances.
- To develop basic skills to be able to design, develop and run chemical processes in a sustainable way.

Learning Outcomes:

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

- Design and develop materials/ processes that reduce the use and generation of hazardous substances in industry.
- Describe how injudicious use of chemicals can have an adverse/potentially damaging effect on humans and the environment.
- Propose ideas for innovative approaches to environmental and societal challenges.
- Critically analyse the existing traditional chemical pathways/processes and creatively think about bringing environmentally benign reformations in these protocols.
- Convert biomass into valuable chemicals through green technologies.

SYLLABUS

Practicals/Hands-on Training **(15 WEEKS)**

1. Definition and Importance of green chemistry. Introduction to the prevention of waste/ by products and waste/ pollution prevention hierarchy. Provide the scheme for the traditional as well as green method for the synthesis of ibuprofen and ask students to compare the amount and hazards of waste generated in both

the processes.

2. Principle and calculation of atom economy. Use of molecular model kit to stimulate the reaction to investigate how the atom economy can illustrate Green Chemistry.

Preparation of propene by two methods can be studied

(I) Hoffman elimination

(II) Dehydration of propanol

The other types of reactions, like addition, elimination, substitution and rearrangement should also be studied for the calculation of atom economy

3. Prevention/ minimization of hazardous/ toxic products reducing toxicity. Risk = (function) hazard x exposure.

(a) Nitration of salicylic acid using green method $Ca(NO_3)_2$

(b) Preparation and characterization of nanoparticles of gold using tea leaves/silver nanoparticles using plant extracts.

(c) Preparation of dibenzalacetone by cross aldol condensation reaction using base catalysed green method

(d) Acetylation of primary aromatic amine using the green method.

4. Use of Green solvents and comparison of greenness of solvents:

(a) Explain about supercritical fluids with special reference to carbon dioxide. Extraction of D-limonene from orange peel using liquid CO_2 prepared from dry ice

(b) Introduction to water as a solvent for chemical reactions. preparation of Manganese (III) acetylacetonate using green method

(c) Advantages and application of solventless processes in organic reactions.

(i) Benzil- Benzilic acid rearrangement in solid State under solvent-free Condition.

(ii) Mechanochemical solvent free, solid–solid synthesis of azomethine using *p*- toluidine and *o*-vanillin/*p*-vanillin

5. Energy requirements for reactions – alternative sources of energy: use of microwaves and photochemical energy.

(a) Photoreduction of benzophenone to benzopinacol in the presence of sunlight.

(b) Microwave assisted ammonium formate-mediated Knoevenagel reaction: *p*-anisaldehyde, ethyl cyanoacetate, ammonium formate.

6. Selection of renewable starting material rather than depleting, Illustrate with few examples such as biodiesel and polymers from renewable resources (such as green plastic). Preparation of biodiesel from waste cooking oil and characterization.

7. Importance of using catalytic reagents in preference to stoichiometric reagents; catalysis and green

chemistry, comparison of heterogeneous and homogeneous catalysis, biocatalysis, asymmetric catalysis and photocatalysis.

(a) Benzoin condensation using Thiamine Hydrochloride as a catalyst instead of cyanide

(b) Rearrangement of diazoamino benzene to *p*-aminoazo benzene using K10 montmorillonite clay

8. Students should be asked to prepare a presentation/project based on any of the following topics:

- Bhopal Gas Tragedy and safer route to carbaryl synthesis
- Flixiborough accident and safer route to cyclohexanol
- Use of Surfactants for SC-CO_2 for precision cleaning and dry cleaning of garments replacing PERC.
- A brief study of Green Chemistry Challenge Awards (Introduction, award categories and study about five last recent awards
- Healthier Fats and oils by Green Chemistry: Enzymatic Interesterification for production of No Trans-Fats and Oils.
- Synthesis of anti-tuberculosis drug Paramycin from waste water stream
- Syntheses of vitamin D_3 using photochemical energy
- Greener Manufacturing of Sitagliptin Enabled by an Evolved Transaminase
- Microwave assisted solvent free synthesis of aspirin
- Synthesis of 6-Aminopenicillanic Acid (6-APA) from penicillin G using biocatalyst.

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 Ed., 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 Ed., CRC Press.
5. Alhuwalia, V.K.; Kidwai, M.R. (2012), **New Trends in Green chemistry**, Kluwer Academic Publishers, Springer.
6. Sidhwani, I.T; Sharma, R.K. (2020), **An Introductory Text on Green Chemistry**, Wiley India Pvt Ltd.
7. Etzkorn, F. A . (2019), **Green Chemistry: Principles and Case Studies**, Royal Society of Chemistry.

Practicals:

1. Kirchoff, M., Ryan, M.A. (2002), **Greener approaches to undergraduate chemistry experiment**, American Chemical Society, Washington DC.
2. Sharma, R.K., Sidhwani, I.T., Chaudhari, M.K. (2013), **Green Chemistry Experiments: A monograph**, I.K. International Publishing House Pvt Ltd. New Delhi.
3. Pavia, D.L., Lamponam, G.H., Kriz, G.S.W. (2006), **Introduction to organic Laboratory Technique- A Microscale approach**, 4th Edition, Brooks-Cole Laboratory Series for Organic chemistry.
4. Sidhwani, I.T. ; Saini, G.; Chowdhury, S. **Wealth from Waste: A green method to produce biodiesel from waste cooking oil and generation of useful products from waste further generated**. University of Delhi, Journal of Undergraduate Research and Innovation, Volume 1, Issue 1, February 2015, ISSN: 2395-2334.
5. Sharma, R. K., Gulati, S., Mehta, S. (2012), **Preparation of Gold Nanoparticles Using Tea: A Green Chemistry Experiment,** Journal of Chemical Education, 89 (10), 1316-1318.

Lab Testing and Quality Assurance

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 (ifany)
		Lecture	Tutorial	Practical/ Practice		
Lab Testing and Quality Assurance	2	1	-	1	XIIth Pass with Science	Basic understanding of chemistry

Learning Objectives:

The objective of this course is :

- To introduce the concept of quality check and quality control in chemical industries.

Learning Outcomes:

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

- Describe role of quality control chemist
- Discuss and demonstrate analytical and separation techniques
- Carry out sample preparation
- Illustrate fundamentals of quality check
- Describe and use safety procedures

SYLLABUS

Unit 1: Introduction **(2 WEEKS)**

Industry and sub-sectors, standards for manufacturing in life-sciences, drug regulatory agencies, role of quality control chemist, quality management systems

Unit 2: Modern Analytical methods and separation techniques **(5 WEEKS)**

Gravimetric methods, volumetric methods, electroanalytical methods, spectroscopic methods, chromatographic techniques

Unit 3: Sample preparation **(2 WEEKS)**

Basics of sample preparation, preservation and storage, standards and guidelines for sample handling, good storage practices

Unit 4: Quality check **(6 WEEKS)**

Overview, productivity concept, statistical analysis of laboratory data, measurements, calibrations, validation, reference standards and materials, requirements of a calibration lab, fundamentals of advanced QC approaches, Trouble shooting in QC, documentation, audit/ process related query, Quality certifications, Government regulations in industries like pharmaceuticals, food supplements, cosmetics.

Practicals/Hands-on-Training (15 WEEKS)

1. Calibration of glassware
2. Weighing of samples, accuracy of measurements
3. Preparation of TLC plates and separation of amino acids
4. Working protocols of various laboratory instruments-oven, pH-meter, conductivity meter, water baths, muffle furnace, spectrophotometer.
5. Calibration of instruments like colourimeter, pH-meter, conductivity meter, spectrophotometer using reference standards or reference materials.

Suggested exercise: Visit some industries to study the validation of simple procedures.

References:

1. Skoog D.A., West D.M., Holler, F.J., Crouch S.R., **Fundamentals of Analytical Chemistry**, 9th Edition, Cengage learning.
2. **Quality control chemist participant manual** prepared by LSSSDC in collaboration with NSDC India.
3. iso.org

Chemistry of Food Flavors and Colourants

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 (ifany)
		Lecture	Tutorial	Practical/ Practice		
Chemistry of Food Flavors and Colourants	**2**	**1**	-	**1**	XIIth Pass with Science	Basic understanding of chemistry

Learning Objectives:

The learning objectives of this course are as follows:

- To provide introduction to quality attributes of food such as appearance and flavour.
- To impart an understanding of the chemistry of the flavour as well as colour constituents of foods.

Learning Outcomes:

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

- Describe mechanisms of flavor perception
- Demonstrate various mechanisms of flavor formation
- Discuss the chemical dimension of flavour.
- Recognize off-flavor defects in foods and strategies to control it.

SYLLABUS

Unit 1: Flavors (9 WEEKS)

Introduction and importance of flavors in food.
Taste & Odour: Structure and physiology of taste organs- tongue, papillae, taste buds, salivary glands, Mechanism of taste and odour perception
Basic Types of taste : Salty, Sweet, Bitter, Sour, Umami taste, Chemical dimensions of basic tastes (sweet, salt, sour, bitter and umami), odour and other sensations (like astringency, coolness, pungency/pungency), Non-nutritive and nutritive sweeteners (including structures of aspartame, saccharin, sucralose, Stevioside), Molecular Theory of Sweetness, Taste Inhibition and enhancement, Chemical dimension of Flavors (peppers, peppermint, coriander, cinnamon, onion), Chemistry of food flavorings: Maillard browning, enzymic browning reactions, caramelisation browning, Off-Flavour in Food (Rancidity in Fats/Oils, Non Enzymic Browning), Control of enzymic browning (acidulants, chelating agents, heat treatment etc)

Unit 2: Food Colours (6 WEEKS)

Introduction, importance, classification: Natural food colourants (Anthocyanins, Carotenoids, Chlorophyll), Examples of Pigments in common food (turmeric, tomato, carrot, orange); Nature-identical colourants (β-Carotene, Canthaxanthin and Riboflavin); Artificial/synthetic colourants: Azo dyes (e.g. amaranth dye, tatrazine, citrous red); Quinoline (e.g. quinoline yellow); Phthalein (e.g. erythrosine); Triarylmethanes and indigoid (e.g. indigo carmine), FD&C Dyes and Lakes.

Practicals/Hands-on-Training **(15 WEEKS)**

1. Determination of the taste threshold for the different sensations – sweet, salty, sour.
2. Extraction of limonene from orange peels using supercritical carbon dioxide.
3. Quantitative determination of food dyes in powdered drink mixes by spectrophotometric method.
4. Extraction and separation of pigments present in spinach by Thin Layer Chromatography (TLC).
5. Experiment to demonstrate the enzymic browning and its prevention.
6. Determination of rancidity of edible oils by Kriess Test.
7. Estimation of carotenoids in sample by colorimetric method.

References:

Theory:

1. DeMan, J.M., Finley, J.W., Hurst, W.J., Lee, C.Y. (2018), **Principles of Food Chemistry**, 4th Edition, Springer.
2. Msagati, T.A.M. (2013), **Chemistry of Food Additives and Preservatives**, Wiley-Blackwell.
3. Fennema, O.R. (2017), **Food Chemistry**, 5th Edition, CRC Press.
4. Attokaran, M. (2017), **Natural Food Flavors and Colorants**, 2nd Ed., Wiley-Blackwell.
5. Potter, N.N., Hotchkiss, J.H, (1995) **Food Science,** 5th Ed., Chapman & Hall.
6. Brannen, D., Davidsin, P.M., Salminen, T. Thorngate III, J.H. (2002), **Food Additives**, 2nd Edition, CRC Press.
7. Coultate, T. (2016), **Food: The Chemistry of its Components**, 6th Edn., Royal Society of Chemistry.
8. Belitz, H. D.; Grosch, W. (2009), **Food Chemistry**, Springer.
9. Course: FOOD CHEMISTRY (iasri.res.in)

Practicals:

1. Ranganna, S. (2017). **Handbook of analysis and quality control for fruits and vegetable products**, 2nd Edn., McGraw Hill Education
2. Sawhney, S.K., Singh, R. (2001), **Introductory Practical Biochemistry**, Narosa Publishing House

PCB Designing and Fabrication

CREDIT DISTRIBUTION, ELIGIBILITY AND PREREQUISITES 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		

UNIVERSITY OF DELHI

CNC-II/093/1(22)/2022-23/ 197
Dated: 14.09.2022

NOTIFICATION

Sub: Amendment to Ordinance V

[E.C Resolution No. 18-1-20 dated 18.08.2022]

Following addition be made to Appendix-II-A to the Ordinance V (2-A) of the Ordinances of the University;

Add the following:

VALUE ADDITION COURSES (VACs)
UNDER
UGCF-2022
LISTED UNDER APPENDIX-II-A TO THE ORDINANCE V (2-A) OF THE ORDINANCES OF THE UNIVERSITY
(With effect from Academic Year 2022-23)

In pursuance of the objectives outlined in the National Education Policy 2020, the Value Addition Courses (VACs) seek to fulfil the mandate of providing holistic education to the students. As the NEP elucidates, "the purpose of the education system is to develop good human beings capable of rational thought and action, possessing compassion and empathy, courage and resilience, scientific temper and creative imagination, with sound ethical moorings and values." The Value Addition Courses will introduce students to the rich heritage of the nation as well as to important social concerns of the current times, helping them to make connections between what they learn and how they live.

The courses have a sound theoretical base as well as appropriate hands-on components. At the same time, they clearly set out measurable and attainable Learning Outcomes. Knowledge, in essence, being integrated, these courses are essentially multidisciplinary in nature.

Designed to ignite the intellectual curiosity of the learners, the Value Addition courses will inspire and guide them in their journey of personal and professional development making them thoughtful, well-rounded, and creative individuals, with a sense of service and responsibility towards the Nation.

A student who pursues any undergraduate programme in the University and its Colleges is offered a pool of Value Addition Courses, from which he has to choose one to study in the first Semester. A list of such courses as passed by the Executive Council in its meeting dated 18.08.2022 is as below:

SL.NO.	COURSE TITLE	TOTAL CREDITS: 2
1	Ayurveda and Nutrition	
2	Constitutional Values and Fundamental Duties	
3	Culture and Communication	
4	Digital Empowerment	
5	Emotional Intelligence	
6	Ethics and Culture	
7	Ethics and Values in Ancient Indian Traditions	
8	Financial Literacy	
9	Fit India	
10	Gandhi and Education	
11	Ecology and Literature	
12	National Cadet Corps-I	
13	Panchkosha: Holistic Development of Personality	
14	Reading Indian Fiction in English	
15	Science and Society	
16	Social and Emotional Learning	
17	Sports for Life-I	
18	Swachh Bharat	
19	The Art of Being Happy	
20	Vedic Mathematics-I	
21	Yoga: Philosophy and Practice	
22	भारतीय भक्ति : परम्परा और मानव मूल्य	
23	साहित्य संस्कृति और सिनेमा	
24	सृजनात्मक लेख के आयाम	

VAC 1: SCIENCE AND SOCIETY

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
		Lecture	Tutorial	Practical/ Practice		
Science and Society	02	1	0	1	Pass in Class 12th	NIL

Learning Objectives

The Learning Objectives of this course are:

- The primary objective of this course is to instil in students an appreciation for science and a scientific outlook and temper.
- The course further aims to increase awareness about fundamental scientific concepts that play an important role in our daily life using various examples and case studies.
- Pedagogy in this course should largely rely on learning by enquiry, observations, experimentation and group discussions using case studies/examples.
- Efforts should be made to instil an interest in students for science. Students should be encouraged to understand and appreciate scientific concepts and their applications rather than solely memorizing factual information.

Learning outcomes

The Learning Outcomes of this course are:

- This paper is interdisciplinary in nature and would provide students with basic exposure to scientific methods, technologies and developments that have played a significant role in the evolution of human society from ancient to modern times.
- 2. Students would also be made aware of the scientific rationale of technological developments that would enable them to make informed decisions about their potential impact on society.

SYLLABUS OF SCIENCE AND SOCIETY

UNIT – I Science and Technology – from Ancient to Modern Times (10 Weeks)

In this section, students should also be made aware about the contributions of Indian scientists since ancient times and the contributions of women in science.

Subtopics

- Philosophy of science, the scientific method, importance of observation, questions and experimental design, rational thinking, myths vs. Facts

- Science, Technology and Traditional Practices: Suggestive areas include: Water harvesting structures and Practices; Construction, architecture and design – use of natural environment-friendly designs and materials; Agriculture including domestication of plants and animals.
In this section, students should also be made aware about the contributions of Indian scientists since ancient times and the contributions of women in science.

- Science and Technology in Modern Times: Suggestive areas include: PublicHealth:Nutrition,Hygiene,PhysicalandMentalHealth,VaccinesandAntibiotics,Anti-microbial resistance; Food Security: Green Revolution, White Revolution; IT Revolution, E-Governance; Clean Energy, Renewable Energy; Space Science and Exploration; Evolution, Ecology and Environment

UNIT II: Scientific Principles, and Concepts in Daily Life (5 Weeks)

Unit Description:

This section aims to encourage appreciation of the scientific method through observation, experimentation, analysis and discussions. Students are required to participate in activities and experiments. A suggestive list is given below:

Subtopics:

Suggested Activities:

- Observing and documenting flora and fauna of College campus/city.
- Visits to science laboratories in the College or neighbouring College/Institute.
- Visits to science museums, planetarium.
- Visits to biodiversity parks and nature walks.
- Participation in a citizen science project/initiative.

Suggested Experiments (minimum any four):

- Measuring the height of the college building using a stick.
- Measuring the curvature of earth, using distance and shadow length.
- Isolation of DNA (DNA Spooling)
- Observing transpiration and photosynthesis in plants
- The blood typing game (online)
- Are fruit juices, soap, carbonated drinks acidic or alkaline? (using pH strips or developing your own Litmus Test)
- Do plants learn and remember?
- Experiments on how migratory birds find their way. (Online)
- How can a mosquito sit on a water surface or a blade float on water?
- How does a submarine dip or rise in the ocean?
- How and why does the path of the sun in the sky change with the seasons?
- Identification of celestial objects with the naked eye
- Types of clouds
- Science of musical sounds
- Science of splitting of colours from white light: rainbow, CD-rom, prism, oil films.
- Lenses, mirrors and the human eye

Practical/ Practice Component : **Please Refer to Unit II.**

Essential/recommended readings

- Basu and Khan (2001). Marching Ahead with Science. National Book Trust
- Gopalakrishnan (2006). Inventors who Revolutionised our Lives. National Book Trust
- Yash Pal and Rahul Pal (2013) Random Curiosity. National Book Trust
- Hakob Barseghyan, Nicholas Overgaard, and Gregory Rupik (****) Introduction to History and Philosophy of Science
- John Avery (2005). Science and Society, 2nd Edition, H.C. Ørsted Institute, Copenhagen.
- Dharampal (2000). Indian Science and Technology in the Eighteenth Century, OIP.

Suggested Readings:

Section 1. Science and Technology – from Ancient to Modern Times:
Philosophy of science:
https://blogs.scientificamerican.com/doing-good-science/what-is-philosophy-of-scienceand- should-scientists-care/
http://abyss.uoregon.edu/~js/21st_century_science/lectures/lec01.html
https://wps.ablongman.com/wps/media/objects/1449/1483820/18_2.pdf

Myths vs. facts:

https://www.sciencelearn.org.nz/resources/415-myths-of-the-nature-of-science
History of technology:

https://www.visualcapitalist.com/history-of-technology-earliest-tools-modernage/

Water harvesting:

https://worldwaterreserve.com/introduction-to-rainwater-harvesting/
Public Health :

https://www.ajpmonline.org/article/S0749-3797(11)00514-9/fulltext
https://study.com/academy/lesson/public-health-vs-medicinedifferences-similarities.html
https://www.deepc.org.in/video-tutorials/public-health
Food Security:

https://www.concern.net/news/what-food-security
Energy:
https://www.nrdc.org/stories/renewable-energy-clean-facts

Space Science:

https://www.isro.gov.in/spacecraft/space-science-exploration
https://www.isro.gov.in/pslv-c11-chandrayaan-1
https://www.isro.gov.in/chandrayaan2-home-0
https://www.britannica.com/science/space-exploration

Contribution of Indian Scientists & Women Scientists:

https://www.tifr.res.in/~outreach/biographies/scientists.pdf
https://indiabioscience.org/media/articles/ISTI.pdf
https://www.thebetterindia.com/63119/ancient-india-science technology/
https://ncsm.gov.in/indian-women-in-science-technology/

Evolution:

https://www.livescience.com/474-controversy-evolution-works.html
https://www.ibiology.org/evolution/origin-of-life/
Climate change and global warming
https://letstalkscience.ca/educational-resources/backgrounders/introductionclimate-change

Biodiversity

https://india.mongabay.com/2020/09/nature-in-peril-as-biodiversity-lossesmount-alarmingly-states-the-living-planet-report/

Genomics and Modern Medicine

https://www.nationalgeographic.com/science/article/partner-contentgenomics-health-care
https://www.mja.com.au/journal/2014/201/1/impact-genomics-future-medicine-and-health
https://www.nature.com/scitable/topicpage/pharmacogenomics-andpersonalized-medicine-643/

Genetically modified engineered crops

https://www.nature.com/scitable/topicpage/genetically-modified-organismsgmos-transgenic-crops-and-732/
https://factly.in/explainer-what-is-the-status-of-gm-crops-in-india/
https://www.fda.gov/food/agricultural-biotechnology/how-gmo-crops-impactour-world

Artificial Intelligence and Robotics

https://www.ohio.edu/mechanical-faculty/williams/html/PDF/IntroRob.pdf
https://nptel.ac.in/content/storage2/courses/106105078/pdf/Lesson%2001.pdf

Big Data Analytics

https://www.researchgate.net/publication/328783489_Big_Data_and_Big_Data_Analytics_Concepts_Types_and_Technologies

Section 2. Scientific Principles, and Concepts in Daily Life Measuring buildings, earth curvature:

https://www.youtube.com/watch?v=hrwL3u2Z4Kg
https://www.youtube.com/watch?v=khRMzxONpLg
https://www.youtube.com/watch?v=YaPa4esJJx4

Isolation of DNA

https://melscience.com/US-en/articles/home-dnaextraction/?irclickid=2hh2pqRY8xyLTbawUx0Mo3ENUkBwlX3pGQDJSc0&utm_source=impact&irpid=2201352&irmpname=Science%20Journal%20for%20Kids&irgwc=1

Transpiration & Photosynthesis

https://www.youtube.com/watch?v=JQvdXX7hGqI
https://www.youtube.com/watch?v=U4rzLhz4HHk
https://www.youtube.com/watch?v=pFaBpVoQD4E

Online game on blood typing

https://educationalgames.nobelprize.org/educational/medicine/bloodtypinggame/gamev3/1.html

Determination of pH
https://www.youtube.com/watch?v=BEz6t_e6gpc

Plant behaviour
https://youtu.be/KyoeCFTIXKk
https://youtu.be/gBGt5OeAQFk

Migratory Birds

https://www.scienceabc.com/nature/how-migrating-birds-geese-navigate-long-distance-earthmagnetic-field.html

VAC 1: SWACHH BHARAT

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
		Lecture	Tutorial	Practical/ Practice		
Swachh Bharat	02	1	0	1	**Pass in Class 12th**	NIL

Learning Objectives

The Learning Objectives of the Course are:

- To understand the developmental challenges with reference to sanitation infrastructure and practices.
- To build values of cleanliness, hygiene and waste management in diverse socio-economic contexts.
- To understand planning of social policy and programmes.
- To use waste management techniques at community level.
- To instil a sense of service towards society and the Nation.

Learning Outcomes

The Learning Outcomes of the course are:

- Understanding the significance of the Swachh Bharat Abhiyan.
- Ability to analyse and predict the sanitation challenges of India
- Determine the link between sanitation and development.
- Contribute to the Swachh Bharat Abhiyan through real time projects/fieldwork.

SYLLABUS OF SWACHH BHARAT

UNIT – I Introduction to Swachh Bharat Abhiyan (4 Weeks)

- Gandhian philosophy of Cleanliness
- Swachh Bharat Abhiyan (SBA)
- Hygiene, Sanitation & Sustainable Waste Management
- Agencies and nodal Ministries for SBA

- Different phases of the SBA and its evaluation
- Citizens' Responsibilities: Role of Swacchagrahi

UNIT – II Swachh Bharat: Rural and Urban Facets (8 Weeks)

- Indicators for Swachh Bharat
- Rural
  i. Sanitation coverage across households (2014 vs. 2022)
  ii. Open Defecation Free (ODF) Villages: Parameters
  iii. ODF plus model: Key indicators
- Urban
  i. Sustainable sanitation
  ii. Waste/water and solid waste management
  iii. Garbage Free Cities

UNIT – III Prospects and Challenges (3 Weeks)

- Attitudes and Perceptions
- Operational and Financial issues
- Monitoring & Supervision
- Community Mobilization

Practical component (if any) – (15 Weeks)

Suggested Activities: List of activities to be undertaken:

- Identify plastic and e-waste in and around the institution and suggest innovative technologies to minimize wastage.
- Identify events/fests that generate maximum waste and ways to minimize it.
- Visit canteen/shops and track the lifecycle of wet/dry waste in and around the institution and document the findings in the form of a Project Report.
- Conduct interviews of stakeholders to understand the level of awareness.
- Conduct a Clean Audit of the Institution and identify areas for action.
- Conduct cleanliness drives.
- Organise Swachhata Pakhwada meetings, rallies, and mobilization camps within the identified communities.
- Students may participate in the Swachh Bharat Internship programme.
- If required students can share their experiences in the form of a Project Report.
- Any other Practical/Practice as decided from time to time

Essential Readings

- "Swachh Bharat Mission - Gramin, Department of Drinking Water and Sanitation, Ministry of Jal Shakti"
- India 2021, Ministry of Information & Broadcasting
- http://swachhbharatmission.gov.in/SBMCMS/swachhta-pakhwada.htm
- https://swachhbharatmission.gov.in/SBMCMS/about-us.htm
- https://www.communityledtotalsanitation.org/sites/communityledtotalsanitation.org/files/ODF_verification_checklist.pdf
- https://sbm.gov.in/phase2dashboard/PhaseII/NationDashboard.aspx
- https://www.niti.gov.in/sites/default/files/2019-08/Report%20of%20Sub-Group%20of%20Chief%20Ministers%20on%20Swachh%20%20Bharat%20Anhiyaan.pdf

Suggested Readings

- https://swachhbharatmission.gov.in/SBMCMS/writereaddata/Portal/Images/pd/brochure/Greywatermanagement.pdf
- https://swachhbharatmission.gov.in/SBMCMS/writereaddata/Portal/Images/pdf/brochure/PWMB5_28th_June.pdf
- GoI (2020). Swachh Bharat Mission (Grameen) Phase 2: Operational guidelines. Department of Drinking Water and Sanitation, Ministry of Jalshakti.
- MoHUA (2017). Guidelines for Swachh Bharat Mission - Urban (PDF). Ministry of Housing and Urban Affairs, Government of India.

Examination scheme and mode: Subject to directions from the Examination Branch/University of Delhi from time to time

VAC 1: THE ART OF BEING HAPPY

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
		Lecture	Tutorial	Practical/ Practice		
The Art of Being Happy	02	1	0	1	**Pass in Class 12th**	NIL

Learning Objectives

- To synthesize the insights developed by Human Development experts, Psychologists, Anthropologists on one hand, and the intellectual traditions of Vedantic Philosophy and Indology on the other towards the experience of happiness.
- To illustrate various factors that determine the subjective experience of happiness in a cross cultural context.

Learning outcomes

- The students shall be able to evaluate the factors contributing to the phenomenon of happiness in the personal, familial and community life of an individual in different cultures in the Indian context.
- They will be able to develop healthy interpersonal relationships and wellbeing cherishing the values of Indian culture and philosophy.
- They will be able to relate to the global phenomenon of sustainable development and become sensitive to the needs of the planet.
- They will be able to apply the experience of *Aananda* at a personal level.

SYLLABUS OF THE ART OF BEING HAPPY

UNIT – I Human Ecology and Happiness Lectures (3 Weeks)

- Definitions/Factors of Happiness: Environmental and Social

- Physical, emotional and psychological well-being for happiness
- Physiological and hormonal basis of happiness
- Coping with Stress: A life saving skill

UNIT – II Indological Theories of Happiness (4 Weeks)

- *Panch Kosh* Theory & Idea ofWell-Being
- Idea of Self and other
- Hierarchy and stages of happiness

UNIT – III Happiness: Cross-cultural Contexts (4 Weeks)

- Culture and Happiness
- Interpersonal Relationship: Comparative Perspective
- Towards Self-Actualization

UNIT – IV Local and Global Perspective of Happiness (4 Weeks)

- Measuring happiness: Key indicators
- Happiness Index
- India in Global Happiness Indices

Practical component (if any) – (15 Weeks)

The course will be based on students' identification and operationalization of the concept of happiness and well-being. Students will explore the indicators and actualization of these concepts in everyday life.

- Community surveys on the facilities promoting positive mental health practices such as Yoga and Meditation Centres, Recreation clubs, and Parks for youth and senior citizens shall be carried out by the students.
- Extending help and social service by visiting old age homes/ hospitals/slum areas or any other disadvantaged groups.
- Students can undertake a field work / project independently or work as an Intern with NGOs working in the area of happiness and well-being.
- Critical appreciation of a documentary/ film based on Happiness and Well-being can be undertaken by the students.
- Workshops/ Sessions for the actualization of innate creative potential- (Music, Drawing, Calligraphy, Dramatics)

- Hands-on Happiness: Gardening, Cleaning, Washing, Cooking, etc.
- If required, students can share their experiences in the form of a Project Report.
- Students may share their experiences in the form of Audio-video presentations of 15-20 minutes.
- Any other Practical/Practice as decided from time to time

Essential/recommended readings

- Banavathy, Vinayachandra & Choudry, Anuradha. (2013). Understanding Happiness: A Vedantic Perspective. Psychological Studies. 59. 141-152. 10.1007/s12646-013-0230-x.
- Leontiev, Dmitry. (2012). Anthropology of Happiness: the state of Well-Being and the way of Joy,In SocialScience,sVol43. No 2 P93-104.
- Snyder .C.R. S.J. Lopez & J.T. Pedrotti. (2015). Positive Psychology (The Scientific and Practical Explorations of Human Strengths): Sage Publication. (Chapter 5: Subjective Well-being: The Science of Happiness and Life Satisfaction, Page 63 to 73)
- World Development Indicators 2016. (2016).United States: World Bank Publications.
- Zelenski, John. (2019) Positive Psychology: The Science of Well-Being, Carleton University, Ottawa, Canada, Sage Publications Chapter 3:Happiness;page (77 to 110)

Suggestive readings

- Baumgardner,S&Crothers,M.(2014).Positive Psychology. New Delhi: Pearson Education, India.
- Goleman,D.(2007).Social Intelligence: The new science of human relationships, RHUK
- Mathews, Gordon and Carolina Izquierdo (eds). (2010). Pursuits of Happiness: Well being in Anthropological Perspective. Berghan Books
- Seligman,M.(2002). Authentic happiness: Using the new positive psychology to realize your potential for lasting fulfilment. NewYork:Free Press.
- Sri Aurobindo, The Synthesis of Yoga, Part Three: The Yoga of Divine Love, Chapter 7, The Ananda Brahman, pp. 569-570

Examination scheme and mode: Subject to directions from the Examination Branch/University of Delhi from time to time

VAC 1: VEDIC MATHEMATICS - 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
		Lecture	Tutorial	Practical/ Practice		
Vedic Mathematics - I	02	1	0	1	12^{TH} Pass	NIL

Learning Objectives

The Learning Objectives of the course are:

- Foster love for maths and remove its fear through Vedic Mathematics
- Enhance computation skills in students through Vedic Mathematics
- Develop logical and analytical thinking
- Promote joyful learning of mathematics
- Discuss the rich heritage of mathematical temper of Ancient India

Learning outcomes

The Learning Outcomes of the course are

- Overcome the fear of maths
- Improved critical thinking
- Familiarity with the mathematical underpinnings and techniques
- Ability to do basic maths faster and with ease.
- Appreciate the Mathematical advancements of Ancient India.

SYLLABUS OF VEDIC MATHEMATICS - I

UNIT – I Vedic Maths- High Speed Addition and Subtraction Sessions/Lectures (5 Weeks)

- Vedic Maths: History of Vedic Maths and its Features
- Vedic Maths formulae: Sutras and Upsutras
- Addition in Vedic Maths: Without carrying, Dot Method

- Subtraction in Vedic Maths: Nikhilam Navatashcaramam Dashatah (All from 9 last from 10)
- Fraction –Addition and Subtraction

UNIT – II Vedic Maths- Miracle Multiplication and Excellent Division (4 Weeks)

- Multiplication in Vedic Maths: Base Method (any two numbers upto three digits)
- Multiplication by Urdhva Tiryak Sutra
- Miracle multiplication: Any three-digit number by series of 1's and 9's
- Division by Urdhva Tiryak Sutra (Vinculum method)

UNIT – III Vedic Maths-Lightening Squares and Rapid Cubes (3 Weeks)

- Squares of any two-digit numbers: Base method
- Square of numbers ending in 5: Ekadhikena Purvena Sutra
- Easy square roots: Dwandwa Yoga (duplex) Sutra
- Square root of 2: Baudhayana Shulbasutra
- Cubing: Yavadunam Sutra

UNIT – IV Vedic Maths-Enlighten Algebra and Geometry (3 Weeks)

- Factoring Quadratic equation: Anurupyena, Adyamadyenantyamanty Sutra
- Concept of Baudhayana (Pythagoras) Theorem
- Circling a square: Baudhayana Shulbasutra
- Concept of pi: Baudhayana Shulbasutra
- Concept angle (θ) 0o, 30o, 45o, 60o and 90o: Baudhayana number

Practical component : (If any) (15 Weeks)

The students are expected to demonstrate the application of Vedic Maths: Sutra and Upsutra

- Conduct workshops under the supervision of the course teacher to spread awareness on the utility of Vedic Mathematics.
- Students are required to visit nearby retail shops/local vendors to purchase stationery/vegetables/bread and butter and use tricks of Vedic maths of addition and subtraction to calculate the amount to pay and receive the difference.
- Students may share their experience with the class teacher in the form of audio-video presentations of 15 minutes.
- If required, students can share their experiences in the form of a Project Report.
- Any other Practical/Practice as decided from time to time

Essential Readings

- The Essential of Vedic Mathematics, Rajesh Kumar Thakur, Rupa Publications, New Delhi 2019.
- Vedic Mathematics Made Easy, Dahaval Bathia, Jaico Publishing, New Delhi 2011
- Vedic Mathematics: Sixteen Simple Mathematical formulae from the Vedas, Jagadguru Swami Sri Bharati Krishna Trithaji, Motilal Banarasidas, New Delhi 2015.
- Learn Vedic Speed Mathematics Systematically, Chaitnaya A. Patil 2018.

Suggested Readings

- A Modern Introduction to Ancient Indian Mathematics, T S Bhanumurthy, Wiley Eastern Limited, New Delhi.
- Enjoy Vedic Mathematics, S M Chauthaiwale, R Kollaru, The Art of Living, Bangalore.
- Magical World of Mathematics, VG Unkalkar, Vandana publishers, Bangalore.

Examination scheme and mode: Subject to directions from the Examination Branch/University of Delhi from time to time