**DEPARTMENT OF CHEMISTRY**
**Category-I**

**B.Sc. (H) 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 | 0 | 01 | Class 12th Pass | ---- |

**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:**

- Learn the fundamental principles of metallurgy and understand the importance of recovery of by-products during extraction.
- Applications of thermodynamic concepts like that of Gibbs energy and

entropy to the principles of extraction of metals.

- Learn about the characteristics of s- and p- block elements as well as the synthesis, structure, bonding and uses of their compounds
- Understand the concept and use of internal and external redox indicators
- Comprehend the theory and application of iodometric and iodimetric titrimetric analysis

**SYLLABUS OF DSC-4**

**UNIT – I: General Principles of Metallurgy (6 Hours)**

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 – II: Chemistry of s- Block Elements (15 Hours)**

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 – III: Chemistry of *p*-Block Elements (9 Hours)**

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 – IV: Compounds of *p*-Block Elements (15 Hours)**

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 – 30 Hours**

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.


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

## 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, Haloarenes, Alcohols, Phenols, Ethers and Epoxides (DSC-5: Organic Chemistry-II) | 04 | 02 | 0 | 02 | Class 12$^{th}$ Pass | --- |

**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:**

- Understand reactions of arenes, haloarenes and some oxygen containing functional groups.
- Understand the concept of protection and deprotection
- 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 ( 10 Hours)**

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 - II: Aromatic Hydrocarbons (06 Hours)**

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 - III: Aryl halides (04 Hours)**

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 - IV: Alcohols, Phenols, Ethers & Epoxides (10 Hours)**

*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 - 60 Hours**

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.
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.


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

## 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 Pass | ---- |

**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:

- Understand the three laws of thermodynamics, concept of State and Path functions, extensive and intensive properties.
- Derive the expressions of ΔU, ΔH, ΔS, ΔG, ΔA for an ideal gas under different conditions.
- Explain the concept of partial molar properties.

**SYLLABUS OF DSC-6**

**UNIT – I: Basic Concepts of Chemical Thermodynamics (06 Hours)**

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 – II: First law and Thermochemistry (15 Hours)**

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 – III: Second Law (15 Hours)**

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 – IV Third Law (03 Hours)**

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 – V Systems of Variable Composition (06 Hours)**

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 – 30 Hours**

**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 Thermodynamics**. CRC Press.


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

2. Mann, F.G.; Saunders, B.C. (2009), **Practical Organic Chemistry**, Pearson Education.
3. Dhingra, S; Ahluwalia V.K., (2017), **Advanced Experimental Organic Chemistry**, Manakin Press.
4. Pasricha, S., Chaudhary, A. (2021), **Practical Organic Chemistry: Volume I**, I K International Publishing House Pvt. Ltd., New Delhi.

**Teaching Learning Process:**

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

**Assessment Methods:**

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

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

## SEMESTER-II

### 11.1.2: Course Code: DSC-4 CHEMISTRY- II

### Course Title: Periodic Properties and Chemical bonding

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

**Total Lectures: Theory- 30, Practical-60**

**Objectives:** The course discusses the periodicity in properties with reference to the s, p and d block, which is necessary in understanding their group chemistry. It provides basic knowledge about ionic, covalent and metallic bonding underlining the fact that chemical bonding is best regarded as a continuum between the three cases. It provides an overview of hydrogen bonding and van der Waal's forces which influence the melting points, boiling points, solubility and energetics of dissolution of compounds.

**Learning Outcomes:**

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

- Understand periodicity in ionization enthalpy, electron gain enthalpy, electronegativity and enthalpy of atomization.
- Understand variability in oxidation state, colour, metallic character, magnetic and catalytic properties and ability to form complexes
- Understand the concept of lattice energy using Born-Landé expression.
- Draw Born Haber Cycle and analyse reaction energies.
- Draw the plausible structures and geometries of molecules using VSEPR theory.
- Understand and draw MO diagrams (homo- & hetero-nuclear diatomic molecules).
- Understand the importance and applications of hydrogen and van der Wall bonding.

**Unit I: Periodic Properties** **Lectures: 12**

Electronic configurations of the atoms. Stability of half-filled and completely filled orbitals, concept of exchange energy, inert pair effect.

General group trends of s, p and d block elements with special reference to Ionization Enthalpy, Electron Gain Enthalpy, Electronegativity, Enthalpy of Atomization, oxidation state, colour, metallic character, magnetic and catalytic properties, ability to form complexes

**UNIT II: Chemical Bonding** **Lectures: 18**

**Ionic Bonding**: General characteristics of ionic bonding, Lattice Enthalpy and Solvation Enthalpy and their relation to stability and solubility of ionic compounds, Born-Lande equation for calculation of Lattice Enthalpy (no derivation), Born-Haber cycle and its applications, polarizing power and polarizability, Fajan's rules, ionic character in covalent compounds, bond moment, dipole moment and percentage ionic character.

**Covalent Bonding**: Valence Bond Approach, Hybridization and VSEPR Theory with suitable examples, Concept of resonance and resonating structures in various inorganic and organic compounds, Molecular Orbital Approach: Rules for the LCAO method, bonding, nonbonding and antibonding MOs and their characteristics for s-s, s-p and p-p combinations of atomic orbitals, MO treatment of homonuclear diatomic molecules of 1st and 2nd periods (including idea of s-p mixing) and heteronuclear diatomic molecules such as CO, NO and $NO^+$.
Brief introduction to Metallic Bonding, Hydrogen Bonding, van der Waal's Forces

**PRACTICALS:** **Credits: 02**

**(Laboratory periods: 60)**

1. Preparation of standard solutions.
2. Estimation of Sodium carbonate with HCl
3. Estimation of oxalic acid by titrating it with $KMnO_4$.
4. Estimation of Mohr's salt by titrating it with $KMnO_4$.
5. Estimation of water of crystallization in Mohr's salt by titrating with $KMnO_4$.
6. Estimation of Fe (II) ions by titrating it with $K_2Cr_2O_7$ using internal and external indicators.
7. Estimation of Cu (II) ions iodometrically using $Na_2S_2O_3$.
8. Chromatographic separation of mixture of metal ions $Cu^{2+}$, $Cd^{2+}$ or $Ni^{2+}$, $Co^{2+}$.
9. Estimation of Fe (II) ions by titrating it with K 2 Cr 2 O 7 using