

## DEPARTMENT OF CHEMISTRY

BSc. (Hons.) Chemistry

Category-I

### DISCIPLINE SPECIFIC CORE COURSE -1 (DSC-1): Atomic Structure & Chemical 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		
Atomic Structure & Chemical Bonding (DSC-1: Inorganic Chemistry -I)	04	03	—	01	Physics, Chemistry, Mathematics	--

#### Learning 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

## SYLLABUS OF DSC-1

### UNIT – I (15 Hours)

#### Unit 1: 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  $\psi$  and  $\psi^2$ . Quantum mechanical treatment of H- atom, Quantum numbers 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 – II (6 Hours)

#### Unit 2: Periodic properties of Elements & Periodic Trends

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

- Effective nuclear charge, shielding or screening effect and Slater's rules
- Atomic and ionic radii
- Ionization enthalpy (Successive ionization enthalpies)
- Electron gain enthalpy
- Electronegativity, Pauling's scale of electronegativity. Variation of electronegativity with bond order and hybridization.

### UNIT – III (12 Hours)

#### Unit 3: Ionic bond

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 – IV (12 Hours)

#### Unit 4: Covalent bond

Valence shell electron pair repulsion (VSEPR) theory, shapes of the following simple molecules and ions containing lone pairs and bond pairs of electrons: H<sub>2</sub>O, NH<sub>3</sub>, PCl<sub>3</sub>, PCl<sub>5</sub>,

SF<sub>6</sub>, ClF<sub>3</sub>, I<sub>3</sub>, BrF<sub>2</sub><sup>+</sup>, PCl<sub>6</sub><sup>-</sup>, ICl<sub>2</sub><sup>-</sup>, ICl<sub>4</sub><sup>-</sup>, and SO<sub>4</sub><sup>2-</sup>. 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<sub>2</sub>, O<sub>2</sub>, C<sub>2</sub>, B<sub>2</sub>, F<sub>2</sub>, CO, NO] and their ions; HCl (idea of s-p mixing and orbital interaction to be given).

### Practical component

#### Practicals: Inorganic Chemistry-I

(30 Hours)

(Laboratory periods: 15 classes of 2 hours each)

##### 1. Titrimetric Analysis:

- (i) Calibration and use of apparatus
- (ii) Preparation of solutions of different 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<sub>4</sub> solution
- (ii) Estimation of water of crystallization in Mohr's salt by titrating with KMnO<sub>4</sub>.
- (iii) Estimation of oxalic acid and sodium oxalate in a given mixture.

### Essential/recommended readings

#### 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**, 5<sup>th</sup> 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**, 5<sup>th</sup> 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**, 5<sup>th</sup> Edition, Pearson.

9. Shiver, D.; Weller, M.; Overton, T.; Rourke, J.; Armstrong, F. (2014), **Inorganic Chemistry**, 6<sup>th</sup> Edition, Freeman & Company
10. Das, A. K.; Das, M. (2014), **Fundamental Concepts of Inorganic Chemistry**, 1<sup>st</sup> 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**, 9<sup>th</sup> Edition, Freeman and Company

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

**DISCIPLINE SPECIFIC CORE COURSE – 2 (DSC-2): Basic Concepts and Aliphatic Hydrocarbons**

**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		
Basic Concepts and Aliphatic Hydrocarbons (DSC-2: Organic Chemistry-I)	04	03	--	01	Physics, Chemistry, Mathematics	--

**Learning 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

## SYLLABUS OF DSC- 2

### UNIT – I ( 9 Hours)

#### Unit I: Basic Concepts of Organic Chemistry

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 (18 Hours)

#### Unit II: Stereochemistry

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 (18)

#### Unit III: Aliphatic Hydrocarbons

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<sub>2</sub>, X<sub>2</sub>, 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 component

## **Practical (30 Hours)**

**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

## **Essential/recommended readings**

### **References:**

#### **Theory**

1. Morrison, R.N., Boyd, R.N., Bhattacharjee, S.K. (2010), **Organic Chemistry**, 7<sup>th</sup> Edition, Dorling Kindersley (India) Pvt. Ltd., Pearson Education.
2. Finar, I.L. (2002), **Organic Chemistry**, Volume 1, 6<sup>th</sup> 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**, 4<sup>th</sup> 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**, 3<sup>rd</sup> Edition, CRC Press.
5. Pasricha, S., Chaudhary, A. (2021), **Practical Organic Chemistry: Volume-I**, I K International Publishing house Pvt. Ltd, New Delhi

## Suggestive readings

### Additional Resources:

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

## DISCIPLINE SPECIFIC CORE COURSE– 3 (DSC-3): Gaseous and Liquid

### 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		
Gaseous and Liquid State (DSC-3: Physical Chemistry-I)	04	02	--	02	Physics, Chemistry, Mathematics	--

### Learning 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.

## SYLLABUS OF DSC-3

### UNIT – I (24 Hours)

#### Gaseous state

**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 Waals equation, Physical significance of van der Waals constants, application of van der Waals 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 – II (6 Hours)

#### Liquid state

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 component**

### **Practicals**

**60 Hours**

**(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  
$$\text{Mg(s)} + 2\text{HCl (aq)} \rightarrow \text{MgCl}_2 \text{ (aq)} + \text{H}_2 \text{ (g)}$$

#### **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.

### **Essential/recommended readings**

#### **References:**

#### **Theory:**

1. Atkins, P.W.; Paula, J.de. (2014), **Atkin's Physical Chemistry Ed.**, 10<sup>th</sup> Edition, Oxford University Press.
2. Ball, D. W. (2017), **Physical Chemistry**, 2<sup>nd</sup> Edition, Cengage Learning, India.
3. Castellan, G. W. (2004), **Physical Chemistry**, 4<sup>th</sup> Edition, Narosa.
4. Kapoor, K.L. (2015), **A Textbook of Physical Chemistry**, Vol 1, 6<sup>th</sup> 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, 1<sup>st</sup> Edition, McGraw Hill Education.
- Garland, C. W.; Nibler, J. W.; Shoemaker, D. P. (2003), **Experiments in Physical Chemistry**, 8<sup>th</sup> Edition, McGraw-Hill, New York.

#### **Suggestive readings**

#### **Additional Resources:**

1. Moore, W.J. (1972), **Physical Chemistry**, 5<sup>th</sup> Edition, Longmans Green & Co. Ltd.
- Glasstone, S. (1948), **Textbook of Physical Chemistry**, D. Van Nostrand company, New York.

**BSc. IN ANALYTICAL CHEMISTRY**  
*Multidisciplinary*

**DISCIPLINE SPECIFIC CORE COURSE (DSC1-AC1): Basic Principles and Laboratory Operations**

**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 and Laboratory Operations (DSC1-AC1)	<b>04</b>	<b>02</b>	<b>00</b>	<b>02</b>	Physics, Chemistry and Mathematics	<b>NIL</b>

### Learning Objectives

The Learning Objectives of this course are as follows:

- make students aware about the SI Units, concentration terms, various analytical methods, and safe usage of chemicals and its waste.

### Learning outcomes

The Learning Outcomes of this course are as follows:

- The students will be able to Understand SI units
- The students will be able to Learn the use of analytical equipment
- The students will be able to Know the types of errors in chemical analysis
- The students will be able to handle statistical tests of data

### SYLLABUS OF DSC1-AC1

#### UNIT – I: Basic Concepts (6 Hours)

##### A. SI Units

- Definitions of the Seven Base Units
- Derived units
- Conversion between units
- Significant figures

##### B. Chemical concentrations

- Mole, molar mass (calculations in grams and moles)
- Solutions and their concentrations

- Molar concentration
- Analytical molarity
- Equilibrium molarity of a particular species
- Percent concentration
- Parts per million/billion (ppm, ppb)
- Volume ratios for dilution procedures
- p-functions.

#### **UNIT – II: Introduction to Analytical Chemistry and Analytical Methods (4 Hours)**

1. General steps in chemical analysis.
2. Introduction to methods of detecting analytes
  - a) Physical
  - b) Electromagnetic radiations
  - c) Electric charge.

#### **UNIT – III: Errors in Chemical Analysis (20 Hours)**

- Types of errors
- Accuracy and Precision, Absolute and relative uncertainty, propagation of uncertainty
- The Gaussian distribution
- Mean and standard deviation
- Confidence intervals
- Statistical tests of data (F test, t test, Q test for bad data)
- Method of least squares
- Calibration curve
- Safety with chemicals and waste

#### **Practical component 60 Hours (Credits: 02; Laboratory Periods: 60; 15 Classes of 4 hours each)**

1. Description, Use and Calibration of Common Laboratory Apparatus I: Glassware: Volumetric flasks, Burettes, Pipettes, Weighing bottles, Drying ovens.
2. Description, Use and Calibration of Common Laboratory Apparatus II: Different types of Funnels, Chromatographic columns, Chromatographic jars, Desiccators, Filter crucibles, Rubber policeman.
3. Preparing Solutions: Standard solutions (acids and bases), primary standards & secondary standards, and to find out their concentration by any suitable methods.
4. Determination of strength of given strong acid using strong base volumetrically
5. Estimation of sodium carbonate by titrating with hydrochloric acid.
6. Use and maintenance of pH meter. Determination of pH of given dilute solutions of shampoos, soaps, fruit juices, and different soft drinks.
7. Determination of cell constant of a conductometric cell using standard KCl solutions.
8. To check the conductivity of various water samples (*Collect at least four samples*).

#### **Essential/recommended readings**

- Higson, S. P.J. (2003), Analytical Chemistry, Oxford University Press.

- Skoog, D.A.; West, D.M. (2003), Fundamentals of Analytical Chemistry, Brooks/Cole.
- Christian, G.D. (2004), Analytical Chemistry, 6th Edition, John Wiley & Sons, New York.
- Fifield, F.W.; Kealey, D. (2000), Principles and Practice of Analytical Chemistry, Wiley.
- Harris, D. C. (2007), Exploring Chemical Analysis, W.H. Freeman and Co.

### Suggestive readings

- Day, R. A.; Underwood, A. L. (1991), Quantitative Analysis, Prentice Hall of India.
- Gordus, A. A. (1985), Schaum's Outline of Analytical Chemistry, Tala McGraw-Hill.
- Dean J. A. (1997), Analytical Chemistry Handbook, McGraw Hill.
- 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 modes shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

## DISCIPLINE SPECIFIC CORE COURSE – 2 (DSC2-C1): Fundamentals of Organic Chemistry, Stereochemistry and Hydrocarbons

### 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		
Fundamentals of Organic Chemistry, Stereochemistry and Hydrocarbons (DSC2-C1)	04	02	00	02	Physics, Chemistry and Mathematics	-

### Learning Objectives

The Learning Objectives of this course are as follows:

- The course is infused with the recapitulation of fundamentals of organic chemistry and visualizing the organic molecules in a three-dimensional space.
- To establish the applications of these concepts different class of mechanism is included.
- 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 behaviour of organic compounds based on fundamental concepts learnt.
- Understand the stereochemistry of aliphatic and aromatic hydrocarbons
- 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 electrophilic addition, nucleophilic addition, nucleophilic substitution, and electrophilic substitution.
- Understand the mechanism of reactions of hydrocarbons

## SYLLABUS OF DSC2-C1

### UNIT – I: Fundamentals of Organic Chemistry (4 Hours)

Introduction to carbon compounds, an overview of Fundamentals (Electronic displacement-Inductive effect, Resonance effect, Hyperconjugation, Electromeric Effect). Reactive intermediates and their stability: carbocations, free radicals, carbanions, benzyne, carbene.

Acidity and basicity in carbon compounds (comparison of carboxylic acids, alcohols, phenols, primary, secondary and tertiary aliphatic amines, aniline and its derivative).

### UNIT – II: Stereochemistry (8 Hours)

Types of projection formulas of carbon compound - Flying Wedge Formula, Newmann, Sawhorse and Fischer representations and their interconversion.

Stereoisomerism: the concept of chirality (upto two carbon atoms). Configurational Isomerism: geometrical and optical isomerism; enantiomerism, diastereomerism and meso compounds). Threo and erythro; D and L; cis-trans nomenclature; CIP Rules: R/ S (for upto 2 chiral carbon atoms) and E / Z nomenclature (for upto two C=C systems).

Conformational isomerism with respect to ethane, butane and cyclohexane.

### UNIT – III: Aliphatic Hydrocarbons (12 Hours)

Functional group approach for the following reactions: preparations, physical property & chemical reactions to be studied with the mechanism in context to their structure.

**Alkanes:** Preparation: catalytic hydrogenation, Wurtz reaction, Kolbe's synthesis, Grignard reagent. Reactions: Free radical substitution: Halogenation.

**Alkenes:** Preparation: Elimination reactions: Dehydration of alcohols and dehydrohalogenation of alkyl halides (Saytzeff's rule); cis alkenes (Partial catalytic hydrogenation) and trans alkenes (Birch reduction). Reactions: cis-addition (alk.  $\text{KMnO}_4$ ) and trans-addition (bromine), the addition of HX (Markownikoff's and anti-Markownikoff's addition), Hydration, Ozonolysis, oxymercuration-demercuration, Hydroboration oxidation.

**Alkynes:** Preparation: Acetylene from  $\text{CaC}_2$  and conversion into higher alkynes; by dehalogenation of tetrahalides and dehydrohalogenation of vicinal-dihalides. Reactions: formation of metal acetylides and acidity of alkynes, the addition of bromine and alkaline

KMnO<sub>4</sub>, ozonolysis and oxidation with hot alk. KMnO<sub>4</sub>. Hydration to form carbonyl compounds.

#### UNIT – IV: Aromatic Hydrocarbons (6 Hours)

**Aromaticity:** benzenoids and Hückel's rule. Structure and aromatic character of benzene.

**Preparation:** methods of preparation of benzene from phenol, benzoic acid, acetylene and benzene sulphonic acid. Reactions: electrophilic substitution reactions in benzene citing examples of nitration, halogenation, sulphonation and Friedel-Craft's alkylation and acylation with emphasis on carbocationic rearrangement, side-chain oxidation of alkylbenzenes.

#### Practical component (60 Hours) (Credits: 02; Laboratory Periods: 60; 15 C lasses of 4 hours each)

1. Purification of organic compounds by crystallization using the following solvents:
  - a. Water
  - b. Alcohol
  - c. Water + alcohol
2. Determination of the melting points of organic compounds using Kjeldahl method and electrically heated melting point apparatus.
3. To study the effect of impurities on the melting point.
4. To identify the organic compounds using mixed melting point experiment. (*Identify at least two organic compounds*).
5. Determination of boiling point of liquid organic compounds using both distillation and capillary method.
6. Detection of extra elements present in an organic compounds (*Upto two extra elements*).
7. Organic Preparations:
  - a. Bromination of acetanilide, phenol and aniline
  - b. Nitration of nitrobenzene and bromobenzene

#### Essential/recommended readings

- Sykes, P.(2005), A Guide Book to Mechanism in Organic Chemistry, Orient Longman.
- Eliel, E. L. (2000), Stereochemistry of Carbon Compounds, Tata McGraw Hill.
- Morrison, R. N.; Boyd, R. N. (2010) Organic Chemistry, Dorling Kindersley (India) Pvt. Ltd. (Pearson Education), 7<sup>th</sup> Edition.
- Bahl, A; Bahl, B. S. (2012), Advanced Organic Chemistry, S. Chand.
- Furniss, B.S.; Hannaford, A.J.; Smith, P.W.G.; Tatchell, A.R. (2012), Vogel's Textbook of Practical Organic Chemistry, Pearson.
- Mann, F.G.; Saunders, B.C.(2009), Practical Organic Chemistry, Pearson Education.
- Dhingra, S; Ahluwalia V.K., (2017), Advanced Experimental Organic Chemistry, Manakin Press.

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

**BSc. In Industrial Chemistry**  
*Multidisciplinary*

**DISCIPLINE SPECIFIC CORE COURSE (DSC-IC 1): INDUSTRIAL  
CHEMICALS AND ENVIRONMENT**

**CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE  
COURSE**

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Industrial Chemicals and Environment, DSC- IC 1	04	02	-	02	Chemistry+Physics +Maths	NA

**Industrial Chemicals and Environment, DSC- IC 1**

**Learning Objectives**

The Learning Objectives of this course are as follows:

- The objective of this course is to teach the Chemistry of the general industrial separation and purification techniques.
- Production, uses and hazards associated with different industrial gases and chemicals.
- Air pollution, air pollutants, pollutants control procedures, greenhouse effect, global warming,
- Water pollution, water pollutants, industrial effluents and their treatment.
- Water quality parameters and water purification techniques.

**Learning outcomes**

The Learning Outcomes of this course are as follows:

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

- Know the various separation and purification techniques used in industries like distillation, solvent extraction, absorption, adsorption etc.
- Know the production, uses and hazards of important gases like oxygen, helium, argon, hydrogen, acetylene, ammonia etc.



- Know the production, uses and hazards of important inorganic chemicals like hydrochloric acid, sulphuric acid, nitric acid, sodium hydroxide, potassium hydroxide etc.
- Learn about air pollution, air pollutants, their control procedure, global warming, ozone depletion, water pollution, water pollutants, effluents from different industries, their treatment, water quality parameters and water purification techniques like reverse osmosis, electro dialysis and ion exchange.

## **SYLLABUS OF DSC- IC-1**

### **UNIT – I (06 Hours)**

#### **Unit 1: General industrial processes**

Basic principles of distillation, solvent extraction, solid-liquid leaching and liquid-liquid extraction, separation by absorption and adsorption

### **UNIT – II ( 12 Hours)**

#### **Unit 2: Industrial Gases and Inorganic Chemicals**

(a) *Industrial Gases*: Production, uses and hazards in handling of the following gases: oxygen,

nitrogen, argon, neon, helium, hydrogen, acetylene, chlorine, fluorine and ammonia.

(b) *Inorganic Chemicals*: Production, uses and hazards in handling the following chemicals: hydrochloric acid, nitric acid, sulphuric acid, sodium hydroxide, potassium hydroxide, bleaching

powder, hydrogen peroxide, potash alum, chrome alum, potassium dichromate and potassium permanganate.

### **UNIT – III (12 Hours)**

#### **Unit 3: Environment**

(a) *Air Pollution*: Pollutants and their sources, pollution by SO<sub>2</sub>, CO, NO<sub>x</sub>. Methods of estimation of CO, NO<sub>x</sub>, SO<sub>x</sub> and their control procedures. Greenhouse effect and global warming, Ozone depletion by oxides of nitrogen, chlorofluorocarbons and halogens, Particulate matter and its types.

(b) *Water Quality Standards and Water pollution*: Water quality parameters like pH, alkalinity, DO, BOD, COD, chloride, sulphate, available chlorine etc. Water treatment and purification processes (reverse osmosis, electro dialysis, ion exchange). Pollutants and their sources. Effluent treatment (primary, secondary and tertiary treatment). Industrial effluents from the following industries and their treatment: textile, tannery, dairy and petrochemicals and agrochemicals.

### **Practical component (60 Hours)**

#### **Practical**

(Credits: 02, Laboratory periods: 60)

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

4. Measurement of chloride and sulphate ions of water samples by simple titration method. (With AgNO<sub>3</sub> and potassium chromate).
5. Measurement of salinity of water samples by simple titration method. (With AgNO<sub>3</sub> and potassium chromate).
6. Estimation of total alkalinity of water samples (CO<sub>3</sub><sup>2-</sup>, HCO<sub>3</sub><sup>-</sup>) using double titration method.
7. Determination of Percentage of available chlorine in bleaching powder.
8. Isolation of compounds using solvent extraction method.

### Essential/recommended readings

#### References (Theory):

1. Stocchi, E. (1990), **Industrial Chemistry**, Vol-I, Ellis Horwood Ltd. UK.
2. Kent, J. A. (ed.) (1997), **Riegel's Handbook of Industrial Chemistry**, CBS Publishers, New Delhi.
3. Austin, G.T (2012), **Shreve's Chemical Process Industries**, Tata McGraw-Hill Education Private Limited.
4. Girard, J.E, (2011), **Principles of Environmental Chemistry**, Jones & Bartlett India Pvt. Limited.
5. Sodhi, G.S. ((2013), **Fundamental Concepts of Environmental Chemistry**, Narosa Publishing House.
6. Vermani, O.P; Narula, A.K. (2012), **Industrial Chemistry**, Galgotia Publishing Pvt. Limited.
7. Sharma, B.K. (2011), **Industrial Chemistry**, Goel Publishing House.
8. Pani, B. (2017), **Textbook of Environmental Chemistry**, I.K. International Publishing House.
9. De, A. K. (2015), **Environmental Chemistry**, New Age International Pvt, Ltd, New Delhi.
10. Khopkar, S.M. (2012), **Environmental Pollution Analysis**, New Age International Publisher.

#### References (Practical):

1. Bassett, J.; Denney, R.C.; Jeffery, G.H.; Mendham, J. (1996) **Vogel Textbook of quantitative inorganic analysis**, 7th edition, ELBS edition. Prentice Hall Publications.
2. 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.
3. Mittal, K.; Chandra, L. (2013) **Experiments in organic chemistry**, Anne Books Pvt. Limited.
4. Gulati, S.; Sharma, J.L.; Manocha, S. (2017) **Practical Inorganic Chemistry**. CBS, Publications.
5. Rogers, A. (2015) **Laboratory Guide of Industrial chemistry**, Palala Press.

#### Suggestive readings (if any)

**DISCIPLINE SPECIFIC CORE COURSE – 2 (DSC-C 1):  
Basic Concepts of Organic Chemistry**

**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		
Basic Concepts of Organic Chemistry, DSC- C1	04	02	-	02	NA	NA

**Basic Concepts of Organic Chemistry, DSC- C1**

**Learning Objectives**

The Learning Objectives of this course are as follows:

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

**Learning outcomes**

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

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

**SYLLABUS OF DSC- C 1**

**UNIT – I ( 6 Hours)**

**Unit 1: Fundamentals of organic chemistry**

Types of Electronic displacements: Inductive effect, Resonance effect, Hyperconjugation, Electromeric Effect. Reactive intermediates and their stability: carbocations, free radicals, carbanions, benzyne, carbenes.

Acidity and basicity in organic compounds (comparison of carboxylic acids, alcohols, phenols, primary, secondary and tertiary aliphatic amines, aniline and its derivatives)

## **UNIT – II ( 8 Hours)**

### **Unit 2: Stereochemistry**

Types of projection formulae: Flying Wedge Formula, Newmann, Sawhorse and Fischer representations and their interconversion.

Stereoisomerism: Concept of chirality (upto two carbon atoms). Configurational isomerism: geometrical and optical isomerism; enantiomerism, diastereomerism and meso compounds). Threo and erythro; D and L; *Cis-trans* nomenclature; CIP Rules: R/ S (for upto 2 chiral carbon atoms) and *E/Z* nomenclature (for upto two C=C systems).

Conformational isomerism with respect to ethane, butane and cyclohexane.

## **UNIT – III ( 16 Hours)**

### **Unit 3: Types of Organic Reactions (Including reactions of alkenes, alkyl and aryl halides, alcohols, aldehydes, ketones) Lectures: 18**

#### ***Electrophilic addition reactions***

Electrophilic addition reaction (with respect to propene, propyne, 3,3-dimethyl-1-butene): Hydration,

Addition of HX in the absence and presence of peroxide, Hydroboration oxidation, Addition of bromine (with stereochemistry).

#### ***Nucleophilic addition reactions***

Nucleophilic addition reaction of carbonyl compounds: Addition of HCN, ammonia derivatives

(Hydroxylamine, Hydrazine, Semicarbazide and 2,4-DNP), the addition of carbanion (Aldol condensation, Claisen Schmidt, Benzoin condensation, Perkin reaction, reactions involving Grignard reagent).

#### ***Elimination and Nucleophilic substitution reactions***

Nucleophilic substitution reaction (SN1 and SN2) in alkyl halides (mechanisms with stereochemical aspect), alcohols (with nucleophiles like ammonia, halides, thiols, ambident nucleophiles (cyanide and nitrite ion)), ethers (Williamson ether synthesis), Elimination reaction (E1 & E2), elimination *vs* substitution (*w.r.t.* potassium t-butoxide and KOH); Nucleophilic aromatic substitution in aryl

halides-elimination addition reaction *w.r.t.* chlorobenzene, including the effect of nitro group (on the ring) on the reaction. relative reactivity and strength of C-X bond in alkyl, allyl, benzyl, vinyl and aryl halides towards substitution reactions

#### ***Electrophilic substitution reactions***

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

#### ***Reactive intermediates and Rearrangement Reactions***

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

## Practical component (60 Hours)

### Practical

(Credits: 02, Laboratory periods: 60)

1. Purification of an organic compound by crystallization (from water and alcohol) and distillation, Criteria of purity: Determination of M.P.
2. Determination of boiling point of liquid compounds. (Boiling point lower than and more than 100 °C by distillation and capillary method)
3. Detection of extra element
4. Preparations: (Mechanism of various reactions involved to be discussed).
  - a. Bromination of phenol/aniline.
  - b. 2,4-Dinitrophenylhydrazone of aldehydes and ketones
  - c. Semicarbazone of aldehydes/ ketones
  - d. Aldol condensation reaction using green method.
  - e. Bromination of Stilbene.
  - f. Acetanilide to p-Bromoacetanilide.

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

### Essential/recommended readings

#### References (Theory):

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

#### References (Practical):

1. Furniss, B.S.; Hannaford, A.J.; Smith, P.W.G.; Tatchell, A.R. (2012), **Vogel's Textbook of**

**Practical Organic Chemistry**, Pearson.

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

3. Dhingra, S; Ahluwalia V.K., (2017), **Advanced Experimental Organic Chemistry**, Manakin Press.

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

## DISCIPLINE SPECIFIC CORE COURSE – 3 (DSC-MP 1): Calculus

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Calculus, DSC-MP 1	04	02	-	02	NA	NA

**Course Code: Mathematics DSC-MP 1**

**Course Title: Calculus**

### Learning Objectives

The Learning Objectives of this course are as follows:

**Course Objectives:** The primary objective of this course is to introduce the basic tools of calculus which are helpful in understanding their applications in many real-world problems. Students will be able to understand/create various mathematical models in everyday life.

### Learning outcomes

The Learning Outcomes of this course are as follows:

This course will enable the students to:

- i) Understand continuity and differentiability in terms of limits and graphs of certain functions.
- ii) Describe asymptotic behaviour in terms of limits involving infinity.
- iii) Use of derivatives to explore the behaviour of a given function locating and classify its extrema and graphing the function.
- iv) Apply the concepts of asymptotes, and inflexion points in tracing of cartesian curves.
- v) Compute the reduction formulae of standard transcendental functions with applications.

## SYLLABUS OF DSC- MP 1

### UNIT – I (10 Hours)

#### Unit 1: Limits, Continuity and Differentiability

Limit of a function,  $\epsilon$ - $\delta$  definition of a limit, Infinite limits, Continuity and types of discontinuities; Differentiability of a function, Successive differentiation: Calculation of the  $n$ th derivatives, Leibnitz theorem; Partial differentiation, Euler's theorem on homogeneous functions.

### UNIT – II (10 Hours)

#### Unit 2: Mean Value Theorems and its Applications

Rolle's theorem, Mean value theorems and applications to monotonic functions and inequalities; Taylor's theorem, Taylor's series, Maclaurin's series expansions of  $e^x$ ,  $\sin x$ ,  $\cos x$ ,  $\log x$  and  $\ln x$ ; Indeterminate forms.

### UNIT – III (10 Hours)

#### Unit 3: Tracing of Curves and Reduction Formulae

Asymptotes (parallel to axes and oblique), Concavity and inflexion points, Singular points, Tangents at the origin and nature of singular points, Curve tracing (cartesian and polar equations). Reduction formulae for  $\int \sin^m x \cos^n x dx$ ,  $\int \cos^m x \sin^n x dx$ , and  $\int \sin^m x \cos^n x dx$  and their applications.

### Essential/recommended readings

**References:**

1. Prasad, Gorakh (2016). *Differential Calculus* (19th ed.). Pothishala Pvt. Ltd. Allahabad.
2. Prasad, Gorakh (2015). *Integral Calculus*. Pothishala Pvt. Ltd. Allahabad.

**Additional Readings:**

- i. Apostol, T. M. (2007). *Calculus: One-Variable Calculus with An Introduction to Linear Algebra* (2nd ed.). Vol. 1. Wiley India Pvt. Ltd.
- ii. Ross, Kenneth. A.(2013). *Elementary Analysis: The Theory of Calculus* (2nd ed.). Undergraduate Texts in Mathematics, Springer. Indian reprint.

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