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 t itle & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite o f 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

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 ψ and ψ^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 o*rbitals, 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 andtheir 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 – 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_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).

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 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.

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**, 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 andCompany

Note: E xamination s cheme a nd m ode s hall be a s pr escribed by t he E xamination 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 t itle & 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_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 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**, 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

Suggestive readings

Additional Resources:

1. Solomons, T.W.G., Fryhle, C.B., Snyder, S.A. (2017), **Organic C hemistry**, 12th Edition, Wiley.
2. Bruice, P.Y. (2020), **Organic Chemistry**, 8th Edition, Pearson.
3. Clayden, J., Greeves, N., Warren, S. (2014), **Organic Chemistry**, Oxford.
4. Nasipuri, D. (2018), **Stereochemistry o f O rganic C ompounds: P rinciples a nd Applications**, 4th Edition, New Age International.
5. Gunstone, F.D. (1975), **Guidebook to Stereochemistry**, Prentice Hall Press.
6. Gupta, S.S. (2018), **Basic S tereochemistry o f O rganic Mo lecules,** 2nd Edition, Oxford University Press.

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

Credit distribution, Eligibility and Pre-requisites of the Course

Course t itle & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of t he co urse (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 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 – 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.
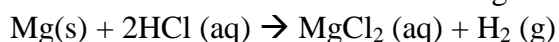
Practical component
Practicals   **60 Hours**

(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
        $Mg(s) + 2HCl\ (aq) \rightarrow MgCl_2\ (aq) + H_2\ (g)$

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.

Essential/recommended readings
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.

Suggestive readings

Additional Resources:

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