

States of matter, and Ionic equilibrium**Course 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 practical 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.

Course Outcomes:

1. Derive mathematical expressions for different properties of gas and liquid and understand their physical significance.
2. Apply the concepts of gas equations and liquids while studying other chemistry courses and understand the importance of pH in every-day life.
3. Understand different lattice systems and apply working principles of XRD for understanding crystal structure by powder and single crystal method.
4. Handle stalagmometer and Ostwald viscometer properly and determine the density of aqueous solutions. Data reduction, interpretation using numerical and graphical methods.

Unit-I: Gaseous state

Kinetic molecular model of a gas, Collision frequency, Collision diameter, Collision cross section, Mean free path and viscosity of gases, including their temperature and pressure dependence, Relation between mean free path and coefficient of viscosity, Maxwell distribution of molecular velocities (no derivation); average, root mean square and most probable velocities and average kinetic energy, Law of equipartition of energy, Behaviour of real gases: Deviations from ideal gas behavior, Causes of deviation from ideal behavior, Vander Wall equation and its application, Compressibility factor Z, and its variation with pressure for different gases, Critical Phenomenon and critical constant derivation.

Unit-II: Liquid state

Qualitative treatment of the structure of the liquid state; physical properties of liquids; vapour pressure, surface tension and coefficient of viscosity, and their determination. Effect of addition of various solutes on surface tension and viscosity. Capillary action in relation to cohesive and adhesive forces, Explanation of cleansing action of detergents. Temperature variation of viscosity of liquids and comparison with that of gases. Qualitative discussion of structure of water.

Unit-III: Solid state

Nature of the solid state, law of constancy of interfacial angles, law of rational indices, Miller indices, elementary ideas of symmetry, symmetry elements and symmetry operations, seven crystal systems and fourteen Bravais lattices; X-ray diffraction, Bragg's law, a simple account of rotating crystal method and powder pattern method. Analyses of powder diffraction patterns of NaCl, CsCl and KCl. Defects in crystals (stoichiometric and non-stoichiometric).

Unit-IV: Ionic equilibria

Strong, moderate and weak electrolytes, 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. 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 and its application.

List of experiments:

1. Determine the surface tension by (i) drop number (ii) drop weight method.
2. Study the variation of surface tension of detergent solutions with concentration and determination of CMC
3. Determination of viscosity of aqueous solutions of (i) polymer (ii) ethanol and (iii) sugar at room temperature.

4. Study the variation of viscosity of sucrose solution with the concentration of solute.
5. pH metric titration of (i) strong acid vs. strong base, (ii) weak acid vs. strong base.
6. Preparation of buffer solutions of different pH (i) Sodium acetate-acetic acid (ii)
7. Ammonium chloride-ammonium hydroxide
8. Determination of dissociation constant of a weak acid.
9. Determination of solubility product of PbI_2 by titrimetric method.

Text Books:

- ✓ *P. W. Atkins, J. de Paula, Elements of Physical Chemistry, Oxford University Press, 6th Ed., 2006.*
- ✓ *G. W. Castellan Physical Chemistry 4th Edn. Narosa 2004.*
- ✓ *Khosla, B. D.; Garg, V. C. & Gulati, A. Senior Practical Physical Chemistry, R. Chand & Co., New Delhi 2011.*

Reference books:

- ✓ *Puri, Sharma & Pathania, Principles of Physical Chemistry, Vishal Publishing Co, 47th Edn., 2017.*
- ✓ *R. G., Mortimer Physical Chemistry, Elsevier (Academic Press), 3rd Ed, 2008.*
- ✓ *T. Engel & P. Reid Physical Chemistry, 3rd Ed. Pearson 2013*
- ✓ *Kapoor K. L., Text Book of Physical Chemistry, McGraw Hill, 3rd Edn. 2017*
- ✓ *Hrishikesh Chatterjee, Understanding PHYSICAL CHEMISTRY Through Theories and Problems, Nonlinear insights (opc) pvt. ltd. Publication division, 1st Ed., 2023.*