JEE Advanced Syllabus 2025

Chemistry

General Topics

- Concept of atoms and molecules
  - Dalton's atomic theory
  - Mole concept
- Chemical formulae
- Balanced chemical equations
- Calculations (based on mole concept and stoichiometry)
  - Common redox reactions
  - Neutralization reactions
  - Displacement reactions
- Concentration
  - Mole fraction
  - Molarity
  - Molality
  - Normality

States of Matter: Gases and Liquids

- Gases
  - Gas laws and ideal gas equation
  - Absolute scale of temperature
  - Deviation from ideality, van der Waals equation
  - Kinetic theory of gases
    - Average velocities
    - Root mean square velocities
    - Most probable velocities
    - Relation with temperature
  - Law of partial pressures
  - Diffusion of gases
- Liquids
  - Intermolecular interactions
    - Types
    - Distance dependence
    - Effect on properties
  - Vapour pressure
  - Surface tension
  - Viscosity

Atomic Structure

- Bohr model
  - Spectrum of hydrogen atom
- Wave-particle duality
  - De Broglie hypothesis
- Uncertainty principle
- Quantum mechanical picture of hydrogen atom
  - Energies
  - Quantum numbers
  - Wave function and probability density (plots only)
  - Shapes of s, p and d orbitals
- Aufbau principle
- Pauli's exclusion principle
- Hund's rule

Chemical Bonding and Molecular Structure

- Orbital overlap and covalent bond
- Hybridization (s, p, and d orbitals)
- Molecular orbital energy diagrams (homonuclear diatomic species up to Ne_2)
- Hydrogen bond
- Polarity in molecules
  - Dipole moment
- VSEPR model and shapes of molecules
  - Linear
  - Angular
  - Triangular
  - Square planar
  - Pyramidal
  - Square pyramidal
  - Trigonal bipyramidal
  - Tetrahedral
  - Octahedral

Chemical Thermodynamics

- Properties
  - Intensive
  - Extensive
- State functions
- First law of thermodynamics
- Internal energy, work (pressure-volume only), and heat
- Enthalpy
  - Heat capacity
  - Standard state

    - Hess's law
    - Enthalpy of reaction
    - Enthalpy of fusion
    - Enthalpy of vaporization
    - Lattice enthalpy
- Second law of thermodynamics
    - Entropy
    - Gibbs energy
    - Criteria of equilibrium and spontaneity

Chemical and Ionic Equilibrium

- Law of mass action
- Significance of Δ□ and Δ□ □ in chemical equilibrium
- Equilibrium constant (Kp and Kc) and reaction quotient
- Le Chatelier's principle (effect of concentration, temperature, and pressure)
- Solubility product and its applications
- Common ion effect
- pH and buffer solutions
- Acids and bases (Brønsted and Lewis concepts)
- Hydrolysis of salts

Electrochemistry

- Electrochemical cells and cell reactions
- Standard electrode potentials
- Electrochemical work
- Nernst equation
- Electrochemical series
- EMF of galvanic cells
- Faraday's laws of electrolysis
- Electrolytic conductance
    - Specific conductivity
    - Equivalent conductivity
    - Molar conductivity
- Kohlrausch's law
- Batteries
    - Primary
    - Secondary
    - Fuel cells
- Corrosion

Chemical Kinetics

- Rates of chemical reactions
- Order and molecularity of reactions
- Rate law, rate constant, half-life

- Differential and integrated rate expressions (zero and first order)
- Temperature dependence of rate constant (Arrhenius equation and activation energy)
- Catalysis
  - Homogeneous
  - Heterogeneous
  - Activity and selectivity of solid catalysts
  - Enzyme catalysis and its mechanism

Solid State

- Classification of solids
- Crystalline state
  - Seven crystal systems (cell parameters a, b, c, α, β, γ)
- Close packed structures
  - Cubic
  - Hexagonal
- Packing in lattices
  - FCC
  - BCC
  - HCP
- Nearest neighbors
- Ionic radii and radius ratio
- Point defects

Solutions

- Henry's law
- Raoult's law
- Ideal solutions
- Colligative properties
  - Lowering of vapor pressure
  - Elevation of boiling point
  - Depression of freezing point
  - Osmotic pressure
- Van't Hoff factor

Surface Chemistry

- Adsorption
  - Physisorption
  - Chemisorption
  - Freundlich adsorption isotherm
- Colloids
  - Types
  - Methods of preparation
  - General properties
- Emulsions, surfactants, and micelles (definitions and examples)

Classification of Elements and Periodicity in Properties

- Modern periodic law and the present form of periodic table
- Electronic configuration of elements
- Periodic trends
  - Atomic radius
  - Ionic radius
  - Ionization enthalpy
  - Electron gain enthalpy
  - Valence
  - Oxidation states
  - Electronegativity
  - Chemical reactivity

Hydrogen

- Position in periodic table
- Occurrence
- Isotopes
- Preparation
- Properties
- Uses
- Hydrides
  - Ionic
  - Covalent
  - Interstitial
- Water
  - Physical properties
  - Chemical properties
  - Heavy water
- Hydrogen peroxide
  - Preparation
  - Reactions
  - Uses
  - Structure
- Hydrogen as a fuel

s-Block Elements

- Alkali and alkaline earth metals
  - Reactivity towards air, water, dihydrogen, halogens, acids
  - Reducing nature (solutions in liquid ammonia)
  - Uses
  - General characteristics of oxides, hydroxides, halides, salts of oxoacids
  - Anomalous behavior of lithium and beryllium
- Compounds of sodium

    - Sodium carbonate
    - Sodium chloride
    - Sodium hydroxide
    - Sodium hydrogen carbonate
- Compounds of calcium
    - Calcium oxide
    - Calcium hydroxide
    - Calcium carbonate
    - Calcium sulphate

p-Block Elements

- Oxidation states and trends in chemical reactivity (groups 13-17)
- Anomalous properties (B, C, N, O, F)
- Group 13
    - Reactivity towards acids, alkalis, halogens
    - Borax
    - Orthoboric acid
    - Diborane
    - Boron trifluoride
    - Aluminum chloride
    - Alums
    - Uses of boron and aluminum
- Group 14
    - Reactivity towards water and halogen
    - Allotropes of carbon and uses
    - Carbon monoxide
    - Carbon dioxide
    - Silicon dioxide
    - Silicones
    - Silicates
    - Zeolites
- Group 15
    - Reactivity towards hydrogen, oxygen, halogen
    - Allotropes of phosphorus
    - Dinitrogen
    - Ammonia
    - Nitric acid
    - Phosphine
    - Phosphorus trichloride
    - Phosphorus pentachloride
    - Oxides of nitrogen
    - Oxoacids of phosphorus
- Group 16

    - Reactivity towards hydrogen, oxygen, halogen
    - Simple oxides
    - Allotropes of sulfur
    - Dioxygen
    - Ozone
    - Sulfur dioxide
    - Sulfuric acid
    - Oxoacids of sulfur
- Group 17
    - Reactivity towards hydrogen, oxygen, metals
    - Chlorine
    - Hydrogen chloride
    - Interhalogen compounds
    - Oxoacids of halogens
    - Bleaching powder
- Group 18
    - Chemical properties
    - Uses
    - Compounds of xenon with fluorine and oxygen

d-Block Elements

- Oxidation states and stability
- Standard electrode potentials
- Interstitial compounds
- Alloys
- Catalytic properties
- Applications
- Oxoanions of chromium and manganese

f-Block Elements

- Lanthanoid and actinoid contractions
- Oxidation states
- General characteristics

Coordination Compounds

- Werner's theory
- Nomenclature
- Isomerism
    - cis-trans
    - Ionization
- Hybridization and geometries (linear, tetrahedral, square planar and octahedral) of mononuclear coordination compounds
- Bonding
    - VBT (Valence Bond Theory)

    - CFT (Crystal Field Theory) (octahedral and tetrahedral fields)
- Magnetic properties (spin-only) and colour of 3d-series coordination compounds
- Ligands and spectrochemical series
- Stability
- Importance and applications
- Metal carbonyls

Isolation of Metals

- Metal ores and their concentration
- Extraction of crude metal from concentrated ores
    - Thermodynamic principles (iron, copper, zinc)
    - Electrochemical principles (aluminium)
- Cyanide process (silver and gold)
- Refining

Principles of Qualitative Analysis

- Groups I to V (only Ag+, Hg2+, Cu2+, Pb2+, Fe3+, Cr3+, Al3+, Ca2+, Ba2+, Zn2+, Mn2+ and Mg2+)
- Anions
    - Nitrate
    - Halides (excluding fluoride)
    - Carbonate and bicarbonate
    - Sulphate and sulphide

Environmental Chemistry

- Atmospheric pollution
- Water pollution
- Soil pollution
- Industrial waste
- Strategies to control environmental pollution
- Green chemistry

Basic Principles of Organic Chemistry

- Hybridisation of carbon
- σ and π-bonds
- Shapes of simple organic molecules
- Aromaticity
- Isomerism
    - Structural
    - Geometrical
- Stereoisomers and stereochemical relationship (enantiomers, diastereomers, meso) of compounds containing only up to two asymmetric centres (R,S and E,Z configurations excluded)
- Determination of empirical and molecular formulae of simple compounds by combustion method only

- IUPAC nomenclature of organic molecules (hydrocarbons, including simple cyclic hydrocarbons and their mono-functional and bi-functional derivatives only)
- Hydrogen bonding effects
- Inductive, Resonance and Hyperconjugative effects
- Acidity and basicity of organic compounds
- Reactive intermediates produced during homolytic and heterolytic bond cleavage
- Formation, structure and stability of carbocations, carbanions and free radicals

Alkanes

- Homologous series
- Physical properties (melting points, boiling points and density) and effect of branching on them
- Conformations of ethane and butane (Newman projections only)
- Preparation from alkyl halides and aliphatic carboxylic acids
- Reactions
  - Combustion
  - Halogenation (including allylic and benzylic halogenation)
  - Oxidation

Alkenes and Alkynes

- Physical properties (boiling points, density and dipole moments)
- Preparation by elimination reactions
- Acid catalysed hydration (excluding the stereochemistry of addition and elimination)
- Metal acetylides
- Reactions of alkenes
  - With $KMnO_4$
  - With ozone
- Reduction of alkenes and alkynes
- Electrophilic addition reactions of alkenes with X_2, HX, HOX, (X=halogen)
- Effect of peroxide on addition reactions
- Cyclic polymerization reaction of alkynes

Benzene

- Structure
- Electrophilic substitution reactions
  - Halogenation
  - Nitration
  - Sulphonation
  - Friedel-Crafts alkylation
  - Friedel-Crafts acylation
- Effect of directing groups (monosubstituted benzene) in these reactions

Phenols

- Physical properties
- Preparation

- Electrophilic substitution reactions of phenol
  - Halogenation
  - Nitration
  - Sulphonation
- Reimer-Tiemann reaction
- Kolbe reaction
- Esterification
- Etherification
- Aspirin synthesis
- Oxidation and reduction reactions of phenol

Alkyl Halides

- Rearrangement reactions of alkyl carbocation
- Grignard reactions
- Nucleophilic substitution reactions and their stereochemical aspects

Alcohols

- Physical properties
- Reactions
  - Esterification
  - Dehydration (formation of alkenes and ethers)
- Reactions with
  - Sodium
  - Phosphorus halides
  - ZnCl2/concentrated HCl
  - Thionyl chloride
- Conversion of alcohols into aldehydes, ketones and carboxylic acids

Ethers

- Preparation by Williamson's synthesis
- C-O bond cleavage reactions

Aldehydes and Ketones

- Preparation of aldehydes and ketones
  - From acid chlorides and nitriles
  - Aldehydes from esters
  - Benzaldehyde from toluene and benzene
- Reactions
  - Oxidation
  - Reduction
  - Oxime and hydrazone formation
  - Aldol condensation
  - Cannizzaro reaction
  - Haloform reaction

- Nucleophilic addition reaction with
  - RMgX
  - NaHSO3
  - HCN
  - Alcohol
  - Amine

Carboxylic Acids

- Physical properties
- Preparation
  - From nitriles
  - From Grignard reagents
  - Hydrolysis of esters and amides
  - Benzoic acid from alkylbenzenes
- Reactions
  - Reduction
  - Halogenation
  - Formation of esters
  - Formation of acid chlorides
  - Formation of amides

Amines

- Preparation from nitro compounds, nitriles and amides
- Reactions
  - Hoffmann bromamide degradation
  - Gabriel phthalimide synthesis
  - Reaction with nitrous acid
  - Azo coupling reaction of diazonium salts of aromatic amines
  - Sandmeyer and related reactions of diazonium salts
  - Carbylamine reaction
  - Hinsberg test
  - Alkylation reactions
  - Acylation reactions

Haloarenes

- Reactions
  - Fittig reaction
  - Wurtz-Fittig reaction
- Nucleophilic aromatic substitution in haloarenes and substituted haloarenes (excluding benzyne mechanism and cine substitution)

Biomolecules

- Carbohydrates
  - Classification

    - Mono- and di-saccharides (glucose and sucrose)
    - Oxidation
    - Reduction
    - Glycoside formation and hydrolysis of disaccharides (sucrose, maltose, lactose)
    - Anomers
- Proteins
    - Amino acids
    - Peptide linkage
    - Structure of peptides (primary and secondary)
    - Types of proteins (fibrous and globular)
- Nucleic acids
    - Chemical composition
    - Structure of DNA and RNA

Polymers

- Types of polymerization
    - Addition
    - Condensation
- Homo and copolymers
- Examples
    - Natural rubber
    - Cellulose
    - Nylon
    - Teflon
    - Bakelite
    - PVC
    - Bio-degradable polymers
- Applications of polymers

Chemistry in Everyday Life

- Drug-target interaction
- Therapeutic action and examples (excluding structures) of
    - Antacids
    - Antihistamines
    - Tranquilizers
    - Analgesics
    - Antimicrobials
    - Antifertility drugs
- Artificial sweeteners (names only)
- Soaps, detergents, and cleansing action

Practical Organic Chemistry

- Detection of elements (N, S, halogens)
- Detection and identification of the following functional groups

- Hydroxyl (alcoholic and phenolic)
- Carbonyl (aldehyde and ketone)
- Carboxyl
- Amino
- Nitro