NCERT Chemistry Formula Book
Classes 11 & 12

Compiled from NCERT Textbooks

Contents

Chemical Constants and Values

Fundamental Constants

Constant	Symbol	Value
Avogadro's number	N_A	6.022×10^{23} mol^{-1}
Gas constant	R	8.314 J/mol $\cdot$ K
Faraday constant	F	96485 C/mol
Planck's constant	h	6.626×10^{-34} J $\cdot$ s
Speed of light	c	3×10^{8} m/s
Boltzmann constant	k_B	1.381×10^{-23} J/K
Electronic charge	e	1.602×10^{-19} C

Common Conversion Factors

Conversion	Value
1 atm	101.325 kPa
1 bar	100 kPa
1 calorie	4.184 J
1 eV	1.602×10^{-19} J
1 Debye	3.336×10^{-30} C $\cdot$ m

Chapter 1

Physical Chemistry Formulas

1.1 Some Basic Concepts of Chemistry

Mole Concept: Number of moles $= \dfrac{\text{Mass}}{\text{Molar mass}}$

Definition: Fundamental concept relating mass to number of particles. 1 mole contains 6.022×10^{23} entities.

Percentage Composition: % of element $= \dfrac{\text{Mass of element in compound}}{\text{Molar mass of compound}} \times 100$

Definition: Mass percentage of each element in a compound.

Empirical Formula: Simplest whole number ratio of atoms

Definition: Derived from percentage composition data.

Molecular Formula: Actual number of atoms of each element

Definition: Multiple of empirical formula.

Stoichiometry: Calculation of reactants and products

Definition: Based on balanced chemical equations.

1.2 States of Matter: Gases and Liquids

Ideal Gas Law: $PV = nRT$

Definition: Relationship between pressure, volume, temperature and moles of ideal gas. Applies to gases at high temperature and low pressure.

Combined Gas Law: $\dfrac{P_1V_1}{T_1} = \dfrac{P_2V_2}{T_2}$

Definition: For fixed amount of gas, PV/T is constant.

Dalton's Law: $P_{\text{total}} = P_1 + P_2 + P_3 + \cdots$

Definition: Total pressure equals sum of partial pressures in gas mixture.

Graham's Law: $\frac{r_1}{r_2} = \sqrt{\frac{M_2}{M_1}}$

Definition: Rate of effusion/diffusion inversely proportional to square root of molar mass.

Kinetic Gas Equation: $PV = \frac{1}{3}mN\bar{c}^2$

Definition: Relates pressure to molecular speed and mass.

Van der Waals Equation: $\left(P + \frac{an^2}{V^2}\right)(V - nb) = nRT$

Definition: Modified gas equation for real gases accounting for molecular size and intermolecular forces.

1.3 Thermodynamics

First Law: $\Delta U = q + W$

Definition: Law of conservation of energy. Change in internal energy equals heat added to system plus work done on system.

Work: $W = -P_{\text{ext}}\Delta V$

Definition: Work done in expansion/compression at constant pressure.

Enthalpy: $H = U + PV$

Definition: Heat content at constant pressure.

Entropy: $\Delta S = \frac{q_{\text{rev}}}{T}$

Definition: Measure of disorder or randomness in system.

Gibbs Free Energy: $\Delta G = \Delta H - T\Delta S$

Definition: Predicts spontaneity of process. Negative ΔG indicates spontaneous process.

1.4 Chemical Equilibrium

Equilibrium Constant: $K_c = \frac{[C]^c[D]^d}{[A]^a[B]^b}$ for aA + bB $\rightleftharpoons$ cC + dD

Definition: Ratio of product concentrations to reactant concentrations at equilibrium.

Relationship: $K_p = K_c(RT)^{\Delta n_g}$

Definition: Relates concentration and pressure equilibrium constants.

Le Chatelier's Principle

Definition: System at equilibrium responds to counteract applied stress.

1.5 Electrochemistry

Ohm's Law: $V = IR$

Definition: Voltage equals current times resistance.

Conductivity: $\kappa = G\frac{l}{A}$

Definition: Measure of ability to conduct electric current.

Nernst Equation: $E = E^0 - \frac{RT}{nF}\ln Q$

Definition: Electrode potential under non-standard conditions.

Faraday's Laws:

$$\text{First Law: } m = ZIt$$
$$\text{Second Law: } \frac{m_1}{m_2} = \frac{E_1}{E_2}$$

Definition: Quantitative relationships in electrolysis.

Chapter 2

Organic Chemistry - Named Reactions

2.1 Alkyl Halides

Wurtz Reaction: $_2R{-}X + {}_2Na \longrightarrow R{-}R + {}_2NaX$

Definition: Coupling of two alkyl halides with sodium metal to form alkane. Used for preparation of symmetrical alkanes.

Finkelstein Reaction: $R{-}X + NaI \longrightarrow R{-}I + NaX$

Definition: Halogen exchange reaction in acetone. Iodides prepared from chlorides/bromides.

Swarts Reaction: $R{-}X + AgF \longrightarrow R{-}F + AgX$

Definition: Preparation of fluorides from alkyl halides.

2.2 Aromatic Compounds

Friedel-Crafts Alkylation: $Ar{-}H + R{-}X \longrightarrow Ar{-}R + HX$ (with $AlCl_3$)

Definition: Introduction of alkyl group on aromatic ring using alkyl halide and Lewis acid catalyst.

Friedel-Crafts Acylation: $Ar{-}H + RCOX \longrightarrow Ar{-}COR + HX$ (with $AlCl_3$)

Definition: Introduction of acyl group on aromatic ring using acid chloride and Lewis acid catalyst.

Reimer-Tiemann Reaction: $Ar{-}OH + CHCl_3 + NaOH \longrightarrow Ar{-}CHO$

Definition: Formylation of phenols to produce salicylaldehyde.

2.3 Carbonyl Compounds

Cannizzaro Reaction: $_2Ar{-}CHO + NaOH \longrightarrow Ar{-}CH_2OH + Ar{-}COONa$

Definition: Disproportionation of aldehydes lacking alpha-hydrogen in presence of strong base.

Clemmensen Reduction: $Ar{-}COR + {}_4[H] \longrightarrow Ar{-}CH_2{-}R + H_2O$ (with Zn-Hg/HCl)

Definition: Reduction of carbonyl to methylene group using zinc amalgam and hydrochloric acid.

Wolff-Kishner Reduction: $Ar{-}COR \longrightarrow Ar{-}CH_2{-}R$ (with NH_2NH_2/KOH)

Definition: Alternative method for carbonyl to methylene reduction using hydrazine and base.

Aldol Condensation: $_2R{-}CH_2{-}CHO \longrightarrow R{-}CH_2{-}CH(OH){-}CH(R){-}CHO$

Definition: Carbon-carbon bond formation between carbonyl compounds having alpha-hydrogen.

Perkin Reaction: $Ar{-}CHO + (CH_3CO)_2O \longrightarrow Ar{-}CH{=}CH{-}COOH$ (with CH_3COONa)

Definition: Synthesis of cinnamic acids from aromatic aldehydes and acid anhydrides.

2.4 Carboxylic Acids and Derivatives

Hell-Volhard-Zelinsky Reaction: $R{-}COOH \longrightarrow R{-}CH_2{-}COOH$ (with P,Br_2)

Definition: Alpha-bromination of carboxylic acids.

Claisen Condensation: $_2R{-}CH_2{-}COOR' \longrightarrow R{-}CH_2{-}CO{-}CH(R){-}COOR'$

Definition: Ester analogue of aldol condensation producing beta-keto esters.

Dieckmann Condensation: Intramolecular Claisen condensation

Definition: Cyclization via intramolecular ester condensation forming cyclic beta-keto esters.

2.5 Amines

Hofmann Bromamide Reaction: $R{-}CONH_2 + Br_2 + {}_4NaOH \longrightarrow R{-}NH_2 + {}_2NaBr + Na_2CO_3 + {}_2H_2O$

Definition: Conversion of amides to amines with one less carbon atom using bromine and sodium hydroxide.

Carbylamine Reaction: $R{-}NH_2 + CHCl_3 + {}_3KOH \longrightarrow R{-}NC + {}_3KCl + {}_3H_2O$

Definition: Test for primary amines producing isocyanides (bad smelling compounds).

Hinsberg Test: Distinguishes between 1°, 2°, and 3° amines

Definition: Reaction with benzenesulfonyl chloride for amine classification.

2.6 Important Tests

Tollens' Test: $R{-}CHO + {}_2[Ag(NH_3)_2]^+ + {}_3OH^- \longrightarrow R{-}COO^- + {}_2Ag + {}_4NH_3 + {}_2H_2O$

Definition: Test for aldehydes producing silver mirror. Aldehydes reduce Tollens' reagent to metallic silver.

Fehling's Test: $R{-}CHO + {}_2Cu^{2+} + {}_5OH^- \longrightarrow R{-}COO^- + Cu_2O + {}_3H_2O$

Definition: Test for aldehydes producing red precipitate of cuprous oxide.

Iodoform Test: $CH_3{-}CH(OH){-}R + {}_4I_2 + {}_6NaOH \longrightarrow$
$CHI_3 + R{-}COONa + {}_5NaI + {}_5H_2O$

Definition: Test for methyl ketones and alcohols producing yellow precipitate of iodoform.

Chapter 3

Inorganic Chemistry - Important Processes

3.1 Industrial Processes

Ostwald Process:

$$
\begin{aligned}
{}_4NH_3 + {}_5O_2 &\longrightarrow {}_4NO + {}_6H_2O \\
{}_2NO + O_2 &\longrightarrow {}_2NO_2 \\
{}_3NO_2 + H_2O &\longrightarrow {}_2HNO_3 + NO
\end{aligned}
$$

Definition: Industrial production of nitric acid from ammonia through catalytic oxidation.

Contact Process:

$$
\begin{aligned}
{}_2SO_2 + O_2 &\rightleftharpoons {}_2SO_3 \quad (V_2O_5 \text{ catalyst}) \\
SO_3 + H_2SO_4 &\longrightarrow H_2S_2O_7 \\
H_2S_2O_7 + H_2O &\longrightarrow {}_2H_2SO_4
\end{aligned}
$$

Definition: Industrial production of sulfuric acid from sulfur dioxide.

Haber Process: $N_2 + {}_3H_2 \rightleftharpoons {}_2NH_3$

Definition: Industrial synthesis of ammonia from nitrogen and hydrogen using iron catalyst at high pressure and temperature.

Down's Process: Electrolysis of molten NaCl for sodium metal

Definition: Industrial production of sodium metal by electrolysis of molten sodium chloride.

Castner-Kellner Process: Electrolysis of brine for NaOH

Definition: Industrial production of sodium hydroxide by electrolysis of brine using mercury cathode.

3.2 Extraction Processes

Mond Process: $Ni + {}_4CO \longrightarrow Ni(CO)_4 \longrightarrow Ni + {}_4CO$

Definition: Purification of nickel via formation and decomposition of volatile nickel carbonyl.

Van Arkel Method: Purification of titanium and zirconium

Definition: Using iodine transport method to form volatile iodides which decompose to pure metal.

Thermite Process: $Fe_2O_3 + {}_2Al \longrightarrow {}_2Fe + Al_2O_3$

Definition: Reduction of metal oxides using aluminum as reducing agent, producing molten metal.

3.3 Coordination Compounds

Werner's Theory: Primary and secondary valences

Definition: Foundation of coordination chemistry proposing central metal atom with primary (ionizable) and secondary (non-ionizable) valences.

Valence Bond Theory: Hybridization in complexes

Definition: Explains geometry of complexes using hybridization concept.

Crystal Field Theory: Splitting of d-orbitals

Definition: Explains color and magnetic properties of complexes based on d-orbital splitting in ligand field.

Chapter 4

Biomolecules and Polymers

4.1 Biomolecules

Photosynthesis: ${}_6CO_2 + {}_6H_2O \longrightarrow C_6H_{12}O_6 + {}_6O_2$

Definition: Process by which plants convert light energy to chemical energy using chlorophyll.

Respiration: $C_6H_{12}O_6 + {}_6O_2 \longrightarrow {}_6CO_2 + {}_6H_2O + \text{energy}$

Definition: Cellular process of energy production through oxidation of glucose.

Fermentation: $C_6H_{12}O_6 \longrightarrow {}_2C_2H_5OH + {}_2CO_2$

Definition: Anaerobic breakdown of glucose to ethanol and carbon dioxide by microorganisms.

4.2 Analytical Chemistry

Beer-Lambert Law: $A = \epsilon cl$

Definition: Relationship between absorbance and concentration in spectrophotometry.

Raoult's Law: $P = P^0 x$

Definition: Vapor pressure of ideal solutions is proportional to mole fraction of solvent.

Henry's Law: $P = K_H x$

Definition: Solubility of gases in liquids proportional to pressure of gas over solution.