

Learn these by heart before the exam. 考试前把这些内容背熟。

Atoms, moles and formulae

$$n = \frac{m}{M} \quad \text{moles} = \text{mass} \div \text{molar mass} \quad \text{摩尔}$$

$$n = \frac{N}{N_A}, \quad N_A = 6.02 \times 10^{23} \quad \text{阿伏伽德罗常数}$$

$$n = cV, \quad c = \frac{n}{V} \quad c \text{ in mol/dm}^3, V \text{ in dm}^3 \quad \text{浓度}$$

$$pV = nRT \quad \text{ideal gas; } R = 8.31 \text{ J/(mol K)}, T \text{ in kelvin}$$

Empirical vs molecular formula 实验式与分子式:

empirical = simplest whole-number ratio of atoms;

molecular = actual number in one molecule

$$\text{Percentage yield} = (\text{actual} \div \text{theoretical}) \times 100\%;$$

$$\text{atom economy} = (\text{mass of desired product} \div \text{total mass}) \times 100\%.$$

Bonding and structure

Ionic, covalent, metallic 化学键: ionic = transfer of electrons (giant lattice); covalent = shared pair; metallic = lattice of ions in a sea of delocalised electrons

Electronegativity 电负性: the power of an atom to attract a bonding pair; increases across a period, decreases down a group

Shapes (VSEPR): 2 pairs linear 180°, 3 trigonal 120°, 4 tetrahedral 109.5°, 6 octahedral 90°; lone pairs reduce the angle by ~2.5° each.

Intermolecular forces (weak → strong): London (induced dipole) < permanent dipole < hydrogen bonding – set boiling points.

Energetics and equilibria

$$q = mc\Delta T \quad \text{heat change; then } \Delta H = -\frac{q}{n}$$

$$\Delta H = \Sigma \Delta H_f(\text{products}) - \Sigma \Delta H_f(\text{reactants}) \quad \text{Hess's law; also} = \Sigma \text{bonds broken} - \Sigma \text{bonds made} \quad \text{焓变}$$

$$\Delta G = \Delta H - T\Delta S \quad \text{feasible when } \Delta G < 0 \quad \text{吉布斯自由能}$$

$$K_c = \frac{[C]^c[D]^d}{[A]^a[B]^b} \quad \text{平衡常数}$$

Le Chatelier's principle 勒沙特列原理: a system at equilibrium shifts to oppose a change in concentration, pressure or temperature

A catalyst speeds both directions equally: it does not move the equilibrium position, only reaches it faster.

Kinetics, acids and redox

Activation energy 活化能: the minimum energy colliding particles need to react; a catalyst provides a route with lower E_a

Rate rises with concentration, pressure, surface area, temperature and a catalyst (more frequent / more energetic collisions).

$$\text{pH} = -\log_{10}[\text{H}^+], \quad K_w = [\text{H}^+][\text{OH}^-] = 10^{-14} \quad \text{pH 值}$$

$$K_a = \frac{[\text{H}^+][\text{A}^-]}{[\text{HA}]}, \quad \text{p}K_a = -\log_{10} K_a \quad \text{weak acid; smaller p}K_a = \text{stronger acid}$$

Oxidation and reduction 氧化与还原: OIL RIG – Oxidation Is Loss of electrons, Reduction Is Gain; the oxidising agent is itself reduced

Balance redox by combining half-equations so the electrons cancel.

Organic chemistry

Homologous series 同系物: a family with the same general formula and functional group, differing by CH_2 ; similar reactions, gradual trend in properties

Alkanes → free-radical substitution (UV); alkenes → electrophilic addition; halogenoalkanes → nucleophilic substitution.

Oxidation ladder: primary alcohol → aldehyde → carboxylic acid; secondary alcohol → ketone.

Isomerism 同分异构: structural (same formula, different connectivity) and stereoisomerism – cis/trans (E/Z) and optical (mirror-image) forms

Test: bromine water decolourises with a C=C double bond; 2,4-DNPH gives an orange precipitate with a carbonyl.

Analysis

Mass spectrometry 质谱: the molecular ion peak gives M_r ; fragment peaks reveal parts of the structure

IR: a broad O-H (~3200-3550), sharp C=O (~1700 cm^{-1}) identify functional groups.

NMR: the number of peaks = chemical environments; the ratio of areas = the ratio of H atoms.