

Learn these by heart before the exam.

Atomic Structure and Properties

$$n = \frac{m}{M}, \quad N = nN_A, \quad N_A = 6.022 \times 10^{23}$$

$$\% \text{ by mass} = \frac{\text{mass of element}}{\text{molar mass}} \times 100\% \quad \text{empirical}$$

formula: masses to moles, divide by the smallest, scale to whole numbers

$$E_{\text{photon}} = h\nu = \frac{hc}{\lambda}, \quad c = \lambda\nu$$

PES: peak height is the NUMBER of electrons; binding energy rises with nuclear attraction. Read the 1s peak far left.

Coulomb's law explains all periodic trends: Z_{eff} up and r down means stronger attraction.

Across a period: radius falls, ionisation energy rises. Down a group: radius rises, ionisation energy falls.

Compound Structure and Properties

Lewis: count valence electrons, form bonds, complete octets, place any leftover on the central atom. Check formal charge.

formal charge = $V - N - \frac{1}{2}B$ the best structure keeps formal charges nearest zero

VSEPR: 2 domains linear, 3 trigonal planar, 4 tetrahedral, 5 trigonal bipyramidal, 6 octahedral. Lone pairs squeeze the angles.

Polar molecule needs polar bonds AND asymmetry. CO_2 is nonpolar; H_2O is polar.

IMF strength: ionic > hydrogen bonding > dipole-dipole > London. London rises with more electrons.

Sigma is head-on, pi is side-on. A double bond is 1 sigma + 1 pi; a triple is 1 sigma + 2 pi.

Properties of Substances and Mixtures

$$PV = nRT, \quad R = 0.08206 \text{ L atm mol}^{-1}\text{K}^{-1}$$

$$P_{\text{total}} = \sum P_i, \quad P_i = \chi_i P_{\text{total}}$$

$$M = \frac{n_{\text{solute}}}{V_{\text{solution}}}, \quad M_1V_1 = M_2V_2$$

Real gases deviate at HIGH pressure and LOW temperature: molecules have volume and they attract.

$A = \epsilon bc$ absorbance is proportional to concentration

Chemical Reactions

Limiting reactant: convert BOTH to moles of product; the smaller answer wins. Percent yield

$$= \frac{\text{actual}}{\text{theoretical}} \times 100\%.$$

Net ionic equation: cancel the spectator ions. Show states.

Oxidation is loss of electrons (number rises); reduction is gain. Balance half-equations with $\text{H}^+/\text{H}_2\text{O}$ in acid.

Titration: at equivalence, moles of acid equal moles of base times the stoichiometric ratio.

Kinetics

rate = $k[A]^m[B]^n$ orders come from EXPERIMENT, never from the balanced equation

$$\ln[A]_t = -kt + \ln[A]_0, \quad t_{1/2} = \frac{0.693}{k}$$

$$\frac{1}{[A]_t} = kt + \frac{1}{[A]_0}$$

Linear plot identifies the order: $[A]$ vs t zero order; $\ln[A]$ vs t first; $1/[A]$ vs t second.

The slow step is rate-determining; the rate law must match it. A catalyst lowers E_a and is regenerated.

$$k = Ae^{-E_a/RT}$$

Thermochemistry

$$q = mc\Delta T, \quad q_{\text{sys}} = -q_{\text{surr}}$$

$$\Delta H_{\text{rxn}}^\circ = \sum \Delta H_f^\circ(\text{products}) - \sum \Delta H_f^\circ(\text{reactants})$$

ΔH_f° of an element in its standard state is 0

Hess's law: reverse a step and flip the sign; multiply a step and multiply ΔH .

Bond enthalpy route:

$\Delta H = \sum(\text{bonds broken}) - \sum(\text{bonds formed})$. Breaking costs energy.

Exothermic $\Delta H < 0$ (heat out); endothermic $\Delta H > 0$.

Equilibrium

$$K_c = \frac{[C]^c[D]^d}{[A]^a[B]^b} \quad \text{omit pure solids and liquids}$$

$Q < K$ shifts right; $Q > K$ shifts left; $Q = K$ is at equilibrium.

Le Chatelier: the system opposes the change. Adding heat shifts an endothermic reaction right. An inert gas at constant V does NOTHING.

ICE table: Initial, Change, Equilibrium. If K is very small, approximate x as negligible, then check it is under 5%.

$K_{\text{sp}} = [\text{A}^+]^a[\text{B}^-]^b$ a common ion lowers solubility

Acids and Bases

$$\text{pH} = -\log[\text{H}^+], \quad \text{pOH} = -\log[\text{OH}^-], \quad \text{pH} + \text{pOH} = 14$$

$$K_w = [\text{H}^+][\text{OH}^-] = 1.0 \times 10^{-14}, \quad K_a K_b = K_w$$

$$\text{pH} = \text{p}K_a + \log \frac{[\text{A}^-]}{[\text{HA}]} \quad \text{buffer only; at the half-equivalence point } \text{pH} = \text{p}K_a$$

Strong acid or base dissociates completely, so $[\text{H}^+]$ equals the concentration. Weak needs an ICE table with K_a .

Titration curve: buffer region flattest at half-equivalence; equivalence is the STEEPEST point (pH 7 only for strong-strong).

Thermodynamics and Electrochemistry

$$\Delta G^\circ = \Delta H^\circ - T\Delta S^\circ \quad \Delta G < 0 \text{ means}$$

thermodynamically favourable

$$\Delta G^\circ = -RT \ln K = -nFE^\circ \quad F = 96485 \text{ C/mol} \quad K$$

Entropy rises: solid to liquid to gas, more particles, higher temperature, mixing.

$\Delta H < 0, \Delta S > 0$ always favourable; both positive needs HIGH T ; both negative needs LOW T .

Galvanic cell: oxidation at the ANODE (negative), reduction at the CATHODE. $E_{\text{cell}}^\circ = E_{\text{cat}}^\circ - E_{\text{an}}^\circ > 0$.

$$q = It, \quad n_{e^-} = \frac{It}{F}$$

Exam technique

Justify with particles: say what the atoms, ions or molecules are doing, not just which way the number moved.

Every answer needs units and the right significant figures. Show the setup, not just the calculator result.

'Explain in terms of Coulomb's law / IMF / Le Chatelier' means name the principle AND apply it to this substance.