CHEMWHIZ QUICK REFERENCE

TOPIC 05

Predicting & Balancing Reactions

Balancing, the five reaction families, product prediction, the activity series, and when there is no reaction.

01 Balancing basics — CORE RULE

Atoms are conserved: same count of each element on both sides. Balance with coefficients, never by changing subscripts (that changes the substance).

02 Balancing by inspection — METHOD

Start with the most complex species; balance elements in the fewest formulas first; do O and H last; clear fractions by multiplying through; reduce to smallest whole numbers.

03 The five reaction families — REFERENCE

Family	Pattern	Example
Synthesis	A + B → AB	$2Mg + O_2 \rightarrow 2MgO$
Decomposition	AB → A + B	$2HgO \rightarrow 2Hg + O_2$
Single replacement	A + BC → AC + B	$Zn + 2HCl \rightarrow ZnCl_2 + H_2$
Double replacement	AB + CD → AD + CB	$AgNO_3 + NaCl \rightarrow AgCl + NaNO_3$
Combustion	fuel + O_2 → oxides	$CH_4 + 2O_2 \rightarrow CO_2 + 2H_2O$

04 Combustion routine (C, H, O fuels) — METHOD

Products $CO_2 + H_2O$. Balance C, then H (sets H_2O), then O (adjust O_2, often fractional), then multiply through to clear fractions and reduce.

05 Activity series — REFERENCE

Metals (most → least active): Li > K > Ca > Na > Mg > Al > Mn > Zn > Fe > Ni > Sn > Pb > H > Cu > Ag > Au. A metal displaces one below it; metals above H displace H_2 from acids. Halogens: F > Cl > Br > I.

06 Single-replacement products — CORE RULE

A + BX → AX + B (A above B): $Zn + CuSO_4 \rightarrow ZnSO_4 + Cu$. Metal + acid → salt + H_2 (metal takes its low charge, $Fe \rightarrow Fe^{2+}$). Halogen + halide: $Cl_2 + 2NaBr \rightarrow 2NaCl + Br_2$.

07 Metal + nonmetal → salt — CORE RULE

Cation from group (1→+1, 2→+2, 13→+3), anion from group (15→−3, 16→−2, 17→−1); balance charges. $2Na + Cl_2 \rightarrow 2NaCl$; $3Mg + N_2 \rightarrow Mg_3N_2$.

08 Active metal + water — CORE RULE

Group 1: $2M + 2H_2O \rightarrow 2MOH + H_2$ (all, cold water). Group 2 varies: Be none; Mg very slow in cold water, readily with steam ($\rightarrow MgO + H_2$); Ca, Sr, Ba: $M + 2H_2O \rightarrow M(OH)_2 + H_2$. Al passivated by its oxide layer.

09 Oxides — CORE RULE

Soluble (active-metal) oxide + H_2O → hydroxide: $Na_2O + H_2O \rightarrow 2NaOH$; $CaO + H_2O \rightarrow Ca(OH)_2$ (most metal oxides are insoluble and don't react). Most nonmetal oxides + H_2O → oxoacid, oxidation state preserved: $SO_2 + H_2O \rightarrow H_2SO_3$; $SO_3 + H_2O \rightarrow H_2SO_4$; $CO_2 + H_2O \rightarrow H_2CO_3$.

Metal oxide + acid → salt + H_2O. Nonmetal oxide + base → salt (+ H_2O): $CO_2 + 2NaOH \rightarrow Na_2CO_3 + H_2O$.

Nonmetal + O_2 → oxide (default combustion): $C \rightarrow CO_2$ (CO if O_2 limited), $S \rightarrow SO_2$, $P_4 \rightarrow P_4O_{10}$.

10 Thermal decomposition — CORE RULE

Δ signals: carbonate → oxide + CO_2 ($CaCO_3 \rightarrow CaO + CO_2$); bicarbonate → carbonate + CO_2 + H_2O; heavy hydroxide → oxide + H_2O; chlorate → chloride + O_2 ($2KClO_3 \rightarrow 2KCl + 3O_2$).

11 When to write 'no reaction' — WATCH OUT

No reaction when a single-replacement element is below its target, a halide meets a weaker halogen, or no family pattern fits. The test is whether a pattern applies, not whether a change is visible.