CHEMWHIZ QUICK REFERENCE

TOPIC 29

Main-Group Chemistry

Periodic trends, group reactivity, allotropes, hydrogen, and the key industrial processes.

01 Metallic character & ion charge
CORE RULE

Metallic character rises down a group, falls left-to-right across a period. The group number gives the characteristic ion charge (group 1 → 1+, group 2 → 2+, group 17 → 1−).

02 Group reactivity
CORE RULE

Alkali and alkaline-earth reactivity increases down the group (the valence electron is held more loosely). Group 1 is more reactive than group 2 in the same period.

03 Periodic trends for ranking
CORE RULE

Atomic radius increases down a group, decreases across a period; ionization energy and electronegativity do the opposite (down ↓, across ↑).

04 Metals + water
CORE RULE

Group 1: $2M + 2H_2O \rightarrow 2MOH + H_2$ (all, cold water). Group 2 varies: Be none; Mg slow in hot water (steam → $MgO + H_2$); Ca, Sr, Ba: $M + 2H_2O \rightarrow M(OH)_2 + H_2$. More vigorous for lower, larger metals.

05 Metals + oxygen / halogens
CORE RULE

With O_2: Li → Li_2O, Na → Na_2O_2 (peroxide), K/Rb/Cs → KO_2 (superoxide); group 2 → oxide MO (heavier ones, esp. Ba, form peroxide MO_2 when heated in excess O_2). With halogens → the ionic halide ($2Na + Cl_2 \rightarrow 2NaCl$).

06 Allotropes
CORE RULE

Structure drives properties: graphite (sp^2 layers → soft, conductive) vs diamond (sp^3 network → hard, insulating); white P (strained P_4 → reactive) vs red P (polymeric → stable).

07 Hydrogen behavior
CORE RULE

Hydrogen is a reducing agent: +1 with a more electronegative nonmetal, −1 in ionic metal hydrides. H_2 reduces less-active metal oxides; an ionic hydride + water → metal hydroxide + H_2.

08 Preparing hydrogen
CORE RULE

Water-gas ($C + H_2O \rightarrow CO + H_2$), steam reforming of hydrocarbons, electrolysis of water ($2H_2O \rightarrow 2H_2 + O_2$), and active metal + acid ($Fe + 2H^+ \rightarrow Fe^{2+} + H_2$).

09 Haber-Bosch (ammonia)
CORE RULE

$N_2 + 3H_2 \rightleftharpoons 2NH_3$ ($\Delta H° \approx -92$ kJ), iron catalyst. Exothermic with fewer gas moles, so high pressure and low temperature favor NH_3 at equilibrium; a moderate temperature is a kinetic/yield compromise (speed over yield).

10 Ostwald (nitric acid)
CORE RULE

Oxidize ammonia in stages: $4NH_3 + 5O_2 \rightarrow 4NO + 6H_2O$; $2NO + O_2 \rightarrow 2NO_2$; $3NO_2 + H_2O \rightarrow 2HNO_3 + NO$.

11 Contact (sulfuric acid)
CORE RULE

$2SO_2 + O_2 \rightleftharpoons 2SO_3$ over V_2O_5; absorb SO_3 into H_2SO_4 to make oleum, then dilute to H_2SO_4. Higher pressure and lower temperature favor SO_3.

12 Metallurgy
CORE RULE

Very active metals come from electrolysis of a molten salt: Downs cell ($2NaCl \rightarrow 2Na + Cl_2$), Hall-Héroult (alumina in molten cryolite → Al). Less-active metals come from chemical reduction.