9701 CHEMISTRY · TOPIC 10 · AS LEVEL

Group 2 — The Alkaline Earth Metals

01 · THE GROUP

Be, Mg, Ca, Sr, Ba — all end in **ns^2** and form 2+ ions by losing both outer electrons.

Silvery reactive metals, always found combined in nature. Reactivity **increases down the group**.

02 · WHY REACTIVITY RISES DOWN THE GROUP

Atomic radius increases and shielding increases, so the outer electrons are held less strongly and the **first and second ionisation energies fall**.

The metal is therefore a stronger reducing agent further down, and forms its 2+ ion more readily.

03 · REACTION WITH OXYGEN

$2M + O_2 \rightarrow 2MO$. All burn vigorously to a white ionic oxide.

Flame colours: Mg brilliant white, Ca brick red, Sr crimson, Ba apple green.

04 · REACTION WITH WATER

$M + 2H_2O \rightarrow M(OH)_2 + H_2$

Mg very slow in cold water, but $Mg + H_2O(g) \rightarrow MgO + H_2$ with steam
Ca steady fizzing, cloudy suspension
Sr, Ba increasingly vigorous

The resulting solution is alkaline and gets more so down the group as the hydroxides become more soluble.

05 · REACTION WITH DILUTE ACID

$M + 2HCl \rightarrow MCl_2 + H_2$, increasingly vigorous down the group.

With H_2SO_4 the reaction slows or stops for Ca, Sr and Ba: the insoluble sulfate coats the metal and blocks further attack.

06 · SOLUBILITY TRENDS

Compound	Down the group
hydroxides	solubility **increases**
sulfates	solubility **decreases**

$Mg(OH)_2$ is nearly insoluble (milk of magnesia); $Ba(OH)_2$ dissolves freely. $BaSO_4$ is so insoluble it is safe to swallow as a barium meal, and is the white precipitate in the sulfate test.

07 · THERMAL STABILITY OF CARBONATES

$MCO_3 \rightarrow MO + CO_2$

Stability increases down the group, so the decomposition temperature rises: $MgCO_3$ decomposes easily, $BaCO_3$ needs very strong heating.

Reason: the cation gets larger and less polarising, so it distorts the carbonate ion less. Nitrates follow the same trend: $2M(NO_3)_2 \rightarrow 2MO + 4NO_2 + O_2$.

08 · POLARISING POWER EXPLAINED

A small, highly charged cation pulls electron density from the large anion, weakening a C–O bond within CO_3^{2-} and making decomposition easier.

Charge density falls down the group as the ionic radius grows, so polarisation falls and stability rises. The same argument explains why Group 1 carbonates are more stable than Group 2 ones.

09 · THE OXIDES AND HYDROXIDES

$MO + H_2O \rightarrow M(OH)_2$ — all basic, and increasingly so down the group.

All react with acids: $MO + 2HCl \rightarrow MCl_2 + H_2O$ and $M(OH)_2 + H_2SO_4 \rightarrow MSO_4 + 2H_2O$.

10 · USES

$Ca(OH)_2$ / CaO — neutralising acidic soil and acidic industrial gases; CaO in the blast furnace removes silica as slag.

$Mg(OH)_2$ and $CaCO_3$ — antacids: they neutralise excess stomach acid without being corrosive.

$BaSO_4$ — X-ray contrast medium; **Mg** — lightweight alloys and sacrificial protection.

11 · WORKED EXAMPLE — IDENTIFY THE METAL

A metal reacts steadily with cold water, gives a cloudy alkaline suspension and a brick-red flame colour. Its carbonate decomposes at a moderate temperature. Which is it?

Cold-water reaction rules out Mg
Brick-red flame → **calcium**
$Ca + 2H_2O \rightarrow Ca(OH)_2 + H_2$
Cloudiness is the sparingly soluble $Ca(OH)_2$.

12 · WORKED EXAMPLE — THERMAL DECOMPOSITION

5.00 g of $CaCO_3$ is heated until no further change. What mass of CaO remains?

$n(CaCO_3) = 5.00 \div 100.1 = 0.0500$ mol
$1 : 1 \rightarrow n(CaO) = 0.0500$ mol
$m = 0.0500 \times 56.1 =$ **2.80 g**

The 2.20 g lost is CO_2, which at r.t.p. occupies 1.20 dm^3.

13 · EQUATIONS TO KNOW

$2Mg + O_2 \rightarrow 2MgO$
$Mg + H_2O(g) \rightarrow MgO + H_2$
$Ca + 2H_2O \rightarrow Ca(OH)_2 + H_2$
$CaO + H_2O \rightarrow Ca(OH)_2$
$MgCO_3 \rightarrow MgO + CO_2$
$2Mg(NO_3)_2 \rightarrow 2MgO + 4NO_2 + O_2$
$Mg(OH)_2 + 2HCl \rightarrow MgCl_2 + 2H_2O$
$CaCO_3 + 2HCl \rightarrow CaCl_2 + H_2O + CO_2$

14 · TESTS AND OBSERVATIONS

Test	Observation
flame test	Ca brick red, Sr crimson, Ba green
+ $BaCl_2$ / HCl	white ppt confirms sulfate
limewater + CO_2	milky, then clears in excess
carbonate + acid	fizzing, gas turns limewater milky

Limewater clears because the carbonate converts to soluble hydrogencarbonate: $CaCO_3 + H_2O + CO_2 \rightarrow Ca(HCO_3)_2$ — the origin of temporary hardness in water.

TRENDS IN ONE LINE

Down Group 2: radius ↑, ionisation energy ↓, reactivity ↑, hydroxide solubility ↑, sulfate solubility ↓, carbonate stability ↑.

Every one of these follows from the growing ionic radius and the falling charge density.

MARKS LOST HERE

— Giving the hydroxide and sulfate solubility trends the same way round; they are opposite.

— Writing $MgO + H_2$ for magnesium with **cold water**; that is the steam reaction.

— Explaining carbonate stability by "bigger atoms" rather than lower charge density and less polarisation.

— Forgetting that Group 2 nitrates give NO_2 and O_2, not just the oxide.