**2.4 Periodicity of Period 3**

**Trends in the reactions of the elements with water, limited to Na and Mg**

Sodium reacts with cold water. It fizzes around on surface etc.

\[ 2 \text{Na (s)} + 2 \text{H}_2\text{O (l)} \rightarrow 2 \text{NaOH (aq)} + \text{H}_2 (g) \]

Magnesium reacts very slowly with cold water to form the hydroxide but reacts more readily with steam to form the oxide

\[ \text{Mg (s)} + \text{H}_2\text{O (g)} \rightarrow \text{MgO (s)} + \text{H}_2 (g) \]

**Learn the equations**

**Trends in the reactions of the elements Na, Mg, Al, Si, P and S with oxygen**

The elements all react with oxygen to form oxides.

- Sodium burns with a yellow flame to produce a white solid
- Mg, Al, Si and P burn with a white flame to give white solid smoke
- S burns with a blue flame to form an acidic choking gas.

**You should be able to write these equations.**

Learn the formulae of the oxides

Sodium is stored under oil and phosphorus under water to stop these elements coming into contact and reacting with air.

A survey of the properties of the oxides of Period 3 elements

Understand the link between the physical properties of the highest oxides of the elements Na → S and their structure and bonding.

**Ionic oxides**

The metal oxides (Na₂O, MgO, Al₂O₃) are ionic. They have high melting points. They have **ionic giant lattice structures**: strong forces of attraction between ions: higher mp. They are ionic because of the large electronegativity difference between metal and O.

The increased charge on the cation makes the ionic forces stronger (bigger lattice enthalpies of dissociation) going from Na to Al so leading to increasing melting points.

Al₂O₃ is ionic but does show some covalent character. This can be explained by the electronegativity difference being less big or alternatively by the small aluminium ions with a high charge being able to get close to the oxide ion and distorting the oxide charge cloud.

**Macromolecular oxides**

SiO₂ is Macromolecular: It has many very strong covalent bonds between atoms. High energy needed to break the many strong covalent bonds – very high mp +bp

**Simple molecular oxides:**

P₄O₁₀(s), SO₂(g) are simple molecular with weak intermolecular forces between molecules (van der waals + permanent dipoles) so have lower mp’s. They are covalent because of the small electronegativity difference between the non-metal and O atoms. P₄O₁₀ is a molecule containing 4P’s and 10 O’s. As it is a bigger molecule and has more electrons than SO₂ it will have larger van der waals forces and a higher melting point.

Aluminium metal is protected from corrosion in moist air by a thin layer of aluminium oxide. The high lattice strength of aluminium oxide and its insolubility in water make this layer impermeable to air and water.

To prove that the above compounds contain ions experimentally - melt the solids and show they conduct electricity.

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The reactions of the oxides of the elements Na → S with water

**Metal ionic oxides** tend to react with water to form hydroxides which are alkaline

Na₂O (s) + H₂O (l) → 2Na⁺ (aq) + 2OH⁻ (aq) **pH 13 (This is a vigorous exothermic reaction)**

The ionic oxides are basic as the oxide ions accept protons to become hydroxide ions in this reaction (acting as a bronsted lowry base)

MgO (s) + H₂O (l) → Mg(OH)₂ (s) **pH 9**

Mg(OH)₂ is only slightly soluble in water as its lattice is stronger so fewer free OH⁻ ions are produced and so lower pH

The non-metal, simple molecular, covalent, oxides react with water to give acids

P₄O₁₀ (s) + 6 H₂O (l) → 4 H₃PO₄(aq) **pH 0 (this is a vigorous exothermic reaction)**

SO₂ (g) + H₂O (l) → H₂SO₃ (aq) **pH 3 (weak acid)**

SO₃ (g) + H₂O (l) → H₂SO₄ (aq) **pH 0**

Equations showing formation of ions in solution

The trend is the ionic metal oxides show basic behaviour and the non-metal covalent oxides show acidic behaviour.

The slightly intermediate nature of the bonding in Aluminium oxide is reflected in its amphoteric behaviour: it can act as both a base and an acid

Acid base reactions between period 3 oxides and simple acids and bases.

The basic oxides react with acids to make salts

Na₂O (s) + 2 HCl (aq) → 2NaCl (aq) + H₂O (l)

Na₂O (s) + H₂SO₄ (aq) → Na₂SO₄ (aq) + H₂O (l)

MgO (s) + 2 HCl (aq) → MgCl₂ (aq) + H₂O (l)

Or ionically

Na₂O (s) + 2H⁺ (aq) → 2Na⁺ (aq) + H₂O (l)

MgO (s) + 2 H⁺ (aq) → Mg²⁺ (aq) + H₂O (l)

Amphoteric Oxides

Aluminium oxide can act as both an acid and an alkali and is therefore called amphoteric

Al₂O₃ (s) + 3H₂SO₄ (aq) → Al₂(SO₄)₃ (aq) + 3H₂O (l)

Al₂O₃ + 6HCl → 2AlCl₃ + 3H₂O

Or ionically Al₂O₃ + 6H⁺ → 2Al³⁺ + 3H₂O

Aluminium oxide acting as an acid

Al₂O₃ (s) + 2NaOH (aq) + 3H₂O (l) → 2NaAl(OH)₄ (aq) (this equation needs learning carefully)

Al₂O₃ (s) + 2OH⁻ (aq) + 3H₂O (l) → 2Al(OH)₄⁻ (aq)

The other simple molecular acidic oxides react with bases to form salts.

P₄O₁₀ (s) + 12 NaOH (aq) → 4Na₃PO₄(aq) + 6 H₂O (l)

P₄O₁₀ (s) + 6 NaO → 4Na₃PO₄

SO₂ (g) + 2NaOH (aq) → Na₂SO₃ (aq) + H₂O (l)

SO₃ (g) + 2NaOH (aq) → Na₂SO₄ (aq) + H₂O (l)

Or show ionically

P₄O₁₀ (s) + 12 OH⁻ (aq) → 4PO₄³⁻(aq) + 6 H₂O (l)

SO₂ (g) + 2OH⁻ (aq) → SO₃²⁻ (aq) + H₂O (l)

SO₃ (g) + 2OH⁻ (aq) → SO₄²⁻ (aq) + H₂O (l)

SiO₂ has a giant covalent structure with very strong bonds. This stops SiO₂ dissolving or reacting with water and weak solutions of alkali. It will, however, react with very concentrated NaOH

2NaOH (l) + SiO₂ (s) → Na₂SiO₃ (aq) + H₂O

It is still classed as an acidic oxide