2. Periodicity of Period 3 Elements

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

Learn the equations

Sodium reacts with cold water. It fizzes around on surface etc.
$2\ Na\ (s) + 2\ H_2O\ (l) \rightarrow 2\ NaOH\ (aq) + H_2\ (g)$

Magnesium reacts very slowly with cold water to form the hydroxide but reacts more readily with **steam** to form the oxide
$Mg\ (s) + H_2O\ (g) \rightarrow MgO\ (s) + H_2\ (g)$

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. Mg, Al, Si and P burn with a white flame and S with a blue flame.

$4\ Na\ (s) + O_2\ (g) \rightarrow 2\ Na_2O\ (s)$
$2Mg\ (s) + O_2\ (g) \rightarrow 2MgO\ (s)$
$4Al + 3O_2\ (g) \rightarrow 2Al_2O_3\ (s)$
$Si + O_2\ (g) \rightarrow SiO_2\ (s)$
$4P + 5O_2\ (g) \rightarrow P_4O_{10}\ (s)$
$S + O_2\ (g) \rightarrow SO_2\ (g)$

You should be able to write these equations.

Learn the formulae of the oxides

A survey of the acid-base 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 (Na_2O, MgO, Al_2O_3) 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 going from Na to Al so leading to increasing melting points

Macromolecular oxides
SiO_2 is Macromolecular: very strong covalent bonds between atoms. High energy needed to break the many strong covalent bonds – very high mp +bp

Simple molecular oxides:
P_4O_{10}, SO_2 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

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

know the change in pH of the resulting solutions across the Period.

Metal oxides tend to react with water to form hydroxides which are alkaline
$Na_2O\ (s) + H_2O\ (l) \rightarrow Na^+\ (aq) + 2OH^-\ (aq)$ **pH 13 (This is a vigorous exothermic reaction)**
$MgO\ (s) + H_2O\ (l) \rightarrow Mg(OH)_2\ (s)$ **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

Al_2O_3 and SiO_2 **do not dissolve** in water because of the high strength of the Al_2O_3 ionic lattice and the SiO_2 macromolecular structure, so they give a neutral **pH 7**

The non-metal, **simple molecular**, covalent, oxides react with water to give acids
$P_4O_{10}\ (s) + 6\ H_2O\ (l) \rightarrow 4\ H_3PO_4(aq)$ **pH 0 (this is a vigorous exothermic reaction)**
$SO_2\ (g) + H_2O\ (l) \rightarrow H_2SO_3\ (aq)$ **pH 3 (weak acid)**
$SO_3\ (g) + H_2O\ (l) \rightarrow H_2SO_4\ (aq)$ **pH 0**

Learn the equations !

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

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

The **basic oxides** react with acids to make salts
Na_2O (s) + 2 HCl (aq) → 2NaCl (aq) + H_2O (l)
Na_2O (s) + H_2SO_4 (aq) → Na_2SO_4 (aq) + H_2O (l)
MgO (s) + 2 HCl (aq) → $MgCl_2$ (aq) + H2O (l)

Rather than learning the equations by rote, learn the pattern. Most follow the pattern acid + base = salt + water

Amphoteric Oxides
Aluminium oxide can act as both an acid and an alkali and is therefore called amphoteric
Aluminum oxide acting as a **base**
Al_2O_3 (s)+ $3H_2SO_4$ (aq)→ $Al_2(SO_4)_3$ (aq) + $3H_2O$ (l)
Aluminum oxide acting as a **acid**
Al_2O_3 (s)+ 2NaOH (aq) + $3H_2O$ → $2NaAl(OH)_4$ (this equation needs learning carefully)

The other simple molecular acidic oxides react with bases to form salts.
P_4O_{10} (s) + 12 NaOH (l) → $4Na_3PO_4$(aq) + 6 H_2O
SO_2 (g) + 2NaOH (l) → Na_2SO_3 (aq) + H_2O
SO_3 (g) + 2NaOH(l) → Na_2SO_4 (aq) + H_2O

SiO_2 has a **giant covalent structure** with very strong bonds. This stops SiO_2 reacting with water and weak solutions of alkali. It will, however, react with very concentrated NaOH
2NaOH (l) + SiO_2 (s)→ Na_2SiO_3 (aq) + H_2O
It is still classed as an acidic oxide

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