Topic 11 – Periodicity
Revision Notes

1) Trends across period 3

- Across period 3, nuclear charge increases and shielding remains constant
- There is increased attraction between the nucleus and the outer shell electrons so atomic radius decreases, first ionisation energy increases (apart from dips to Al and S)
- When covalently bonded, there is increased attraction between the nucleus and the shared pair electrons so electronegativity increases
- Na, Mg and Al have metallic bonding. Si is giant covalent. P_4, S_8 and Cl_2 are simple molecular. Ar is simple atomic

2) Reactions of period 3 elements

a) Reactions of Period 3 elements with water

Equation	Observations	Redox
$2Na(s) + 2H_2O(l) \rightarrow 2NaOH(aq) + H_2(g)$	Effervescence Yellow flame	Na from 0 to +1, oxidation H from +1 to 0, reduction
$Mg(s) + 2H_2O(l) \rightarrow Mg(OH)_2(aq) + H_2(g)$	Fine bubbles Slow reaction	Mg from 0 to +2, oxidation H from +1 to 0, reduction

- Magnesium reacts rapidly with steam

$$\mathbf{Mg(s) + H_2O(g) \rightarrow MgO(s) + H_2(g)}$$

b) Reactions of Period 3 elements with oxygen

Equation	Observations	Redox
$4Na(s) + O_2(g) \rightarrow 2Na_2O(s)$	White solid produced	Na from 0 to +1, oxidation O from 0 to -2, reduction
$2Mg(s) + O_2(g) \rightarrow 2MgO(s)$	Bright white flame White solid produced	Mg from 0 to +2, oxidation O from 0 to -2, reduction
$4Al(s) + 3O_2(g) \rightarrow 2Al_2O_3(s)$	White solid produced	Al from 0 to +3, oxidation O from 0 to -2, reduction
$Si(s) + O_2(g) \rightarrow SiO_2(s)$		Si from 0 to +4, oxidation O from 0 to -2, reduction
$P_4(s) + 5O_2(g) \rightarrow P_4O_{10}(s)$		P from 0 to +5, oxidation O from 0 to -2, reduction
$S(s) + O_2(g) \rightarrow SO_2(g)$	Blue flame Pungent/choking gas produced	S from 0 to +4, oxidation O from 0 to -2, reduction

3) <u>Reactions of Period 3 oxides</u>

a) Structure and bonding of oxides

- Na_2O, MgO are giant ionic – high melting and boiling points due to strong attraction between oppositely charged ions
- Al_2O_3 is ionic with covalent character - high melting and boiling points due to strong attraction between oppositely charged ions
- SiO_2 is giant covalent – very high melting and boiling points as there are many strong covalent bonds to break
- P_4O_{10} and SO_3 are simple molecular – low melting and boiling points due to weak VdW forces between molecules

b) Reactions with water

Equation	Observations	Notes
$Na_2O(s) + H_2O(l) \rightarrow 2NaOH(aq)$	Dissolves readily	Alkaline solution, pH 14 **Oxide ions react with water to form OH^-**
$MgO(s) + H_2O(l) \rightarrow Mg(OH)_2(aq)$	Sparingly soluble	Alkaline solution, pH 10 **Oxide ions react with water to form OH^-**
$Al_2O_3(s) + H_2O(l) \rightarrow$ No reaction	Al_2O_3 doesn't dissolve Lattice enthalpy is too high	Al_2O_3 is amphoteric
$SiO_2(s) + H_2O(l) \rightarrow$ No reaction		
$P_4O_{10}(s) + 6H_2O(l) \rightarrow 4H_3PO_4(aq)$		Acidic solution, pH 0
$SO_2(g) + H_2O(l) \rightarrow H_2SO_3(aq)$		Acidic solution, pH 3
$SO_3(g) + H_2O(l) \rightarrow H_2SO_4(aq)$		Acidic solution, pH 0

- Giant ionic oxides produce alkaline solutions
- Al_2O_3 and SiO_2 are insoluble
- Simple molecular oxides produce acidic solutions
- The trend across the Period is from ionic to covalent oxides and from alkaline to acidic solutions

c) Reactions with acids and bases

- Alkaline oxides react with acids e.g.

  $MgO + 2HCl \rightarrow MgCl_2 + H_2O$ or
  $O^{2-} + 2H^+ \rightarrow H_2O$

  This would also apply to amphoteric Al_2O_3 when acting as a base

- Acidic oxides react with bases e.g.

  $P_4O_{10} + 12NaOH \rightarrow 4Na_3PO_4 + 6H_2O$ (ionic version omits Na^+)
  $SiO_2 + CaO \rightarrow CaSiO_3$ (ionic version omits Ca^{2+})

- (Amphoteric) aluminium oxide reacting as an acid

$$\mathbf{Al_2O_3 + 2OH^- + 3H_2O \rightarrow 2[Al(OH)_4]^-}$$