Topic 6 – The Periodic Table
Revision Notes

1) General

- In the Periodic Table the elements are arranged in order of increasing atomic number
- The elements in a period (row) show trends in physical and chemical properties that are repeated across other periods
- Repeating patterns across different rows is called periodicity
- The elements in a group (column) have similar physical and chemical properties
- The similarity in properties of elements is a group is due to them having the same number of outer shell electrons

2) Trends Across Periods 2 and 3

- Be able to **describe and explain** trends in the following:

Electron configuration	Across the period successive elements have one more outer shell electron
Atomic radius	Describe – it decreases Explain – bigger nuclear charge, same shielding, nuclear attraction increases
1st ionisation energy	Describe – general increase Explain – bigger nuclear charge, same shielding, nuclear attraction increases
Melting & boiling points	Na, Mg and Al have metallic bonding. Attraction of positive ions free electrons is strong so melting points are high. Melting point increases from Na to Mg to Al because metal ion has greater charge and there are more free electrons per atom so metallic bonding is stronger. Si has very high melting point. Giant covalent structure has many strong covalent bonds to be broken. P_4, S_8 and Cl_2 have low melting points. These are simple covalent molecules held together by weak van der Waal's forces. Van der Waal's forces increase with molecular mass so S_8 has highest melting point, then P_4 then Cl_2 Ar has simple atomic structure. Fewest electrons, weakest van der Waal's forces

3) Trends Down Groups

- Be able to describe and explain trends in the following:

Atomic radius	Describe – it increases Explain – extra electron shell, outer electron further from nucleus and more shielded. Increased nuclear charge outweighed by greater shielding and distance

1st ionisation energy

Describe – it decreases
Explain – extra electron shell, outer electron further from nucleus and more shielded. Increased nuclear charge outweighed by greater shielding and distance

4) Redox Reactions of Group 2 metals

- Group 2 elements undergo redox reactions with water and oxygen

a) Water

- Fizzing/effervescence will be seen
- The group 2 element will dissolve/disappear

$$Ca(s) + 2H_2O(l) \rightarrow Ca(OH)_2(aq) + H_2(g)$$

Ca: 0 to +2 = oxidation
H: +1 to 0 = reduction

- The overall equation can be split into half-equations, one for the oxidation and one for the reduction:

$Ca \rightarrow Ca^{2+} + 2e^-$	**oxidation (loss of electrons)**
$2H_2O + 2e^- \rightarrow 2OH^- + H_2$	**reduction (gain of electrons)**

- Mg reacts slowly with water but the reaction with steam is much more vigorous. With steam, the oxide is produced rather than the hydroxide

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

b) Oxygen

- Mg burns with a bright white flame
- A white powder will be produced

$$2Mg + O_2 \rightarrow 2MgO$$

Mg: 0 to +2 = oxidation
O: 0 to -2 = reduction

- The overall equation can be split into half-equations, one for the oxidation and one for the reduction:

$Mg \rightarrow Mg^{2+} + 2e^-$	**oxidation (loss of electrons)**
$O_2 + 4e^- \rightarrow 2O^{2-}$	**reduction (gain of electrons)**

c) Trend in reactivity

- Reactivity increases down the group
- The elements lose 2 outer electrons in these reactions
- Down the group the outer electrons are further from nucleus and more shielded
- Nuclear attraction is reduced and so electrons are lost more easily
- Increased nuclear charge outweighed by greater shielding and distance

5) Reactions of Group 2 Compounds

a) Oxides

- Adding water dropwise to CaO produces calcium hydroxide, $Ca(OH)_2(s)$

$$CaO(s) + H_2O(l) \rightarrow Ca(OH)_2(s)$$

- In excess water, calcium hydroxide dissolves to make limewater $Ca(OH)_2(aq)$ whose pH is about 12

b) Carbonates

- Group 2 carbonates decompose when heated e.g.

$$MgCO_3(s) \rightarrow MgO(s) + CO_2(g)$$

- Going down the Group, the carbonates become harder to decompose (i.e. they become more stable)

c) Hydroxides

- Group 2 hydroxides are alkaline and can be used to neutralise acids.
- Calcium hydroxide, $Ca(OH)_2$, can be used in agriculture to neutralise acid soils. $Ca(OH)_2$ should not be used in excessive amounts as this would make the soil too alkaline
- Magnesium hydroxide, $Mg(OH)_2$, is found in milk of magnesia. This is used to treat indigestion by neutralising excess HCl in the stomach (the $Mg(OH)_2$ acts as an antacid).

6) Boiling points of the Group 7 elements

- At room temperature, Cl_2 is a pale green gas, Br_2 is a brown liquid, I_2 is a blue-black solid.
- In Group 7, melting and boiling points increase down the group because the molecules have more electrons and, therefore, stronger van der Waal's forces.

7) Redox reactions of the Group 7 elements and their compounds

a) Displacement reactions

- Reactivity decreases down the group
- This can be shown by halogen displacement reactions where elements higher up the group will displace elements further down the group
- This can be done with chlorine dissolved in water or by bubbling chlorine gas through NaBr(aq) or NaI(aq)

$Cl_2 + 2NaBr \rightarrow 2NaCl + Br_2$	Yellow solution/orange in hexane
$Cl_2 + 2NaI \rightarrow 2NaCl + I_2$	Brown solution/purple in hexane
$Br_2 + 2NaI \rightarrow 2NaBr + I_2$	Brown solution/purple in hexane

- These equations can also be written in ionic form

$$\mathbf{Cl_2 + 2Br^- \rightarrow 2Cl^- + Br_2}$$

$$\mathbf{Cl_2 + 2I^- \rightarrow 2Cl^- + I_2}$$

$$\mathbf{Br_2 + 2I^- \rightarrow 2Br^- + I_2}$$

- The Group 7 elements gain an electron when they react
- Down the group the outer shell is further from nucleus and more shielded
- Nuclear attraction is reduced so an electron is gained less easily

b) Disproportionation reactions

- Chlorine undergoes a redox reaction with water

$$\mathbf{Cl_2(g) + H_2O(l) \quad HCl(aq) + HOCl(aq)}$$

- This reaction is used in water purification to kill bacteria (stopping cholera and typhus)
- There are risks associated with chlorination such as handling toxic chlorine gas and possible risks from the formation of chlorinated hydrocarbons in drinking water
- The benefits from killing bacteria far outweigh the risks involved (in my humble opinion)

- Chlorine also undergoes a redox reaction with cold, dilute sodium hydroxide solution
- This reaction is used to make bleach.

$$\mathbf{Cl_2(g) + 2NaOH(aq) \rightarrow NaCl(aq) + NaOCl(aq) + H_2O(l)}$$

- In both of these reactions the oxidation state of Cl changes from 0 in Cl_2 to –1 in Cl^- and +1 in OCl^-
- Cl is simultaneously oxidised and reduced. This is an example of **disproportionation**

8) <u>Reactions of halide ions (Cl^-, Br^- and I^-)</u>

- Chloride ions, bromide ions and iodide ions produce coloured precipitates with silver nitrate solution, $AgNO_3$(aq)

$$\mathbf{Ag^+(aq) + Cl^-(aq) \rightarrow AgCl(s)}$$
white precipitate

$$\mathbf{Ag^+(aq) + Br^-(aq) \rightarrow AgBr(s)}$$
cream precipitate

$$\mathbf{Ag^+(aq) + I^-(aq) \rightarrow AgI(s)}$$
yellow precipitate

- The difference in colour of the precipitates can be used as a test to show which halide ion is present
- AgCl(s) dissolves in dilute ammonia solution, NH_3(aq)
- AgBr(s) dissolves in concentrated ammonia solution but not in dilute ammonia.
- AgI(s) does not dissolve, even in concentrated ammonia solution