Topic 14b – Group 7, the Halogens
Revision Notes

1) Trends in physical properties of the 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, boiling point increases down the group because the molecules have more electrons and, therefore, stronger van der Waal's forces which require more energy to overcome them
- Electronegativity is the ability of an atom to attract the electrons in a covalent bond
- Down Group 7, the shared electrons are further from the nucleus and more shielded. There is a weaker attraction for the bonding electrons down the Group

2) Trends in chemical properties of the elements

- The Group 7 elements are oxidising agents which gain an electron when they react
- The ability to oxidise decreases down Group 7
- 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)

  $\mathbf{Cl_2 + 2NaBr \rightarrow 2NaCl + Br_2}$
  Pale green solution Yellow solution/orange in hexane

  $\mathbf{Cl_2 + 2NaI \rightarrow 2NaCl + I_2}$
  Pale green solution Brown solution/purple in hexane

  $\mathbf{Br_2 + 2NaI \rightarrow 2NaBr + I_2}$
  Orange solution Brown solution/purple in hexane

- These equations can also be written in ionic form

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

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

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

- Down the group the outer electron is further from nucleus and more shielded so gained less easily

3) Trends in properties of the halides

- The halides (chlorides, bromides and iodides) are reducing agents which lose an electron when they react
- The ability to act as a reducing agent increases down the Group
- Down the group the outer electron is further from nucleus and more shielded so lost more easily
- This can be shown by the reactions of the solid halides with concentrated sulphuric acid

Sodium halide	Observations	Products	Type of reaction
NaF	Steamy fumes	HF(g)	Acid-base (F^- acting as base)
NaCl	Steamy fumes	HCl(g)	Acid-base (Cl^- acting as base)
NaBr	Steamy fumes Colourless gas Brown fumes	HBr(g) SO_2 Br_2	Acid-base (Br^- acting as base) Redox (reduction product of H_2SO_4) Redox (oxidation product of Br^-)
NaI	Steamy fumes Colourless gas Yellow solid Smell of bad eggs Black solid/purple fumes	HI(g) SO_2 S H_2S I_2(s/g)	Acid-base (I^- acting as base) Redox (reduction product of H_2SO_4) Redox (reduction product of H_2SO_4) Redox (reduction product of H_2SO_4) Redox (oxidation product of I^-)

- Iodide ions, I^-, can reduce the S from oxidation state +6 in H_2SO_4 to +4 in SO_2 then to 0 in S and finally to -2 in H_2S
- Bromide ions, Br^-, can reduce the S from oxidation state +6 in H_2SO_4 to +4 in SO_2
- Fluoride and chloride cannot reduce the S in H_2SO_4 under these conditions

4) Reactions of Cl^-, Br^- and I^- with Silver Ions and Ammonia Solution

- Chloride ions, bromide ions and iodide ions produce coloured precipitates with acidified silver nitrate solution. Fluoride ions do not produce a precipitate with $AgNO_3$

$$Ag^+(aq) + Cl^-(aq) \rightarrow AgCl(s)$$
White precipitate

$$Ag^+(aq) + Br^-(aq) \rightarrow AgBr(s)$$
Cream precipitate

$$Ag^+(aq) + I^-(aq) \rightarrow AgI(s)$$
Yellow precipitate

- 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

5) Redox Reactions of Group 7 Elements

- Chlorine undergoes a redox reaction with water. This reaction is used in water purification to kill bacteria

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

- The benefits to health of water treatment outweigh the risks associated with handling toxic chlorine gas

- Chlorine reacts with cold, dilute sodium hydroxide solution. This reaction is used to make household bleach

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

- NaClO is sodium chlorate(I) which is the active ingredient in bleach
- 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

Topic 14a – Group 2, the Alkaline Earth Metals
Revision Notes

1) Trends in Physical Properties Down Group 2 (Be-Ba)

a) Atomic radius

- Increases down the group
- Extra electron shell, outer electron further from nucleus and more shielded
- Increased nuclear charge outweighed by greater shielding and distance

b) 1st ionisation energy

- Decreases down the group
- Extra electron shell, outer electron further from nucleus and more shielded
- Increased nuclear charge outweighed by greater shielding and distance

c) Melting & boiling points

- Decrease down the group
- Metallic bonding gets weaker down the group. Ionic radius of metal ions increases down group so charge density decreases. Weaker attraction between metal ions and delocalised electrons

2) Trends in Chemical Properties Down Group 2 (Be-Ba)

a) Reactivity with Water

- Reactivity increases down the group
- Extra electron shell, outer electrons further from nucleus and more shielded so lost more easily. Increased nuclear charge outweighed by greater shielding and distance
- Mg reacts slowly with cold water. Calcium reacts more vigorously

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

- Mg reacts rapidly with steam

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

b) Solubility of Sulphates

- Solubility of group 2 sulphates decreases down the group i.e. $BaSO_4$ is the least soluble group 2 sulphate
- $BaCl_2(aq)$ is used to test for sulphates. A white precipitate is produced

$$Ba^{2+}(aq) + SO_4^{2-}(aq) \rightarrow BaSO_4(s)$$

- Barium sulphate is used for X-ray imaging and CT scans. It is most often used in imaging of the oesophagus. It is not readily absorbed by the body and absorbs X-rays more strongly than lighter atoms

c) Solubility of hydroxides

- Solubility of group 2 hydroxides increases down the group. $Mg(OH)_2$ is sparingly soluble i.e. only a small amount dissolves
- Group 2 hydroxides are alkaline and can be used to neutralise acids
- Calcium hydroxide, $Ca(OH)_2$, can be used to reduce soil acidity in agriculture
- 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)