WJEC Chemistry AS-Level

2.6: Halogenoalkanes

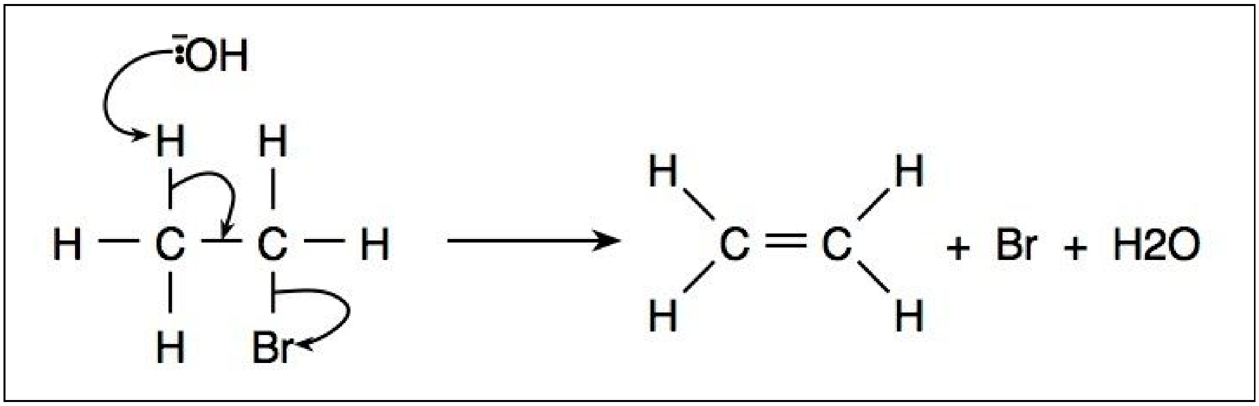
Detailed Notes

English Specification

Elimination Reactions

When a halogenoalkane is mixed with hydroxide ions and heated to **high temperatures** under **alcoholic** conditions, **elimination** occurs. In this reaction, a hydroxide ion **nucleophile** acts as a base and accepts a proton, removing a hydrogen atom from the molecule. This results in the elimination of the **halide** too, producing a **carbon-carbon double bond**.

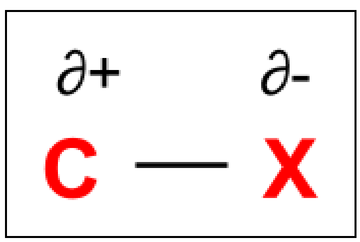
Mechanism - elimination



Nucleophilic Substitution

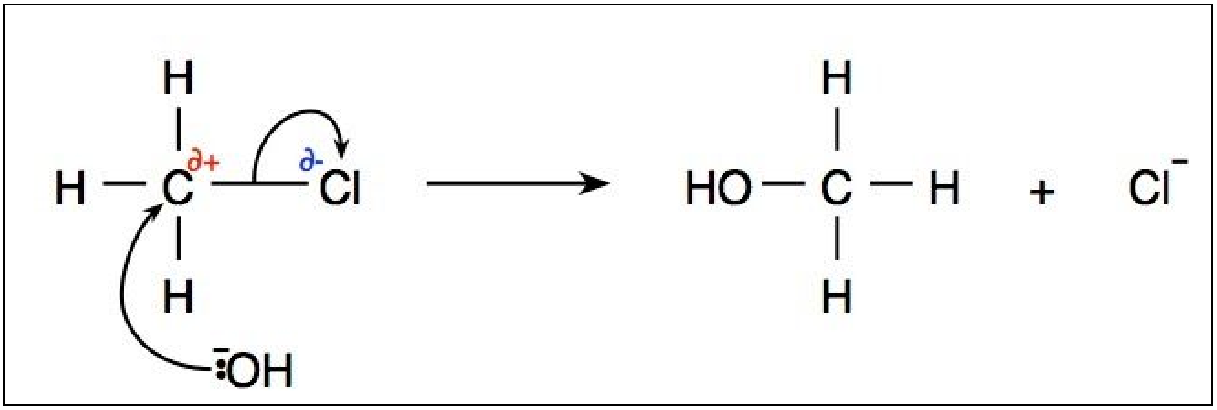
Halogenoalkanes contain **polar bonds** as the halogens are much **more electronegative** than carbon atoms. This means electron density is drawn towards the halogen, forming **∂+** and **∂-** regions.

Example:



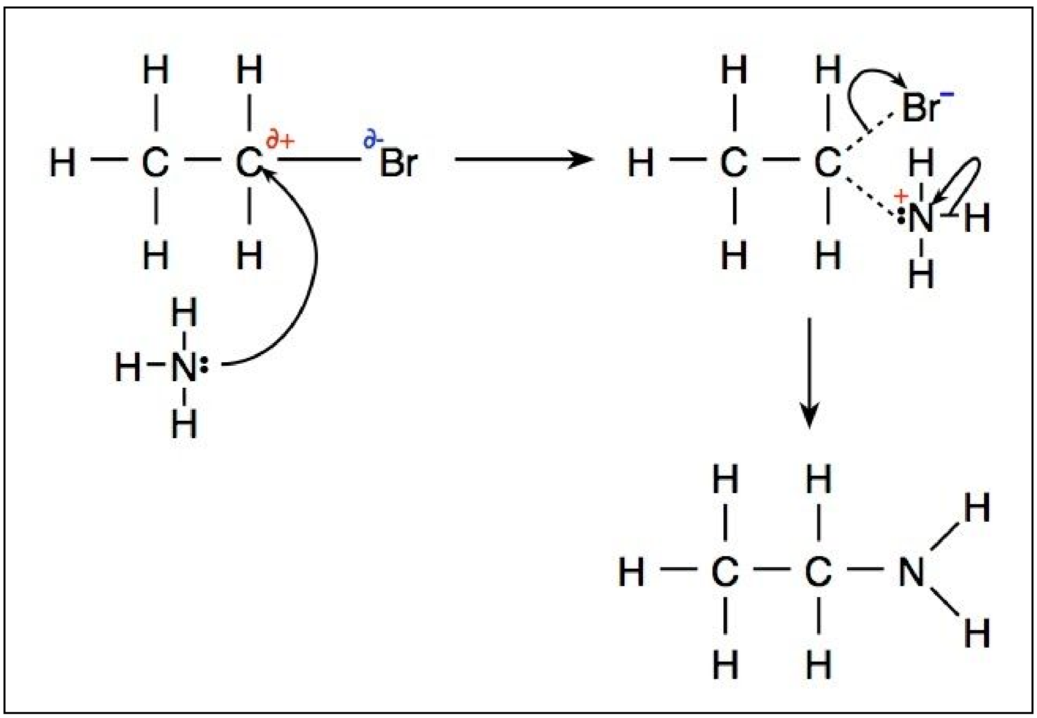
In the reaction mechanism of **nucleophilic substitution**, nucleophiles attack the halogenoalkane and displace the halogen to produce compounds such as **alcohols** and **amines**.

Mechanism - nucleophilic substitution of a halogenoalkane to form an alcohol



The nucleophile attacks the ∂+ carbon and the electrons are transferred to the chlorine.

Mechanism - nucleophilic substitution of a halogenoalkane to form an amine



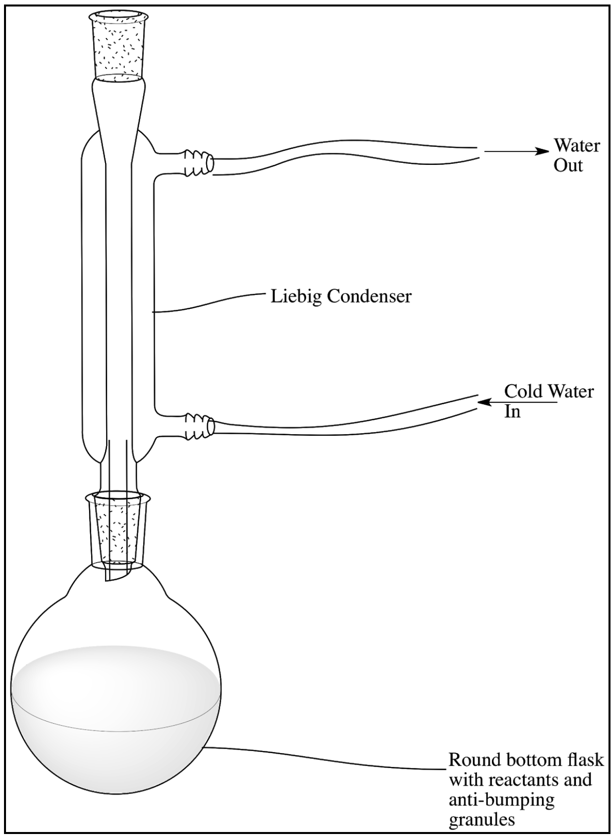
The intermediate formed has an N⁺ atom, so electrons are transferred to it causing a hydrogen to be lost.

The greater the **relative atomic mass of the halogen** in the polar bond, the lower the **bond enthalpy.** The lower the bond enthalpy, the more easily the bond can be broken. Therefore, the higher the relative atomic mass of the halogen atom, the faster the **rate of reaction** for the halogenoalkane.

Reflux

The process of nucleophilic substitution has to be carried out under **reflux conditions** in a **closed system**. In reflux, the vapours of the reaction evaporate, condense and return to the original solution to be heated again.

There is specific **reflux equipment** that can be used to carry out this process, including a **Liebig condenser** and **anti-bumping granules** that help to disperse the heat evenly through the solution.



Testing for Halogenoalkanes

To test for halogenoalkanes, the unknown solution should be **warmed** with a mixture of **sodium hydroxide, ethanol and water**. This is a **hydrolysis** reaction that causes the **displacement** of the halide ion. After the halide ion has been displaced, **dilute nitric acid** is added to the solution to neutralise any excess sodium hydroxide. The type of halide ion present can then be identified specifically by using **silver nitrate solution**. The **Ag^+** ions from silver nitrate react with the halide to produce **coloured precipitates**.

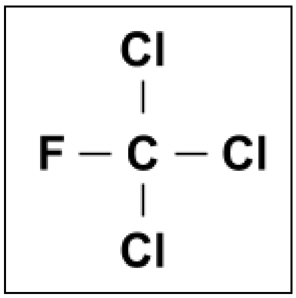
The precipitates formed may not be clear to distinguish so they can be tested further using **ammonia**.

	Cl^-	Br^-	I^-
+ $AgNO_3$	White precipitate ($AgCl$)	Cream precipitate ($AgBr$)	Yellow Precipitate (AgI)
+ dilute NH_3	Precipitate dissolves	No Change	No Change
+ conc. NH_3	Precipitate dissolves	Precipitate dissolves	No Change

Uses of Halogenoalkanes

CFCs (chlorofluorocarbons) are halogenoalkane molecules where all of the hydrogen atoms have been replaced by **fluorine** and **chlorine** atoms.

Example:



They are used for **refrigerants**, **foamed plastic** production, dry cleaning **solvents** and **aerosols** due to their low flammability and toxicity.

However, once released into the atmosphere, CFCs **absorb UV radiation** causing them to break down to form **free radicals**. These free radicals are very harmful to the environment because they can **catalyse ozone depletion**.

Example:

$$O_3 + Cl\bullet \longrightarrow \bullet OCl + O_2$$

$$\bullet OCl + O_3 \longrightarrow 2O_2 + Cl\bullet$$

$$\underline{\text{Overall:}} \quad 2O_3 \longrightarrow 3O_2$$

Ozone, O_3, is in the upper atmosphere and helps to **prevent ultraviolet radiation** from the sun from reaching the earth. Ultraviolet radiation causes **sunburn** and skin cancer so ozone is a very important layer of protection.

Ozone is formed from **oxygen free radicals**:

$$O_2 \longrightarrow O\bullet + O\bullet$$

$$O_2 + O\bullet \longrightarrow O_3$$

CFC-free solvents are now being produced to prevent the damage to the ozone layer.