Answer all the questions below as fully as you can then check your answers below.

1. What is a Nucleophile? What feature will all nucleophiles have in common?

2. Explain why the C-X bond is polar.

a. If a bond is described as polar what does this mean?

3. What is nucleophilic substitution?

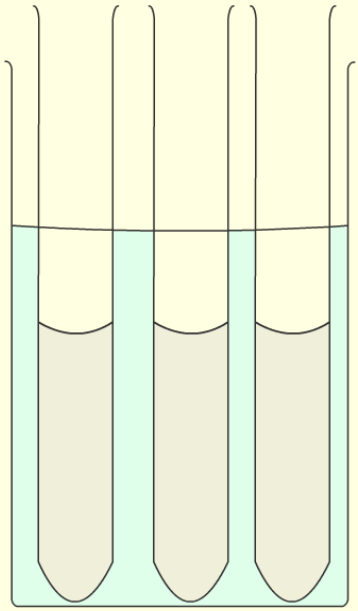
4. What is hydrolysis?

5. Draw the mechanism to show the hydrolysis of bromoethane with water. There are two steps in this mechanism, draw them both and show clearly how the alcohol ethanol is formed.

a. Explain why water is able to act as a nucleophile.

b. Now draw the mechanism to show how ethanol is made by reacting bromoethane with hydroxide ions.

6. A student planned an investigation into factors affecting the rate of the hydrolysis of the halogenalkanes 1-chlorobutane, 1-bromobutane and 1-iodobutane. She set-up a water bath containing 3 test-tubes as shown opposite. She has a bottle of ethanol, silver nitrate solution, a kettle and a stop-clock.



a. What should be placed in each test-tube to measure the rate of this reaction?

b. Outline briefly how the student intends to measure the rate of this reaction.

c. What should the student do to ensure she obtains valid results?

d. Write an equation to show the how the precipitate using the 1-iodobutane is produced.

e. Which precipitate will be produced first? Give a reason for your answer.

f. To speed up the reaction the student could add some sodium hydroxide solution. What problem would this cause in her experiment?

g. Suggest how this problem could be overcome?

Answers

1. What is a Nucleophile? What feature will all nucleophiles have in common?
   Nucleophiles are electron rich species, they have lone pairs of electrons which they donate to form covalent bonds to electron poor species (electrophiles). Nucleophiles have lone pairs of electrons.
2. Explain why the C-X bond is polar.
   Large differences in electronegativity between carbon atom and the halogen atom in the C-X bond means that the electrons in the covalent bond are unequally shared. This means that the carbon atoms will have a δ+ charge and the halogen atoms a δ- charge.

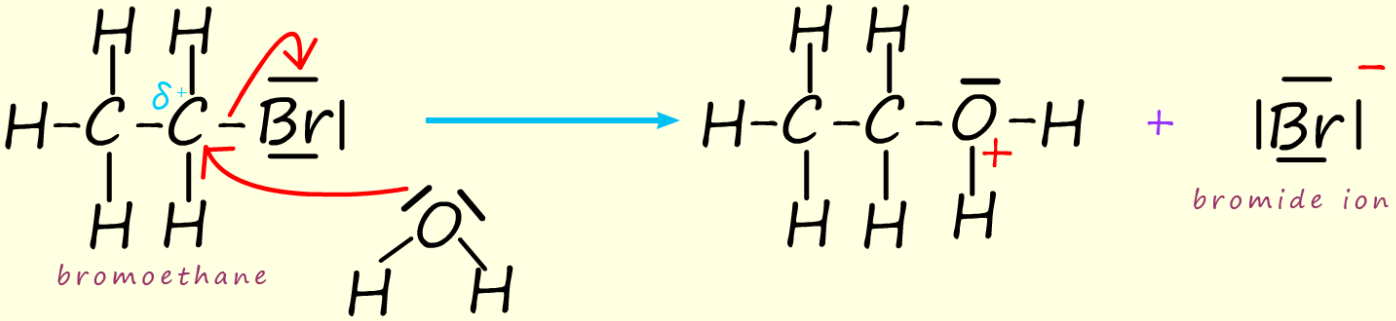
a. If a bond is described as polar what does this mean?
   See answer to question 2.

3. What is nucleophilic substitution?
   Where an electron rich nucleophile attacks a δ+ atom and replaces a functional group in the molecule. The nucleophile will replace or substitute for the leaving group.

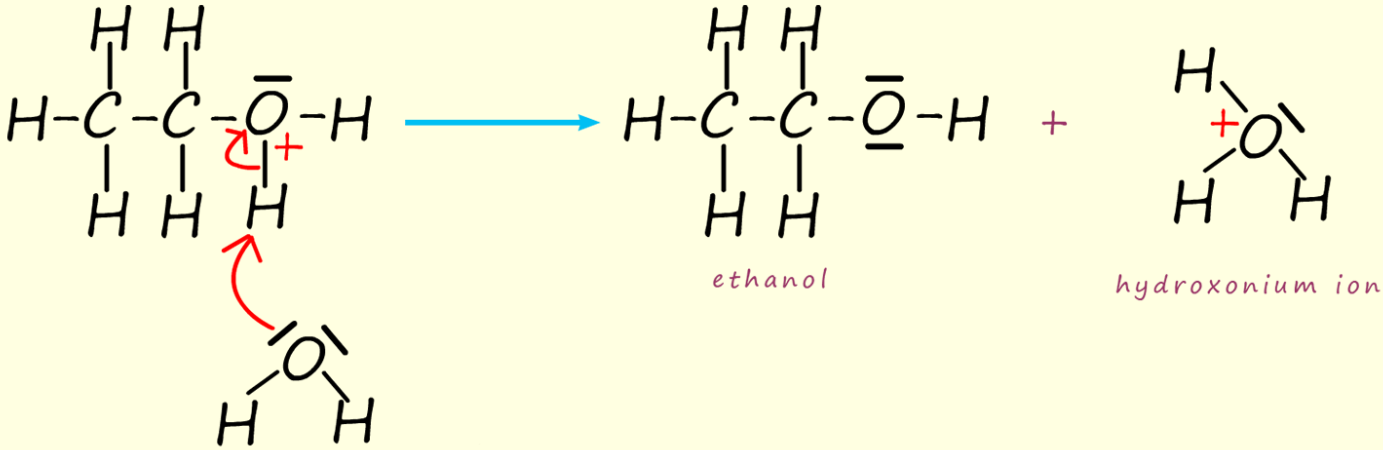
4. What is hydrolysis?
   Its using water to break chemical bonds. As well as water we often talk about acid hydrolysis, here we use H^+ ions from the acid to break the bonds, or in the case of alkaline hydrolysis we use hydroxide ions (OH^-) to break the bonds. H^+ and OH^- are both elements found in water.

5. Draw the mechanism to show the hydrolysis of bromoethane with water. There are two steps in this mechanism, draw them both and show clearly how the alcohol ethanol is formed.

step 1



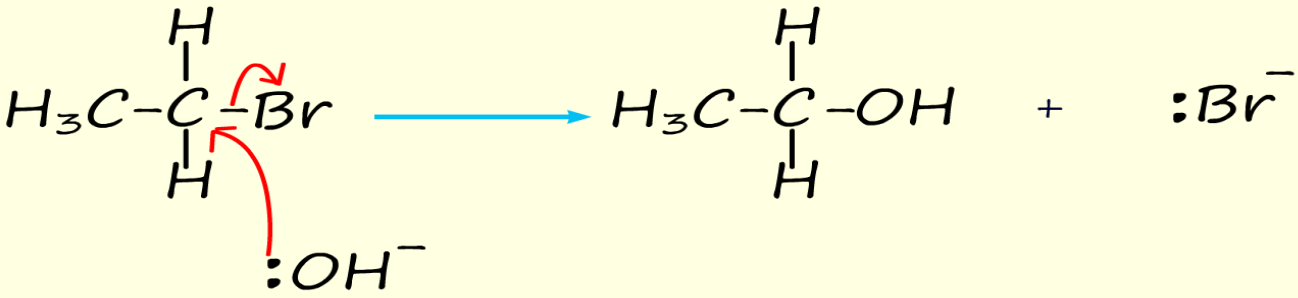
step 2



a. Explain why water is able to act as a nucleophile

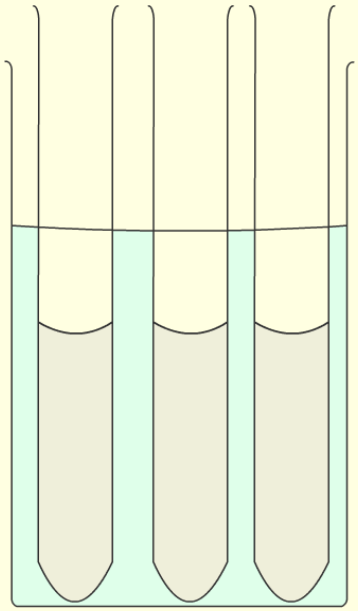
It contains lone pairs of electrons.

b. Now draw the mechanism to show how ethanol is made by reacting bromoethane with hydroxide ions.



bromoethane + sodium hydroxide ⟶ ethanol + sodium bromide

6. A student planned an investigation into factors affecting the rate of the hydrolysis of the halogenalkanes 1-chlorobutane, 1-bromobutane and 1-iodobutane. She set-up a water bath containing 3 test-tubes as shown opposite. She has a bottle of ethanol, silver nitrate solution, a kettle and a stop-clock.



a. What should be placed in each test-tube to measure the rate of this reaction?

5ml of ethanol, 0.5ml of halogenalkane and 5ml of silver nitrate solution. The water both should be warm around 50-60°C

b. Outline briefly how the student intends to measure the rate of this reaction.

The halogen ion from the halogenalkanes will leave as a halide ion and react with the silver ions to form a precipitate of either white silver chloride, cream silver bromide or yellow silver iodide. The student will time how long it takes for each precipitate to appear.

c. What should the student do to ensure she obtains valid results?

Ensure equal volumes and concentrations of all reactants are used, same temperature for each experiment if done separately.

d. Write an equation to show the how the precipitate using the 1-iodobutane is produced.

$Ag^{+}_{(aq)} + I^{-}_{(aq)} \longrightarrow AgI_{(s)}$

e. Which precipitate will be produced first? Give a reason for your answer.

The silver iodide first, then the silver bromide then eventually the silver chloride. Reaction depends on C-X bond strength, the C-I bond is the weakest; the C-Cl bond is the strongest.

f. To speed up the reaction the student could add some sodium hydroxide solution. What problem would this cause in her experiment?

The hydroxide ion will immediately react with the silver ions to form a white precipitate of silver hydroxide.

g. Suggest how this problem could be overcome?

Neutralise any excess sodium hydroxide before adding the silver nitrate solution.