Halogenoalkanes

Question Paper 2

Level	International A Level
Subject	Chemistry
Exam Board	CIE
Topic	Halogen Derivatives
Sub-Topic	Halogenoalkanes
Paper Type	Theory
Booklet	Question Paper 2

Time Allowed: **76 minutes**

Score: **/63**

Percentage: **/100**

Grade Boundaries:

A*	A	B	C	D	E	U
>85%	777.5%	70%	62.5%	57.5%	45%	<45%

1 Alkanes are generally considered to be unreactive compounds, showing an inertness to common reagents such as NaOH, H_2SO_4, and $K_2Cr_2O_7$.

(a) Suggest a reason why these reagents **do not** attack an alkane such as CH_4.

.....

[1]

(b) When a mixture of chlorine and ethane gas is exposed to strong sunlight, an explosion can occur due to the fast exothermic reaction.
Under more controlled conditions, however, the following reaction occurs.

$$C_2H_6 + Cl_2 \longrightarrow C_2H_5Cl + HCl$$

(i) What is the name of this type of reaction?

.....

(ii) Use equations to describe the mechanism of this reaction, naming the steps involved.

.....

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.....

.....

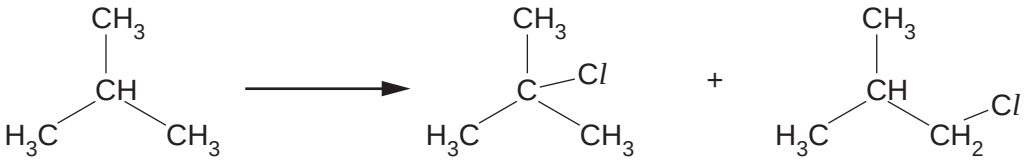
(iii) This reaction can produce organic by-products, in addition to C_2H_5Cl.
Draw the structural formulae of three possible organic by-products. Two of your by-products should contain 4 carbon atoms per molecule.
Briefly describe how each by-product could be formed.

structural formula of by-product	formed by

(iv) It is found by experiment that, during this type of reaction, primary, secondary and tertiary hydrogen atoms are replaced by chlorine atoms at different rates, as shown in the following table.

reaction	relative rate
$RCH_3 \rightarrow RCH_2Cl$	1
$R_2CH_2 \rightarrow R_2CHCl$	7
$R_3CH \rightarrow R_3CCl$	21

Using this information, and considering the number of hydrogen atoms of each type (primary, secondary or tertiary) within the molecule, predict the relative ratio of the two possible products **J** and **K** from the chlorination of 2-methylpropane. Explain your answer.



2-methylpropane **J** **K**

ratio **J**/**K** = ...

explanation:

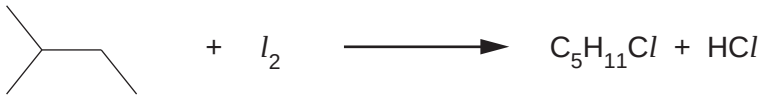
.....

.....

.....

[10]

(c) In the boxes below draw the **skeletal** formulae of **four** different structural isomers of $C_5H_{11}Cl$ that could be obtained from the chlorination of 2-methylbutane. Indicate any chiral centres in your structures by an asterisk (*).



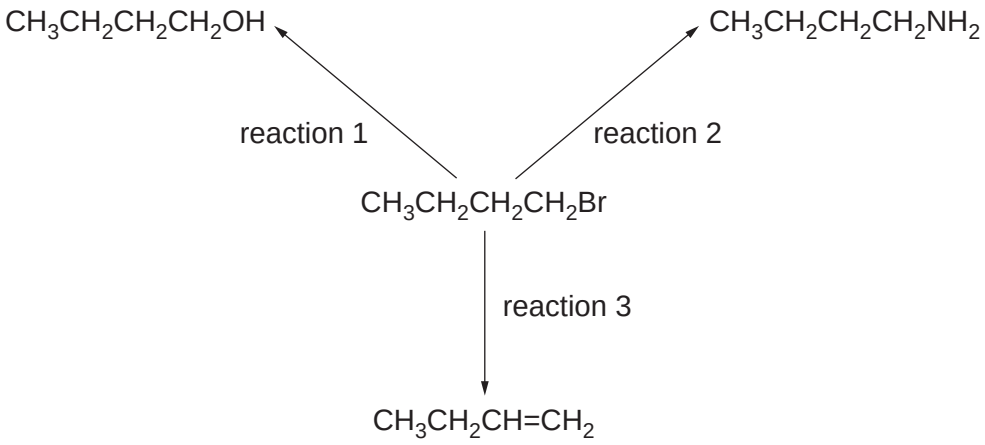
2-methylbutane

[5]

[Total: 16]

2 Halogenoalkanes have many chemical uses, particularly as intermediates in organic reactions.

Three reactions of 1-bromobutane, $CH_3CH_2CH_2CH_2Br$, are shown below.



(a) For **each** reaction, state the reagent and solvent used.

reaction 1 reagent .....

solvent .....

reaction 2 reagent .....

solvent .....

reaction 3 reagent .....

solvent ..... [6]

(b) When 1-iodobutane, $CH_3CH_2CH_2CH_2I$, is reacted under the same conditions as those used in reaction 1, butan-1-ol is formed.

What difference, if any, would there be in the rate of this reaction compared to the reaction of 1-bromobutane?

Use appropriate data from the *Data Booklet* to explain your answer.

.....

.....

.....

..... [3]

Dichlorodifluoromethane, CCl_2F_2, is an example of a chlorofluorocarbon (CFC) that was formerly used as an aerosol propellant. In September 2007, at the Montreal summit, approximately 200 countries agreed to phase out the use of CFCs by 2020.

(c) State two properties of CFCs that made them suitable as aerosol propellants.

1. .....

2. ..... [2]

(d) When CFCs are present in the upper atmosphere, homolytic fission takes place in the presence of ultraviolet light.

(i) What is meant by the term *homolytic fission*?

.....

.....

(ii) Suggest an equation for the homolytic fission of CCl_2F_2.

.....[2]

(e) The most common replacements for CFCs as aerosol propellants are hydrocarbons such as propane and butane.

Suggest **one** disadvantage of these compounds as aerosol propellants.

.....[1]

[Total: 14]

3 Although few halogenoalkanes exist naturally, such compounds are important as intermediates in organic reactions and as solvents.

The bromoalkane **B** has the following composition by mass: C, 29.3%; H, 5.7%; Br, 65.0%. The relative molecular mass of **B** is 123.

(a) Calculate the molecular formula of **B**.

[3]

Halogenoalkanes such as bromoethane, C_2H_5Br, have two different reactions with sodium hydroxide, NaOH, depending on the conditions used.

(b) (i) When hot aqueous NaOH is used, the C_2H_5Br is hydrolysed to ethanol, C_2H_5OH.

Describe the mechanism of this reaction. In your answer, show any relevant charges, dipoles, lone pairs of electrons and movement of electron pairs by curly arrows.

(ii) What will be formed when C_2H_5Br is reacted with NaOH under different conditions?

.....

(iii) What are the conditions used?

.....

(iv) What type of reaction is this?

..... [7]

When 1,4-dichlorobutane, $Cl CH_2CH_2CH_2CH_2Cl$, is reacted with NaOH, two different reactions can occur, depending on the conditions used.

(c) **(i)** Draw the **displayed** formula of the product formed when 1,4-dichlorobutane is reacted with hot aqueous NaOH as in **(b)(i)**.

(ii) Draw the **skeletal** formula of the product formed when 1,4-dichlorobutane is reacted with NaOH in the way you have described in **(b)(ii)** and **(b)(iii)**.

[2]

[Total: 12]

4 A student placed separate small samples of 1-chlorobutane, 1-bromobutane and, 1-iodobutane, in three separate test-tubes. To each test-tube, 1 cm^3 of ethanol was added, followed by 1 cm^3 of aqueous silver nitrate, $AgNO_3$. The tubes were then carefully shaken, placed in a test-tube rack and observed for 30 minutes.

A precipitate was formed in each test-tube but **not** at the same time; the fastest taking about two minutes to become opaque and the slowest about 20 minutes.

(a) What is the identity of the precipitate formed when 1-chlorobutane is used?

.....[1]

(b) What will be the colour of this precipitate?

.....[1]

(c) Which of the three halogenoalkanes will produce a precipitate in about two minutes?

.....[1]

(d) Use appropriate data from the *Data Booklet* to explain why this reaction takes place most quickly of the three.

.....

.....

.....[2]

[Total: 5]

5 One method of making 1-bromobutane in the laboratory is described below.

Stage 1	Place 35 g of powdered sodium bromide, 30 cm^3 of water, and 25 cm^3 (20 g) of butan-1-ol, in a 250 cm^3 two necked flask fitted with a tap funnel and reflux condenser.
Stage 2	Concentrated sulfuric acid (25 cm^3) is then placed in the tap funnel and added drop by drop to the reagents in the flask, keeping the contents well shaken and cooled occasionally in an ice-water bath.

(a) The overall reaction may be considered to take place in two stages. In the first stage the inorganic reagents react together to form HBr. In the second stage, the organic reagent reacts with the HBr that is formed in the first stage.

Write an equation for **each** of these stages.

stage I .....

stage II ..... [2]

(b) In this preparation, by using the amounts given above, **one** of the reagents, sodium bromide or butan-1-ol, will be present in an excess.

Use your equations in **(a)** and the data above to determine, by calculation, which reagent is in an excess.

[2]

(c) In a laboratory preparation of 1-bromobutane, when 15.4 g of butan-1-ol was used, 22.5 g of 1-bromobutane was obtained after purification.

Calculate the yield of 1-bromobutane as a percentage of the theoretical maximum yield.

[2]

(d) When the concentrated sulfuric acid is added to the reaction mixture (stage 2), unless the temperature is controlled carefully, the acid may react with either of the original reactants (sodium bromide or butan-1-ol) to give at least two by-products, one of which is inorganic and the other organic.

What inorganic and organic by-products may be formed?

In **each** case, identify **one** by-product and state the role of the concentrated sulfuric acid in the formation of this by-product.

inorganic by-product .....

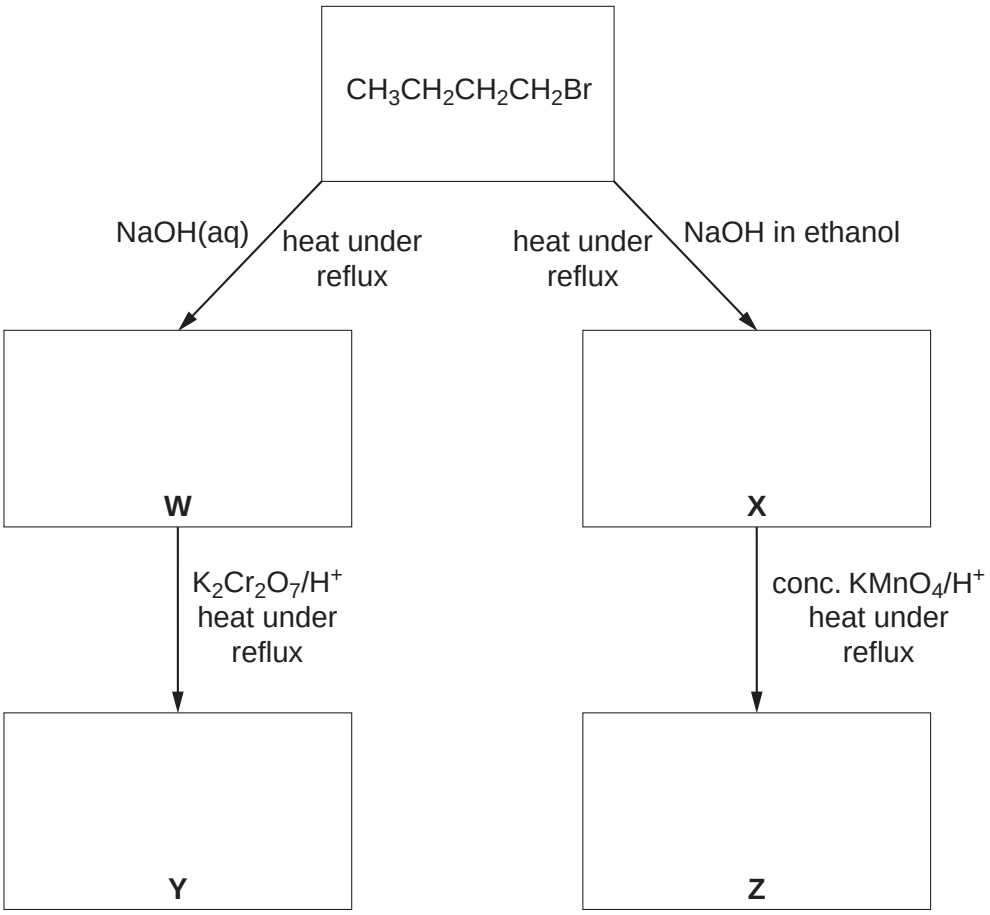
role of conc. H_2SO_4 .....

organic by-product .....

role of conc. H_2SO_4 ..... [4]

[Total: 10]

6 **(a)** Complete the following reaction scheme which starts with 1-bromobutane.
In **each empty** box, write the **structural formula** of the organic compound that would be formed.



[4]

(b) One of the compounds **W**, **X**, **Y** or **Z** can be polymerised.

(i) Identify this compound by its letter.

.....

(ii) Draw a section of the polymer chain formed by this compound.

Show **two** repeat units.

[2]

[Total: 6]