WJEC EDUQAS AS CHEMISTRY · COMPONENT 2

CHEMISTRY



EXAM QUESTION PACK

2.6 HALOGENOALKANES

SCORE	PERCENTAGE
/51	%

STEMUP

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1. (a) In March 2012 the UK Government proposed a minimum price of 40p per unit of alcohol in an effort to 'turn the tide' against binge drinking.

State **one** effect on the human body and **one** effect on society of the excessive use of alcoholic drinks.

[2]

Effect on the human body

Effect on society

(b) Butan-1-ol can be prepared by warming 1-chlorobutane with aqueous sodium hydroxide

(i) Classify the type of reaction occurring and give the mechanism for the reaction

[4]

Reaction type

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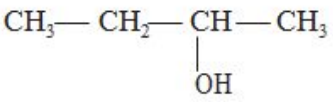
Mechanism

(ii) Use the infrared absorption frequencies given in the Data Sheet to explain how you would know if all the 1-chlorobutane has been converted into butan-1-ol.

[2]

(c) Butan-1-ol has the molecular formula $C_4H_{10}O$.

Two other isomers of $C_4H_{10}O$ are butan-2-ol and methylpropan-1-ol.



butan-2-ol

(i) Draw the **skeletal** formula of methylpropan-1-ol.

[1]

(ii) Name the type of isomerism shown by these isomers.

[1]

(iii) Butan-1-ol can be oxidised by acidified potassium dichromate(VI) to form butanoic acid. State what you would **observe** during this reaction.

[1]

(iv) Butan-1-ol can also be dehydrated. Name a suitable dehydrating agent and write an equation for this reaction.

[2]

Dehydrating agent

Equation

(d) 1-Chlorobutane is an example of a halogenoalkane. One group of halogenoalkanes (CFCs) has been shown to play a role in ozone depletion. Most of these ozone-depleting substances contain chlorine. Halogenoalkanes containing only fluorine do not harm the ozone layer.

Due to the Montreal Protocol of 1987, CFCs have been largely banned and have been replaced in many applications by HFCs, which contain fluorine as the only halogen.

(i) Explain why CFCs deplete the ozone layer, but HFCs do not.

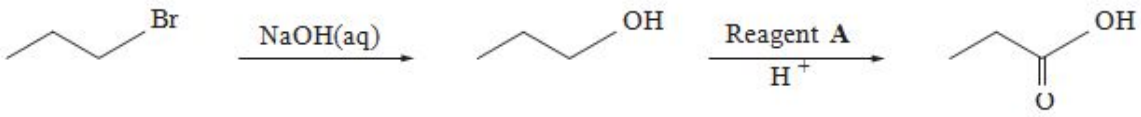
[2]

(ii) Suggest a reason why there is still concern about ozone depletion.

[1]

(Total 16)

2. *(a)* 1-bromopropane can be used to prepare propanoic acid in a two-stage process shown below.



(i) Classify the reaction occurring in the first stage of this process.

[1]

(ii) The first stage uses aqueous sodium hydroxide. Under alternative conditions, 1-bromopropane produces a different product when it reacts with sodium hydroxide.

Give the alternative conditions required, and the product that would be formed from 1-bromopropane under these conditions.

[2]

(iii) For the second stage, state the **full name** of reagent **A** and classify the reaction occurring.

[2]

(iv) Reagent **A** can also be used to produce propanal from propan-1-ol. State how you would isolate propanal from this reaction

[1]

(b) (i) 1-bromopropane can also be used to prepare butanoic acid in a different two-stage process. For **each** of these two stages, give reagents and conditions required, and draw the **displayed** formula (showing all bonds) of the intermediate.

[3]

(ii) Butanoic acid is used to prepare esters used in the flavouring and perfume industries. It may be prepared from 1-bromopropane in a two-stage process as in *(b)* (i) above or from butan-1-ol or butanal in a one-stage process.

Suggest **two** factors that a scientist would consider in choosing between these different routes to produce butanoic acid on a bulk scale.

[2]

(c) Compound **B** is an isomer of formula $C_4H_8O_2$ which exists as a sweet-smelling liquid at room temperature.

(i) Elemental analysis of compound **B** shows that it has a composition of 54.5 % carbon, 9.1 % hydrogen and 36.4 % oxygen, by mass. Show that this composition is consistent with the formula above. [2]

(ii) Compound **B** shows three resonances in its H^1 nuclear magnetic resonance spectrum.

- A triplet at 1.0 ppm with an area of 3
- A singlet at 2.1 ppm with an area of 3
- A quartet at 4.0 ppm with an area of 2

The infrared spectrum of compound **B** shows absorptions at 2981 cm^{-1} and 1750 cm^{-1}.

These are the only significant absorptions above 1500 cm^{-1}.

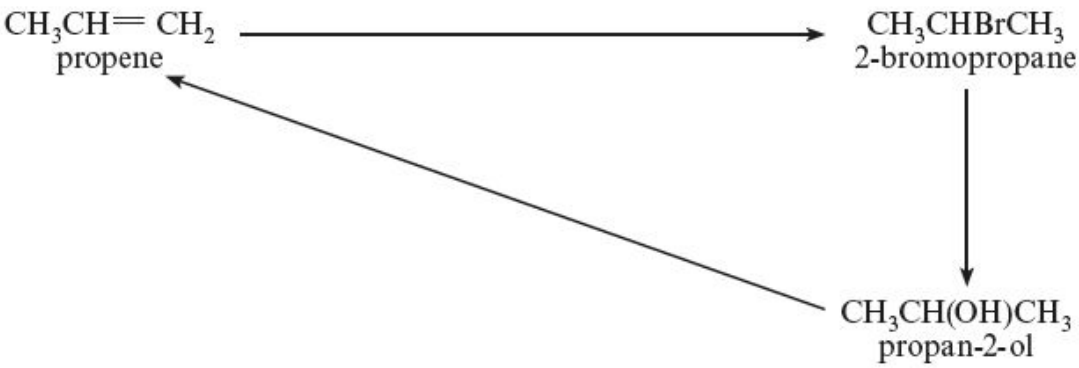
Using **all** the information supplied, deduce the structure of compound **B**.

Give **reasons** in support of your answer.

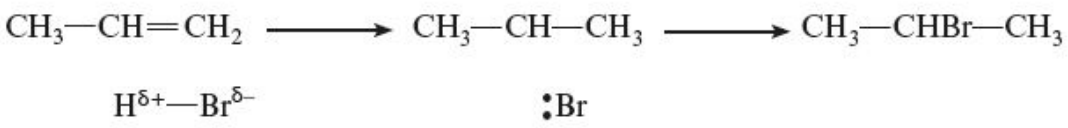
[5] QWC [2]

(Total 20)

3. *(a)* This question is about the compounds and reactions shown in the diagram below.



(i) The addition of hydrogen bromide to propene gives 2-bromopropane as the main product. Complete the outline mechansim below, inserting curly arrows and charges where appropriate. [2]



(ii) The reaction of 2-bromopropane to give propan-2-ol is an example of a nucleophilic substitution reaction. Suggest a nucleophile that can be used for this reaction and give a reason why this is classed as a substitution reaction. [2]

Nucleophile .....

Reason .....

.....

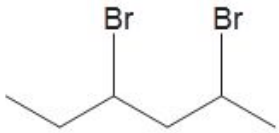
(iii) The production of propene from propan-2-ol is an example of an elimination reaction. Another elimination reaction is the reaction of bromoethane with sodium hydroxide.



Complete the equation by giving the formulae of the other products. [1]

(Total 5)

4. *(a)* State the **molecular** formula of compound **L** that has the skeletal formula shown.



.....

[1]

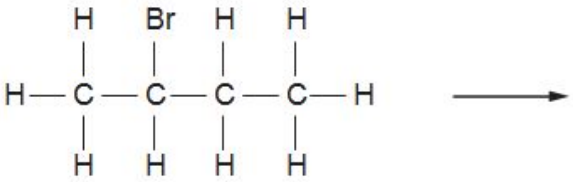
(b) Compound **L** reacts with alcoholic sodium hydroxide solution to give hex-1,3-diene as one of the products.

State the type of reaction that has occurred. [1]

(Total 2)

5. 2-Bromobutane, C_4H_9Br, is a halogenoalkane that behaves in a similar way to 1-chlorobutane.

(a) (i) Complete the diagram below to show the mechanism for the reaction between 2-bromobutane and aqueous sodium hydroxide. You should include relevant charges, dipoles, lone pairs and curly arrows to show the movement of electron pairs. [4]



(ii) What **type** of mechanism is shown in *(a)*(i)?

[1]

(iii) The reaction involves heterolytic bond fission.

What is meant by *heterolytic bond fission*?

[1]

(b) Bromoethane can be converted into ethene.

(i) Name the reagent and solvent needed to convert bromoethane into ethene.

[1]

(ii) What **type** of reaction occurs in *(b)*(i)?

[1]

(iii) 2-Bromobutane behaves in a similar way to bromoethane in this type of reaction. When 2-bromobutane is reacted as described in *(b)*(i) two alkenes that are **structural** isomers are formed

Draw the displayed formulae of these two alkenes

[2]

(Total 10)

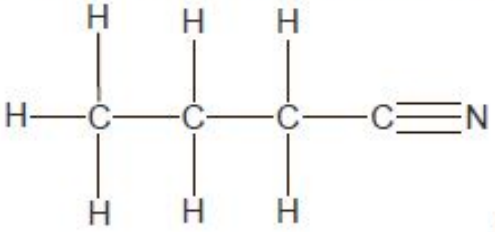
2 (a) (i) Nucleophilic substitution / Hydrolysis [1]

(ii) Dissolved in alcohol (1) Propene or unambiguous structure (1) [2]

(iii) Potassium manganate(VII) / Potassium dichromate(VI) - must be name (1)
Oxidation (1) [2]

(iv) (Add Potassium dichromate(VI)) and distil off the propanal from the reaction mixture [1]

(b) (i) Step 1: Potassium cyanide in ethanol / Heat (1)
Step 2: Heat with aqueous hydrochloric acid (or other acid) (1)



(1) [3]

(ii) Two points from different bullet points – 1 mark each.

- Atom economy / Amount of waste / Whether waste material was recyclable / Whether waste was toxic.
- Amount of energy required / temperature required / pressure required / conditions used
- Rate of production / time
- Availability of catalyst
- Cost of reactants / Availability of reactants / toxicity of reactants.
- Two step processes usually have lower yields than one step processes / percentage yield [2]
- Purification method / separation

(c) (i) Butanoic acid is $C_4H_8O_2$ so $M_r = 88$ (1)
Percentage carbon = 48/88 x 100 = 54.5%; percentage hydrogen = 8/88 = 9.1%;
Percentage oxygen = 32/88 = 36.4% (At least two of these for 1)
OR empirical formula for butanoic acid = C_2H_4O (1) and
calculate empirical formula from percentage masses = C_2H_4O (1) [2]

(ii) Structure 1 mark + 4 marks for explanations.

- Product is ethyl ethanoate. (1)
- Two points from the following required for each mark– MAX 4 marks
  - Sweet-smelling = ester
  - Peak at 1.0ppm implies – CH_3
  - Peak area 3 = CH_3
  - Peak area 2 = CH_2
  - Triplet shows CH_3 is next to a CH_2 group.
  - Singlet shows CH_3 no hydrogen atoms bonded to adjacent carbon.
  - Peak at 2.1 ppm suggests this is next to C=O.
  - Quartet shows CH_2 is adjacent to a CH_3 group.
  - Peak at 4.0 ppm shows it is –O-CH_2-
  - IR Peak at 1752 cm^{-1} = C=O
  - IR Peak at 2981 cm^{-1} = C-H or O-H
  - Cannot be –OH as we know there is no –OH in NMR spectrum

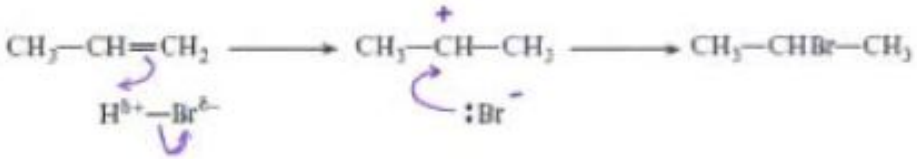
[5]

QWC: selection of a form and style of writing appropriate to purpose and to complexity of subject matter. (1)

QWC: organisation of information clearly and coherently; use of specialist vocabulary where appropriate. (1) [2]

[20 marks]

3 (a) (i)



curly arrows (1)
charges (1) [2]

(ii) Nucleophile hydroxide ion / OH^- / water (1)

Substitution the replacement of one functional group by another (1) [2]

(iii)

$$CH_3CH_2Br + NaOH \rightarrow CH_2\ CH_2 + \mathbf{NaBr} + H_2O$$

(accept $\mathbf{Na^+}$ and $\mathbf{Br^-}$ in place of NaBr) [1]

4 (a) $C_6H_{12}Br_2$ [1]

(b) Elimination [1]

5 (a) (i) $\delta-$ on Br and $\delta+$ on C attached (1)

Arrow from lone pair on OH^- to $\delta+$ on C (1)

Arrow from C-Br bond to Br (1)

Correct alcohol + Br^- (1) [4]

(ii) Nucleophilic substitution [1]

(iii) The bond breaks and both the electrons go to one of the bonded atoms/ the bond breaks and ions are formed. [1]

(b) (i) Sodium hydroxide in ethanol/ alcohol [1]

(ii) Elimination/ dehydrohalogenation [1]

(iii) Structural formulae for but-1-ene (1)

and but-2-ene (1) [2]