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Centre number

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Candidate number

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Surname *StemUp Model Solution*

Forename(s)

Candidate signature

I declare this is my own work.

INTERNATIONAL AS CHEMISTRY (9620)

Unit 2: Organic 1 and Physical 1

Tuesday 12 January 2021 07:00 GMT Time allowed: 1 hour 30 minutes

Materials

For this paper you must have:

- the Periodic Table/Data Sheet, provided as an insert
- a ruler with millimetre measurements
- a scientific calculator, which you are expected to use where appropriate.

Instructions

- Use black ink or black ball-point pen.
- Fill in the boxes at the top of this page.
- Answer **all** questions.
- You must answer the questions in the spaces provided. Do **not** write outside the box around each page or on blank pages.
- If you need extra space for your answer(s), use the lined pages at the end of this book. Write the question number against your answer(s).
- All working must be shown.
- Do all rough work in this book. Cross through any work you do not want to be marked.

Information

- The marks for questions are shown in brackets.
- The maximum mark for this paper is 70.

For Examiner's Use	
Question	Mark
1	
2	
3	
4	
5	
6	
7	
8	
TOTAL	



Answer **all** questions in the spaces provided.

0 1

This question is about halogenoalkanes.

0 1 . 1

A halogenoalkane can be formed from an alkane in a free-radical substitution reaction.

Describe how a covalent bond breaks to form two free-radicals.

Name this step in the mechanism.

[2 marks]

How a covalent bond breaks Homolytic fission; the bond breaks so that one electron from the shared pair goes to each atom.

Name of step Initiation

0 1 . 2

One molecule of a chloroalkane contains seven carbon atoms and one chlorine atom.

Deduce the relative molecular mass of the chloroalkane.

[2 marks]

C₇H₁₅Cl, so there are 15 H atoms

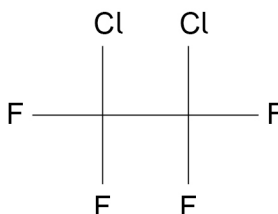
$$M_r = (7 \times 12.0) + (15 \times 1.0) + 35.5$$

$$M_r = 84.0 + 15.0 + 35.5 = 134.5$$

Relative molecular mass 134.5

0 1 . 3

The skeletal formula of a halogenoalkane is shown.



Use IUPAC rules to name this halogenoalkane.

[1 mark]

1,2-dichloro-1,1,2,2-tetrafluoroethane



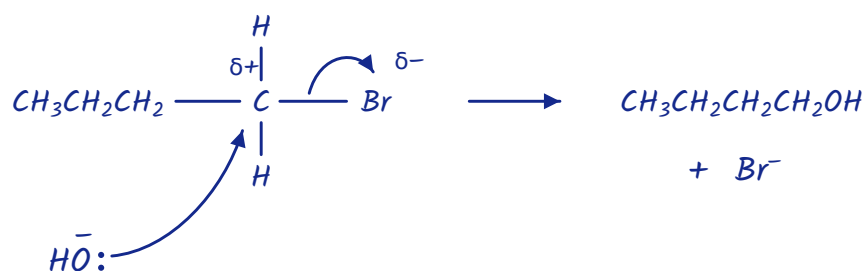
0 1 . 4

1-Bromobutane reacts with a solution of sodium hydroxide to form an alcohol.

Outline the mechanism for this reaction.

[2 marks]

Mechanism



0 1 . 5

1-Bromobutane can also react with sodium hydroxide to form an alkene.

State the role of sodium hydroxide in this reaction.

Give the condition that would produce the maximum yield of alkene.

[2 marks]

Role Base (proton acceptor)Condition NaOH dissolved in ethanol (ethanolic), heated

9

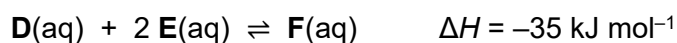
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0 2

This question is about the equilibrium



0 2. 1

State **two** features of a reaction at equilibrium.**[2 marks]**

1 The rate of the forward reaction is equal to the rate of the reverse reaction.

2 The concentrations of the reactants and products remain constant.

0 2. 2

A student adds 0.30 mol of **D** to a solution containing 0.40 mol of **E** and shakes the mixture.

At equilibrium, the mixture contains 0.15 mol of **F**.

Deduce the amount, in mol, of **D** and **E** in the equilibrium mixture.

[2 marks]

F formed = 0.15 mol, so D reacted = 0.15 mol

E reacted = 2 × 0.15 = 0.30 mol

D left = 0.30 – 0.15 = 0.15 mol

E left = 0.40 – 0.30 = 0.10 mol

D 0.15 mol

E 0.10 mol



0 2 . 3

A different mixture of **D** and **E** is allowed to reach equilibrium.

At equilibrium, the concentration of **D** = 0.80 mol dm^{-3} and
the concentration of **F** = 0.40 mol dm^{-3}

The equilibrium constant, $K_c = 4.2 \text{ mol}^{-2} \text{ dm}^6$

Give the expression for the equilibrium constant (K_c) for this reaction.

Calculate the equilibrium concentration, in mol dm^{-3} , of **E**.

[3 marks]

$$K_c = \frac{[F]}{[D][E]^2}$$

Calculation

$$[E]^2 = [F] \div (K_c \times [D])$$

$$[E]^2 = 0.40 \div (4.2 \times 0.80) = 0.119$$

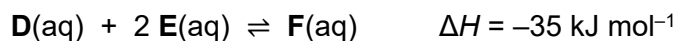
$$[E] = \sqrt{0.119} = 0.345 \text{ mol dm}^{-3}$$

Concentration of **E** 0.345 mol dm^{-3}

Turn over ►



The equation and information about this equilibrium is repeated here



Another equilibrium mixture is established.

0 2 . 4 Some more **E** is added to this equilibrium mixture.

State how the value of K_c would change, if at all.

Place a tick (✓) in the correct box.

[1 mark]

K_c increases	
K_c stays the same	✓
K_c decreases	

D and **E** are white solids that dissolve readily in water to give colourless solutions. An aqueous solution of **F** is blue.

0 2 . 5 Some solid **D** is added to this equilibrium mixture.

State how the colour of this equilibrium mixture would change, if at all.

Place a tick (✓) in the correct box.

[1 mark]

Colour becomes more blue	✓
No change in colour	
Colour becomes less blue	

0 2 . 6 The equilibrium mixture is warmed.

Explain why the colour becomes less blue.

[3 marks]

The forward reaction is exothermic (ΔH is negative), so the reverse reaction is endothermic.

When the mixture is warmed, the position of equilibrium shifts to the left, in the endothermic direction, to oppose the increase in temperature (to lower the temperature).

So less blue F is present.

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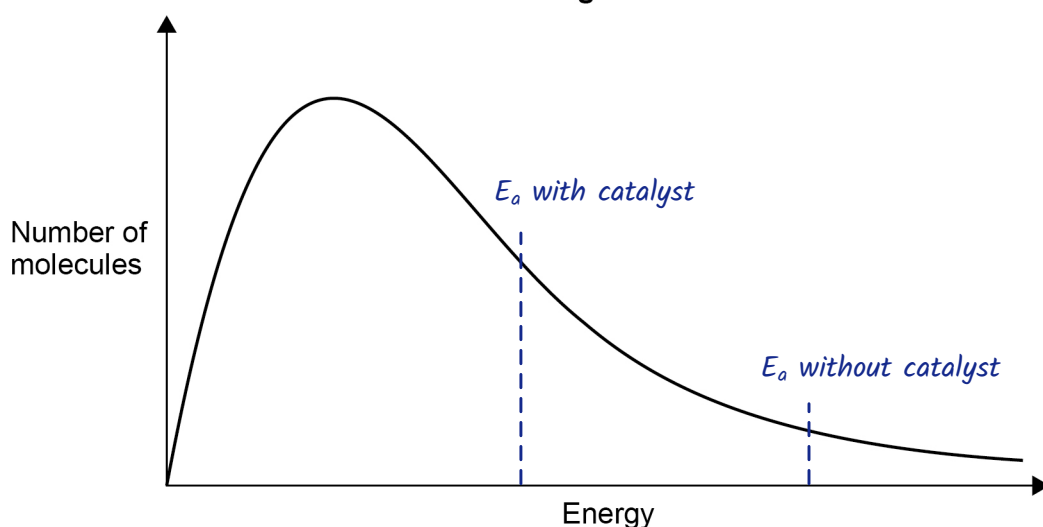


0 3

This question is about rate of reaction.

0 3

1

Figure 1 shows the Maxwell-Boltzmann distribution of molecular energies in a gas.Add labels to **Figure 1** to show the activation energy with a catalyst, and without a catalyst, for a reaction involving this gas.Use **Figure 1** to explain how adding a catalyst increases the rate of this reaction.**[4 marks]****Figure 1**

Explanation The catalyst provides an alternative reaction route with a lower activation energy.

So a greater proportion of the molecules (the area under the curve to the right of E_a) have energy greater than or equal to the activation energy.

This increases the frequency of successful collisions (more successful collisions in a given time), so the rate increases.



0 3 . 2

The amount of catalyst remains constant throughout this reaction but the rate of reaction decreases.

Explain, using collision theory, why the rate of reaction decreases.

[2 marks]

The reactants are used up, so there are fewer reactant particles available to collide (with the catalyst).

So the frequency of collisions decreases, giving fewer successful collisions in a given time.

0 3 . 3

Explain why a small increase in temperature has a bigger effect on the rate of a reaction than a small increase in the concentration of a reactant.

Use collision theory and the Maxwell–Boltzmann distribution of molecular energies in a gas in your answer.

[2 marks]

A small rise in temperature shifts the Maxwell–Boltzmann curve to the right, giving a very large increase in the number of molecules with $E \geq E_a$, so many more successful collisions.

A small rise in concentration has only a very small effect on the number of particles with $E \geq E_a$ (it just gives slightly more collisions).

8

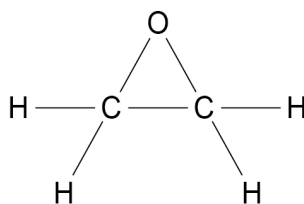
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0 4

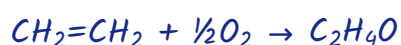
The structure of epoxyethane is shown.



0 4 . 1

Write an equation to show the formation of epoxyethane from ethene.

[1 mark]



0 4 . 2

State the C–O–C bond angle in epoxyethane.

Explain why epoxyethane is very reactive.

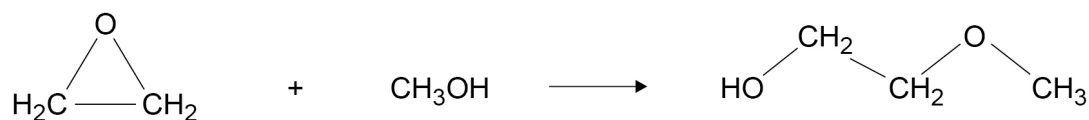
[2 marks]

Bond angle 60°

Explanation The three-membered ring is very strained; the bond angles are much smaller than normal (109.5°), so there is considerable repulsion between the bonding pairs and the C–O bonds break easily.



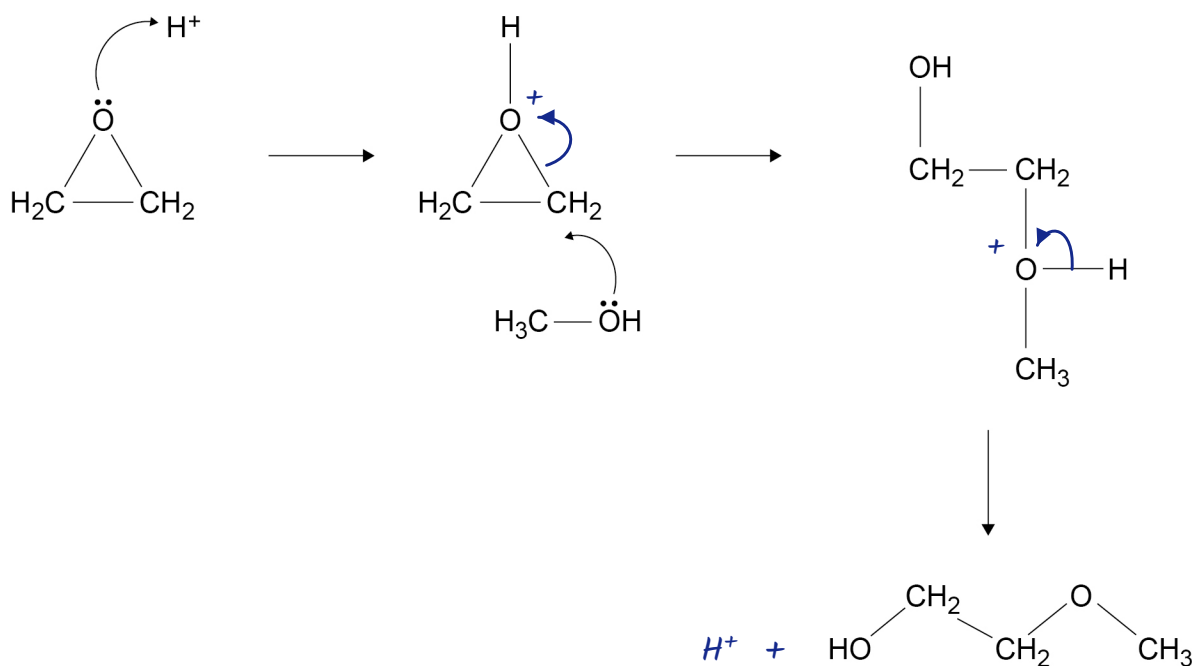
0 4 . 3 In acidic conditions, epoxyethane reacts with methanol.



An incomplete mechanism for this reaction is shown.

Complete the mechanism by adding appropriate curly arrows and charges.

[2 marks]



0 4 . 4 Give **one** use of the product formed in Question **04.3**.

[1 mark]

As a solvent (or a surfactant / antifreeze)

6

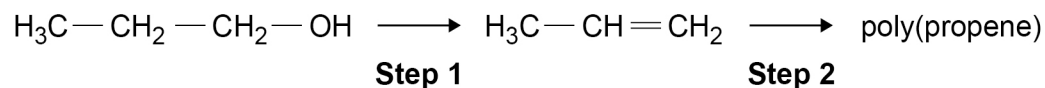
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0 5

This question is about addition polymers.

The addition polymer poly(propene) can be formed from propan-1-ol as shown



0 5 . 1

Name the mechanism in **Step 1**.

Give a reagent for **Step 1**.

[2 marks]

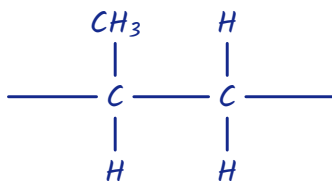
Name of mechanism Elimination

Reagent Concentrated sulfuric acid, conc. H_2SO_4

0 5 . 2

Draw the repeating unit of poly(propene).

[1 mark]



0 5 . 3

State **one** physical property and **one** chemical property of the polymer, poly(propene), that differs from the properties of the monomer, propene.

[2 marks]

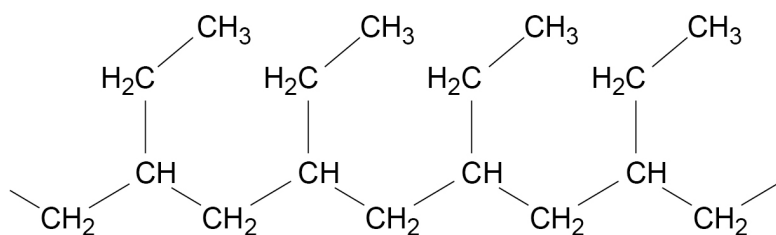
Physical property of polymer Poly(propene) has a much higher melting point: it is a solid at room temperature, while propene is a gas.

Chemical property of polymer Poly(propene) is unreactive (inert) because it is saturated, with no $\text{C}=\text{C}$ double bond.



0 5 . 4

A section of a different addition polymer is shown.



Draw the skeletal formula of the monomer.

[1 mark]



0 5 . 5

Poly(chloroethene), PVC, is an important addition polymer that has many uses.

Name the type of substance added to PVC to make it more flexible.

Explain how this type of substance makes PVC more flexible.

[2 marks]

Type of substance A plasticiser

Explanation Its molecules get between the polymer chains and force them apart, weakening the intermolecular forces between the chains.

8

Turn over ►



0 6

This question is about an experiment to prepare propanal by the oxidation of propan-1-ol.

0 6 . 1

Identify an oxidising agent for this reaction.

[1 mark]

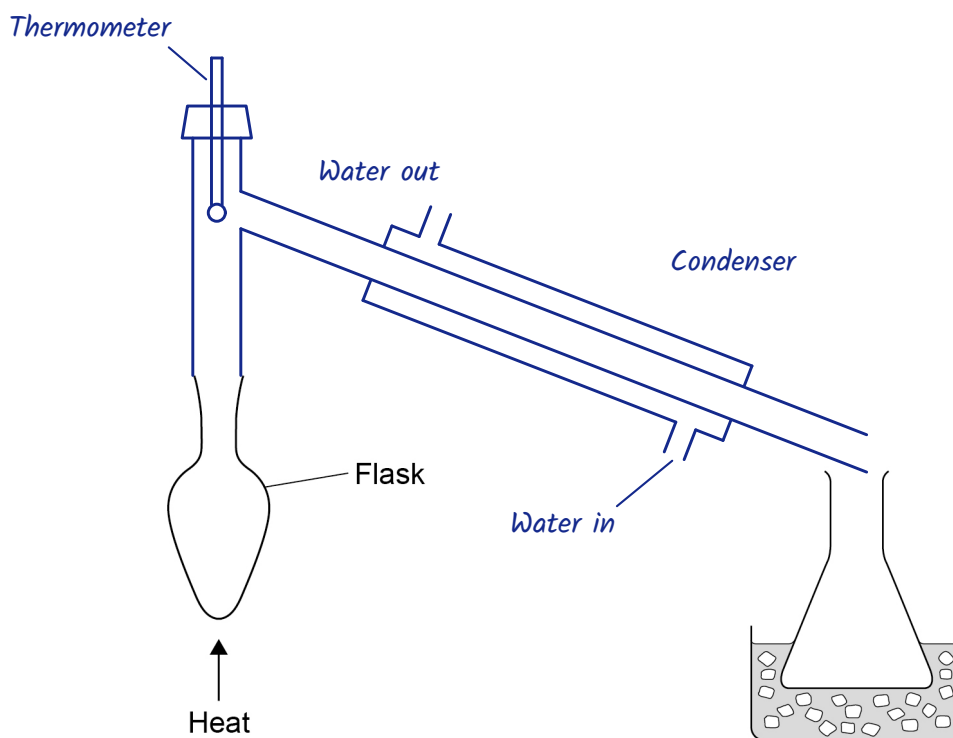
Acidified potassium dichromate(VI), $K_2Cr_2O_7$ with H_2SO_4

0 6 . 2

The propanal is prepared in a flask and collected by distillation.

Complete the diagram to show the apparatus needed to collect propanal by distillation. Label your diagram.

[2 marks]



0 6 . 3

Suggest why the conical flask used to collect the propanal is placed in an ice bath.

[1 mark]

Propanal is volatile (low boiling point), so the ice bath keeps it cool to reduce its evaporation and make sure all the vapour condenses.



06.4

A student oxidises 5.00 cm³ of propan-1-ol and collects 2.68 g of propanal.

Calculate the student's percentage yield.

Give your answer to 3 significant figures.

For propan-1-ol, density = 0.803 g cm⁻³; M_r = 60.0

For propanal, M_r = 58.0

[3 marks]

$$\text{mass of propan-1-ol} = 5.00 \times 0.803 = 4.015 \text{ g}$$

$$n(\text{propan-1-ol}) = 4.015 \div 60.0 = 0.0669 \text{ mol}$$

$$\text{max mass of propanal} = 0.0669 \times 58.0 = 3.88 \text{ g}$$

$$\% \text{ yield} = (2.68 \div 3.88) \times 100 = 69.1 \%$$

Percentage yield 69.1 %

06.5

Propanoic acid can also be formed by the oxidation of propan-1-ol.

Describe how you could use infrared spectroscopy to show that the propanal collected is not contaminated by any propanoic acid.

[1 mark]

Record the IR spectrum of the product: there should be no broad O-H

(carboxylic acid) absorption in the range 2500 to 3000 cm⁻¹.

06.6

State how the apparatus you have drawn in Question 06.2 should be changed so that propanoic acid is formed instead of propanal.

Explain your answer.

[2 marks]

Heat under reflux instead: put the condenser vertically on top of the
flask.

The propanal vapour condenses and returns to the flask, so it stays with
the oxidising agent and is completely oxidised to propanoic acid.

10

Turn over ►



0 7

This question is about alkenes.

0 7 . 1

Write an equation for the complete combustion of the alkene C_6H_{12} Calculate the mass of carbon dioxide formed when 5.6 g of C_6H_{12} combusts completely.

Show your working.

[3 marks]

Equation



Calculation

$$M_r \text{ of } C_6H_{12} = 84.0, \text{ so } n = 5.6 \div 84.0 = 0.0667 \text{ mol}$$

$$n(CO_2) = 6 \times 0.0667 = 0.400 \text{ mol}$$

$$\text{mass of } CO_2 = 0.400 \times 44.0 = 17.6 \text{ g}$$

Mass of carbon dioxide 17.6 gOctane (C_8H_{18}) can be cracked.

0 7 . 2

In a cracking reaction, one molecule of octane is cracked to form one molecule of propene and one molecule of an alkane.

Write an equation for this reaction.

Give **one** condition needed for this reaction.**[2 marks]**

Equation

Condition High temperature, about 1000 K (and high pressure)

0 7 . 3

Identify a reagent that could be used in a simple test-tube reaction to show that octane had been cracked.

State what is observed.

[2 marks]

Reagent Bromine water, $Br_2(aq)$

Observation Orange to colourless (decolourises)

0 7 . 4

The first step in the reaction of propene with hydrogen bromide allows two possible carbocation intermediates to form.

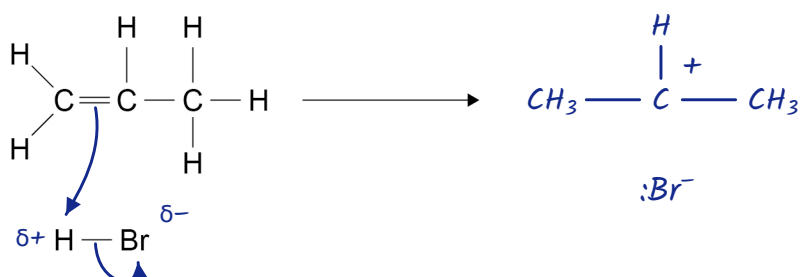
Complete the diagrams, adding appropriate curly arrows and charges, to show how each of these carbocations form.

State whether the more stable carbocation is primary, secondary or tertiary.

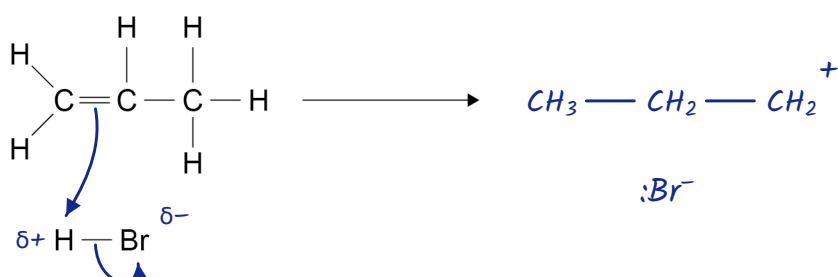
Name the major product formed in this reaction.

[4 marks]

carbocation 1



carbocation 2



More stable carbocation Secondary

Name of major product 2-bromopropane

11

Turn over ►



0 8

This question is about butanal and butanone.

0 8 . 1

Identify the type of structural isomerism shown by butanal and butanone.

[1 mark]

Functional group isomerism

0 8 . 2

Identify a reagent that can be used in a simple test-tube reaction to distinguish between butanal and butanone.

State what is observed in each case.

[3 marks]

Reagent *Tollens' reagent (ammoniacal silver nitrate)*Observation with butanal *A silver mirror (silver precipitate) forms.*Observation with butanone *No visible change; the solution stays colourless.***G** is a non-cyclic structural isomer of butanal that does not have an absorption at 1680–1750 cm⁻¹ in its infrared spectrum.

0 8 . 3

Calculate the m/z value for the molecular ion peak of **G** in its mass spectrum.

[1 mark]

G is C₄H₈O (same molecular formula as butanal)

$$M_r = (4 \times 12.0) + (8 \times 1.0) + 16.0 = 72.0$$

 m/z *72*

0 8 . 4

Give the wavenumber of one absorption that would be present in the infrared spectrum of **G** but **not** in that of butanal.Do **not** include absorptions in the fingerprint region.

[1 mark]

*1650 (C=C stretch)*cm⁻¹

6

END OF QUESTIONS



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2 4



2 1 1 X C H O 2