



Surname _____

Forename(s) _____

Centre Number _____

Candidate Number _____

Candidate Signature _____

I declare this is my own work.

AS

CHEMISTRY

Paper 2 Organic and Physical Chemistry

7404/2

Tuesday 21 May 2024

Morning

Time allowed: 1 hour 30 minutes

At the top of the page, write your surname and forename(s), your centre number, your candidate number and add your signature.

[Turn over]



JUN 24 7404 201

MATERIALS

For this paper you must have:

- **the Periodic Table/Data Sheet, provided as an insert (enclosed)**
- **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.**
- **Answer ALL questions.**
- **You must answer the questions in the spaces provided. Do not write 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

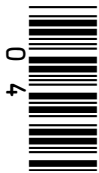
- The marks for questions are shown in brackets.
- The maximum mark for this paper is 80.

ADVICE

You are advised to spend about 65 minutes on SECTION A and 25 minutes on SECTION B.

DO NOT TURN OVER UNTIL TOLD TO DO SO





SECTION A

Answer ALL questions in this section.

0 1

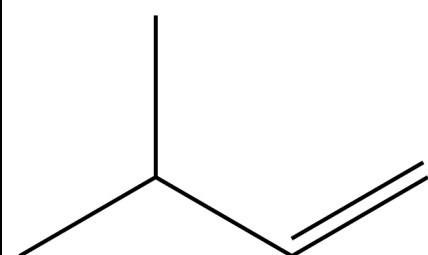
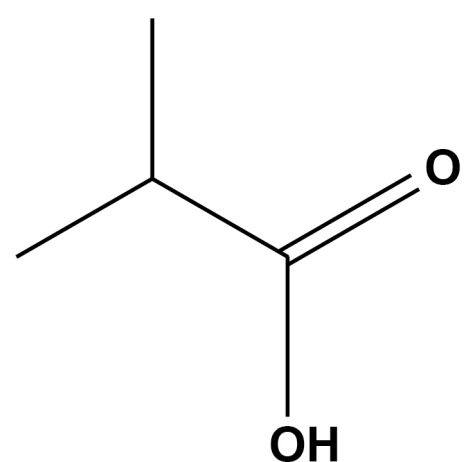
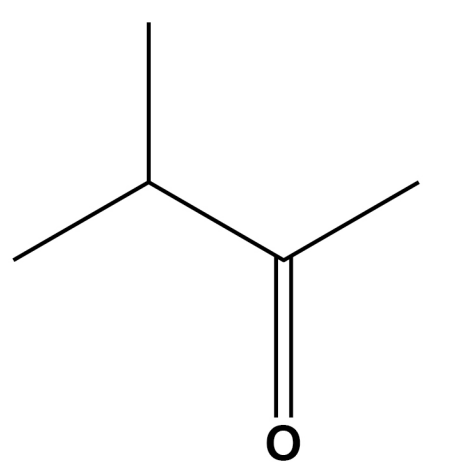
This question is about the analysis of organic compounds.

0 1 . 1

TABLE 1, on the opposite page, shows the results of chemical tests on three organic compounds.

Complete the empty boxes in the table. [3 marks]

**TABLE 1**

Chemical test			
Add bromine water	orange to colourless		no visible change
	no visible change	bubbles of gas	no visible change
Warm with Fehling's solution	no visible change	no visible change	

[Turn over]

0	1	.	2
---	---	---	---

0.500 g of a hydrocarbon is analysed.
The hydrocarbon contains 0.450 g of carbon.

Calculate the empirical formula of this hydrocarbon.
[3 marks]

Empirical formula _____



BLANK PAGE

[Turn over]



0	2
---	---

This question is about infrared spectroscopy.

0	2	.	1
---	---	---	---

Compounds A and B both have the molecular formula $C_4H_8O_2$

FIGURE 1, on the opposite page, shows the infrared spectra of compounds A and B.

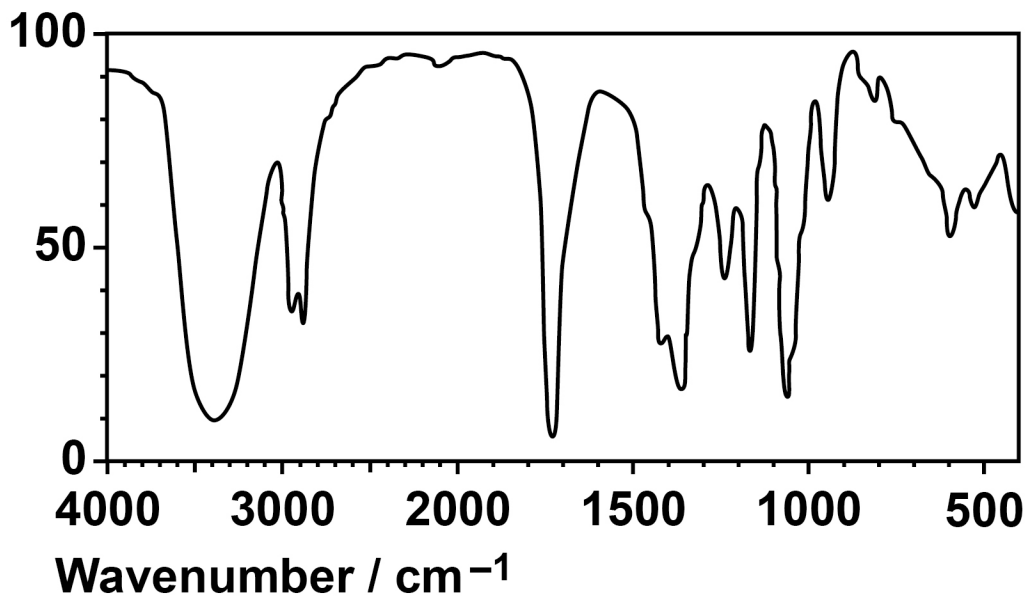
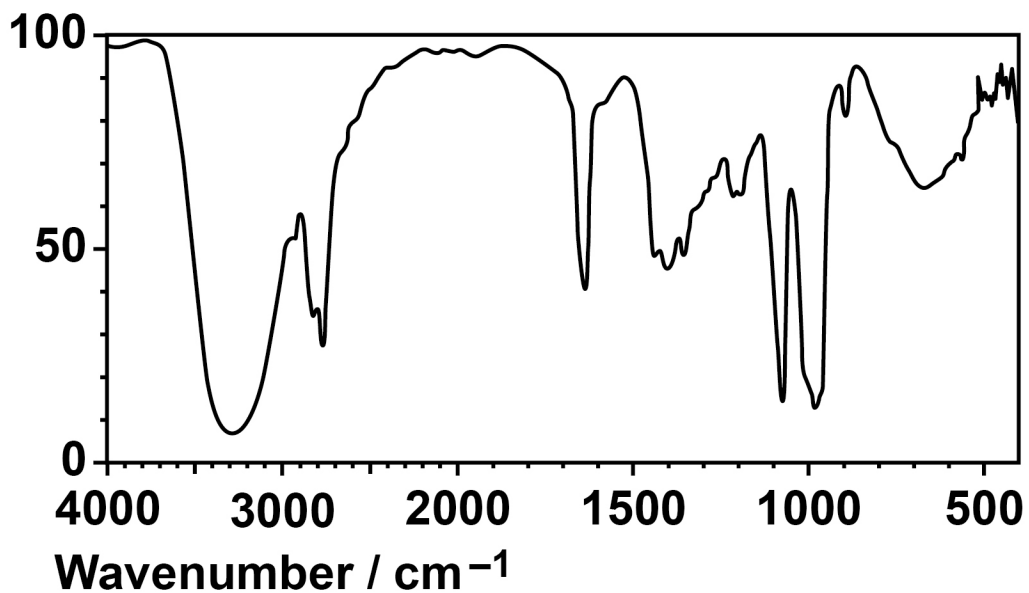
Use the infrared spectra to deduce a possible structural formula for compound A and a possible structural formula for compound B. [2 marks]

Possible structural formula of A

Possible structural formula of B



FIGURE 1

Percentage
transmittancePercentage
transmittance

[Turn over]

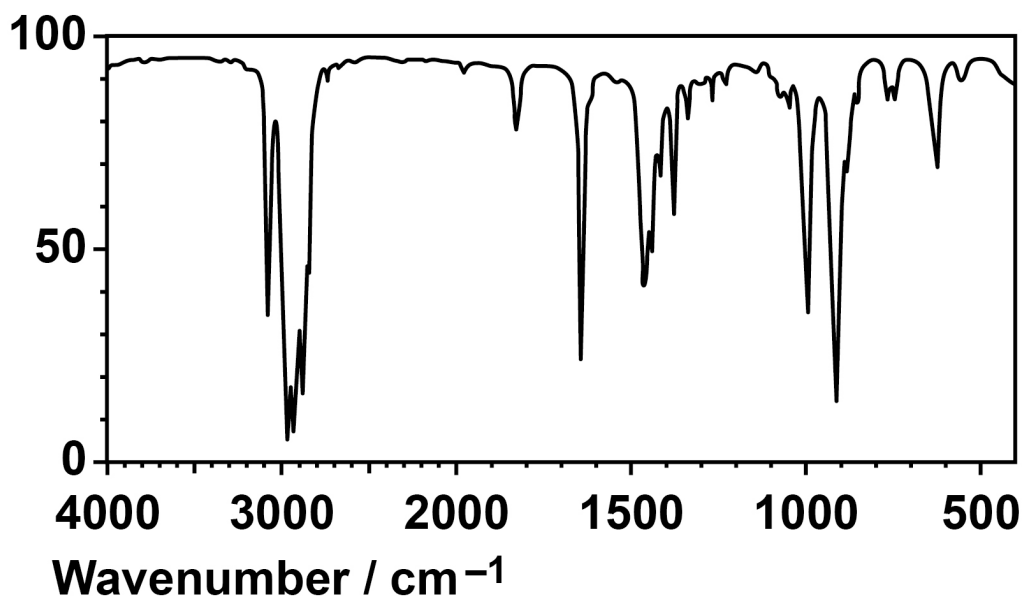


02.2

FIGURE 2 shows the infrared spectrum of either pent-1-ene or 2-methylbut-2-ene.

FIGURE 2

Percentage
transmittance



Outline how to use the infrared spectrum to determine whether the compound is pent-1-ene or 2-methylbut-2-ene. [2 marks]

[Turn over]

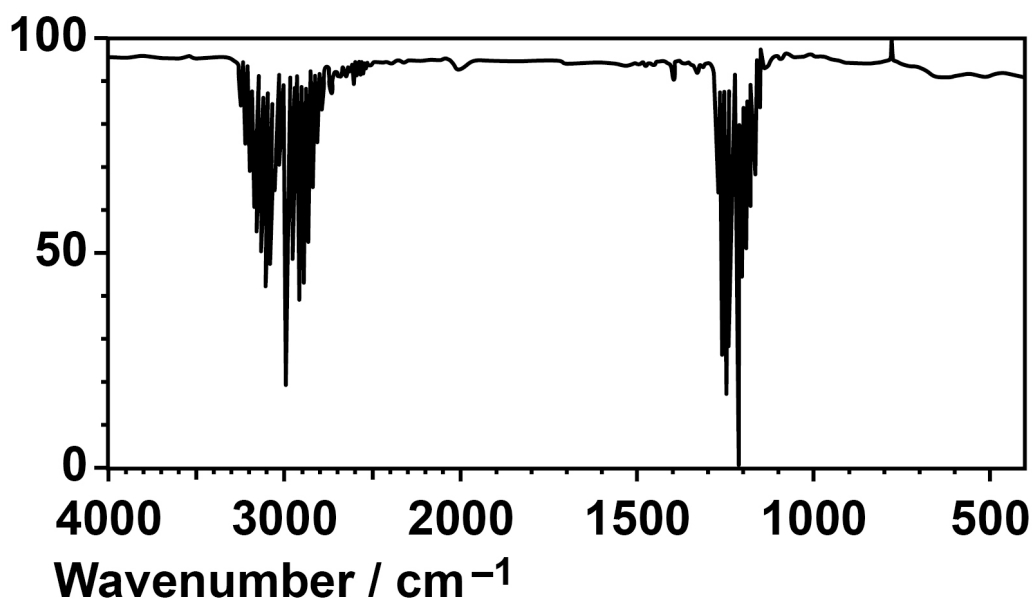


02.3

FIGURE 3 shows the infrared spectrum of methane.

FIGURE 3

Percentage
transmittance



Use information from FIGURE 3 to explain why methane acts as a greenhouse gas. [1 mark]

[Turn over]

5



0	3
---	---

This question is about CFCl_3

CFCl_3 used to be the propellant in most aerosol cans.

0	3	.	1
---	---	---	---

Use IUPAC rules to name CFCl_3 [1 mark]

0	3	.	2
---	---	---	---

Give an equation for each of the two propagation steps in the conversion of CHFCl_2 into CFCl_3 [2 marks]

Equation 1

Equation 2



0	3	.	3
---	---	---	---

In the presence of ultraviolet radiation, CFCl_3 breaks down in the upper atmosphere to form chlorine free radicals.

Give an equation for this reaction. [1 mark]

0	3	.	4
---	---	---	---

Chlorine free radicals catalyse the decomposition of ozone.

Give TWO equations to show how chlorine free radicals decompose ozone. [2 marks]

Equation 1

Equation 2

[Turn over]



0	3	.	5
---	---	---	---

The production and use of CFCs have been banned in many countries because they decrease the amount of ozone in the upper atmosphere.

State why ozone in the upper atmosphere is important for life on Earth. [1 mark]

—
7



BLANK PAGE

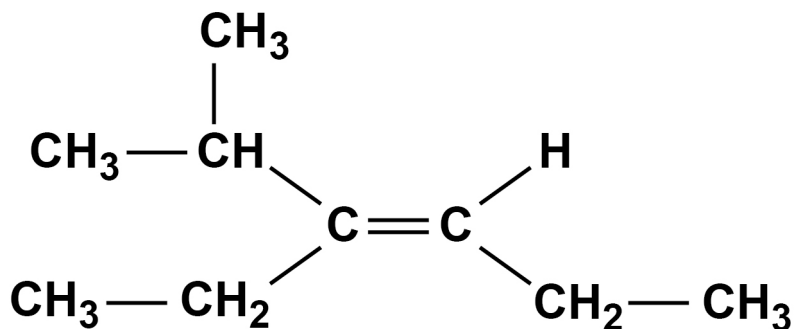
[Turn over]



04.1

Compound J is one of a pair of stereoisomers.

Compound J



Explain:

- what stereoisomers are
- how *E-Z* stereoisomerism occurs
- how the Cahn-Ingold-Prelog rules can be used to decide whether compound J is an *E* or *Z* isomer.

[6 marks]



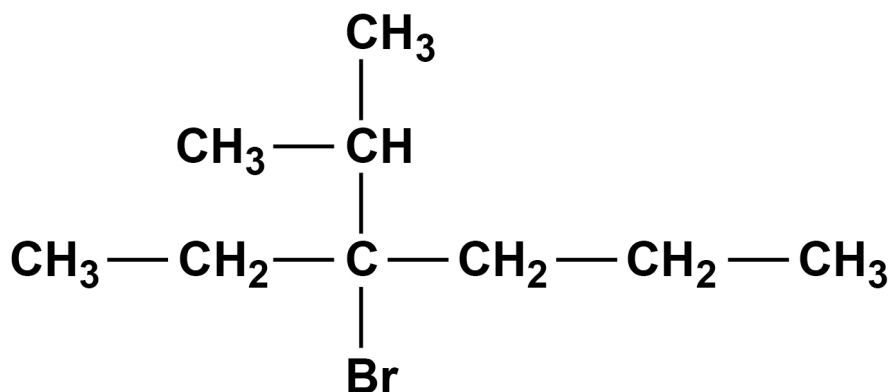
[Turn over]



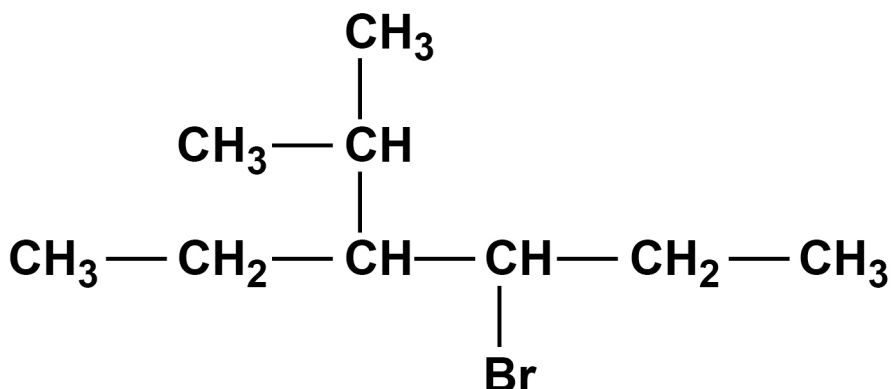
04.2

Compound J reacts with hydrogen bromide to form compounds K and L.

Compound K



Compound L



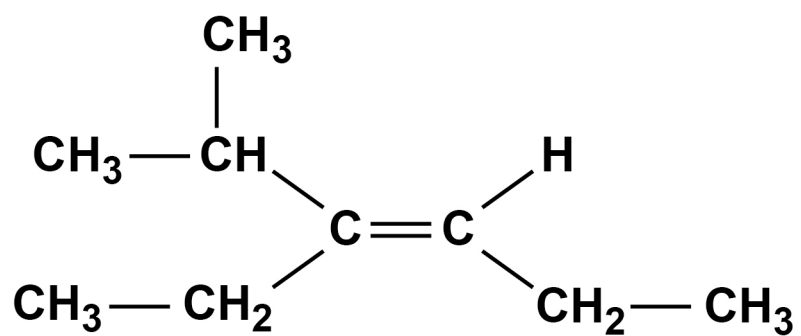
K is the major product.

Name and outline the mechanism for the formation of K.
[5 marks]



Name of mechanism

Outline of mechanism



[Turn over]



BLANK PAGE

[Turn over]

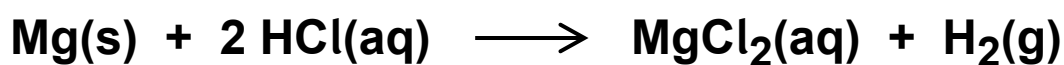


0	5
---	---

This question is about the volumes of gases involved in some reactions.

0	5	.	1
---	---	---	---

Magnesium reacts with hydrochloric acid.



0.400 g of magnesium is added to 20.0 cm³ of 1.50 mol dm⁻³ hydrochloric acid.

Identify the limiting reagent.

Justify your answer.

Calculate the volume, in m³, of hydrogen produced at 101 kPa and 15 °C

The gas constant, $R = 8.31 \text{ J K}^{-1} \text{ mol}^{-1}$

[7 marks]



Limiting Reagent _____

Justification _____

Volume of hydrogen _____ m³

[Turn over]



0	5	.	2
---	---	---	---

Propane (C_3H_8) undergoes complete combustion in a plentiful supply of oxygen.

Give an equation for the complete combustion of propane.

Use this equation to calculate the minimum volume, in cm^3 , of oxygen gas needed for the complete combustion of 50 cm^3 of propane gas.

Assume that the volumes of both gases are measured at the same temperature and pressure. [2 marks]

Equation for combustion

Volume of oxygen gas _____ cm^3

9



BLANK PAGE

[Turn over]



06

A student investigates the effect of changing the temperature on the rate of hydrolysis of 1-iodobutane.

The student follows this method:

- Add 5 cm³ of ethanol and 4 drops of 1-iodobutane to a test tube.
- Mark this test tube with a cross (below the level of the liquid).
- Add 5 cm³ of 0.05 mol dm⁻³ silver nitrate solution to a separate test tube.
- Place a stopper in both test tubes.
- Place both test tubes in a beaker of water at a known temperature (between 5 and 60 °C).
- After 5 minutes, pour the silver nitrate solution into the test tube containing 1-iodobutane and start a timer.
- Look through the transparent reaction mixture in the test tube towards the cross.
- Stop the timer when the cross is no longer visible due to the yellow precipitate formed.



0	6	.	1
---	---	---	---

Identify the yellow precipitate formed in the reaction.
[1 mark]

The student repeats the experiment at different temperatures.

TABLE 2, on page 34, shows the student's results.

[Turn over]



TABLE 2

Temperature / °C	Time t / s	$\frac{1}{t}$ / s ⁻¹
6	125	0.0080
15	83	0.0120
28	50	0.0200
34	38	0.0263
42	26	0.0385

0	6	.	2
---	---	---	---

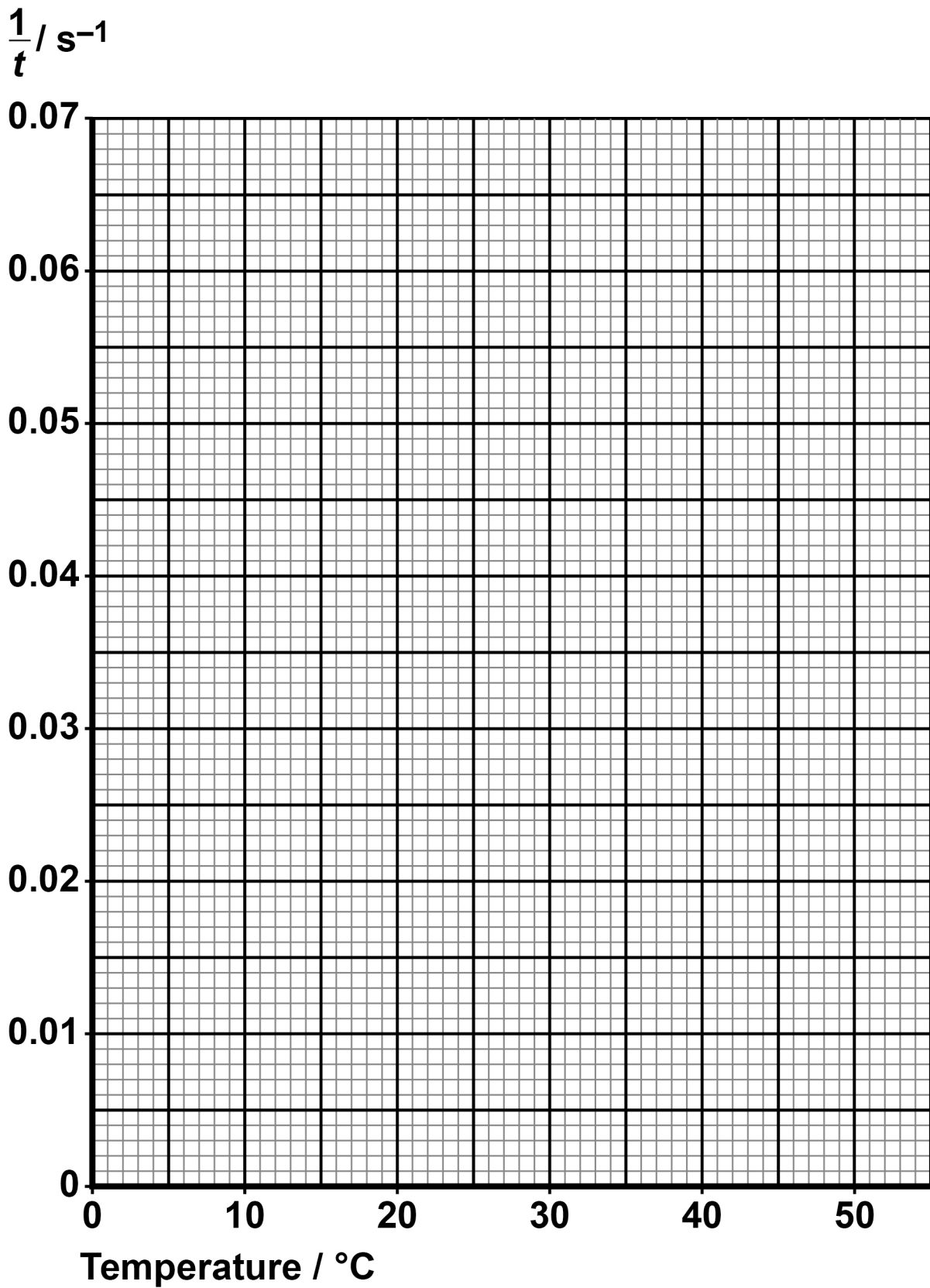
Plot the values of $\frac{1}{t}$ against temperature on the grid, on the opposite page.

Draw a line of best fit.

Use your graph to predict the time, in s, when the cross is no longer visible at 50 °C [3 marks]

Time _____ s





[Turn over]



0	6	.	3
---	---	---	---

The student repeats the investigation using 1-bromobutane instead of 1-iodobutane.

State and explain how the rate of reaction for 1-bromobutane compares with the rate for 1-iodobutane.

Predict how the graph will differ for 1-bromobutane compared to 1-iodobutane. [3 marks]

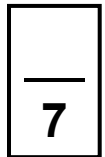
How rate of reaction for 1-bromobutane will compare

Explanation



How graph for 1-bromobutane will differ

[Turn over]

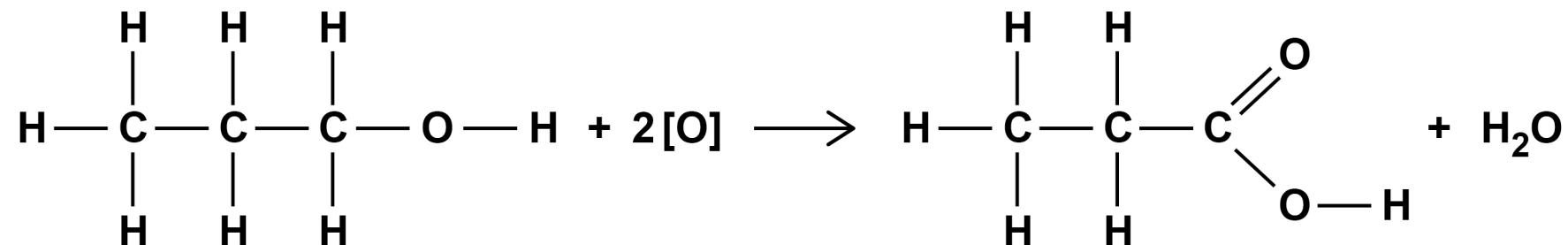




07

This question is about propanoic acid ($\text{CH}_3\text{CH}_2\text{COOH}$).

The equation for the oxidation of propan-1-ol under reflux to form propanoic acid is shown.



07.1

Acidified potassium dichromate(VI) is used as the oxidising agent.

State the colour change in this reaction. [1 mark]

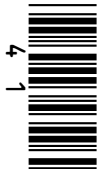


07.2

A second organic product, X, is formed in small quantities.
The boiling point of X is 49 °C

Identify X. [1 mark]

[Turn over]

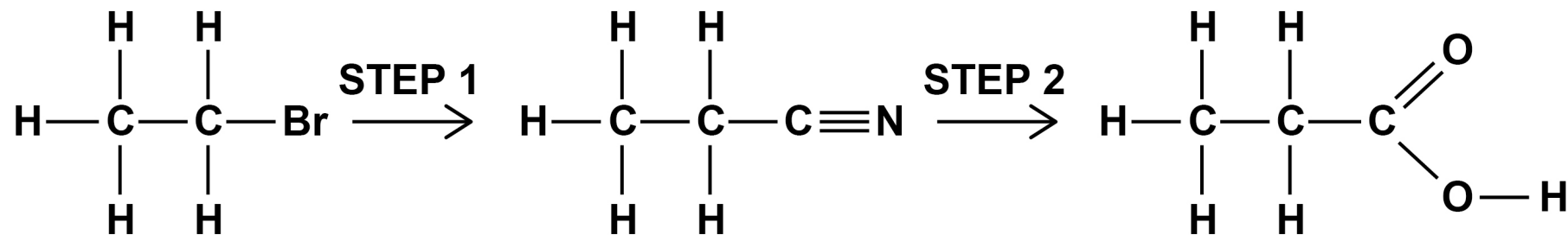


BLANK PAGE

[Turn over]



An alternative method of preparing propanoic acid is shown.



STEP 1 involves the reaction of bromoethane with sodium cyanide under reflux in a suitable solvent.

07.4

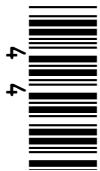
Name and outline the mechanism for **STEP 1**. [3 marks]

Name of mechanism _____



Outline of mechanism

[Turn over]

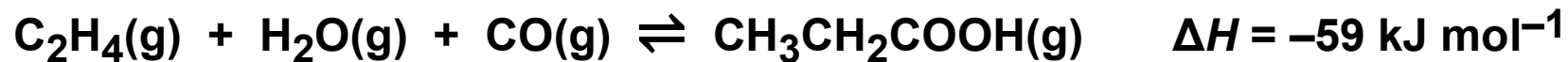


0 7 . 5

**Suggest one reason why water is NOT a suitable solvent for STEP 1 on page 42.
[1 mark]**



A third way of making propanoic acid uses the reaction between ethene, steam and carbon monoxide in the presence of a catalyst.



0 7 . 6

Give an expression for the equilibrium constant (K_c) for this reaction. [1 mark]

$K_c =$

[Turn over]



07.7

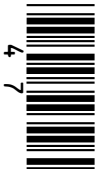
TABLE 3 shows the amount of each substance in an equilibrium mixture in a container of volume 1.20 dm^3 at a constant temperature.

TABLE 3

Substance	$\text{C}_2\text{H}_4(\text{g})$	$\text{H}_2\text{O}(\text{g})$	$\text{CO}(\text{g})$	$\text{CH}_3\text{CH}_2\text{COOH}(\text{g})$
Amount of substance / mol	0.062	0.078	0.062	0.420

Calculate K_c

State the units. [4 marks]



K_c _____

Units _____

[Turn over]



07.8

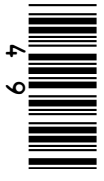
Predict the effect of increasing the temperature on the yield of propanoic acid.

Explain your answer. [3 marks]

Effect on yield _____

Explanation _____

17



BLANK PAGE

[Turn over]

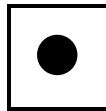
SECTION B

Answer ALL questions in this section.

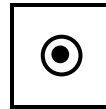
Only ONE answer per question is allowed.

For each question completely fill in the circle alongside the appropriate answer.

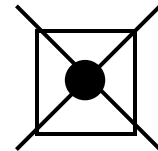
CORRECT METHOD



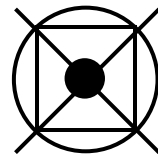
WRONG METHODS



If you want to change your answer you must cross out your original answer as shown.



If you wish to return to an answer previously crossed out, ring the answer you now wish to select as shown.

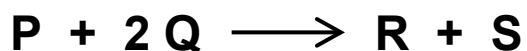


You may do your working in the blank space around each question but this will not be marked.
Do NOT use additional sheets for this working.



0	8
---	---

The equation shows how P reacts with Q to make R and S.



When a mixture of 0.25 mol of P and 0.40 mol of Q react, 0.15 mol of R is obtained.

What is the percentage yield of R in this reaction?
[1 mark]

A $\frac{0.15}{0.20} \times 100$

B $\frac{0.15}{0.25} \times 100$

C $\frac{0.15}{0.40} \times 100$

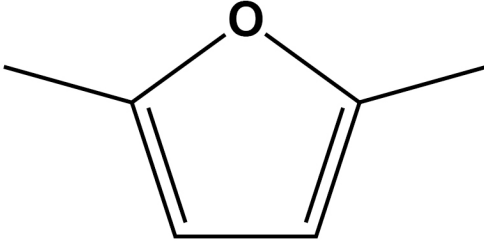
D $\frac{0.15}{0.65} \times 100$

[Turn over]



09

What is the M_r of this compound?



[1 mark]

A 94.0

B 96.0

C 98.0

D 100.0



1	0
---	---

Which statement explains why the rate of a reaction increases when a catalyst is added to a reaction mixture at a constant temperature? [1 mark]

- A The collision frequency increases because there is an increase in the activation energy.**
- B The collision frequency increases because there is an increase in the mean energy of the particles.**
- C The proportion of successful collisions increases because there is a decrease in the activation energy.**
- D The proportion of successful collisions increases because there is an increase in the mean energy of the particles.**

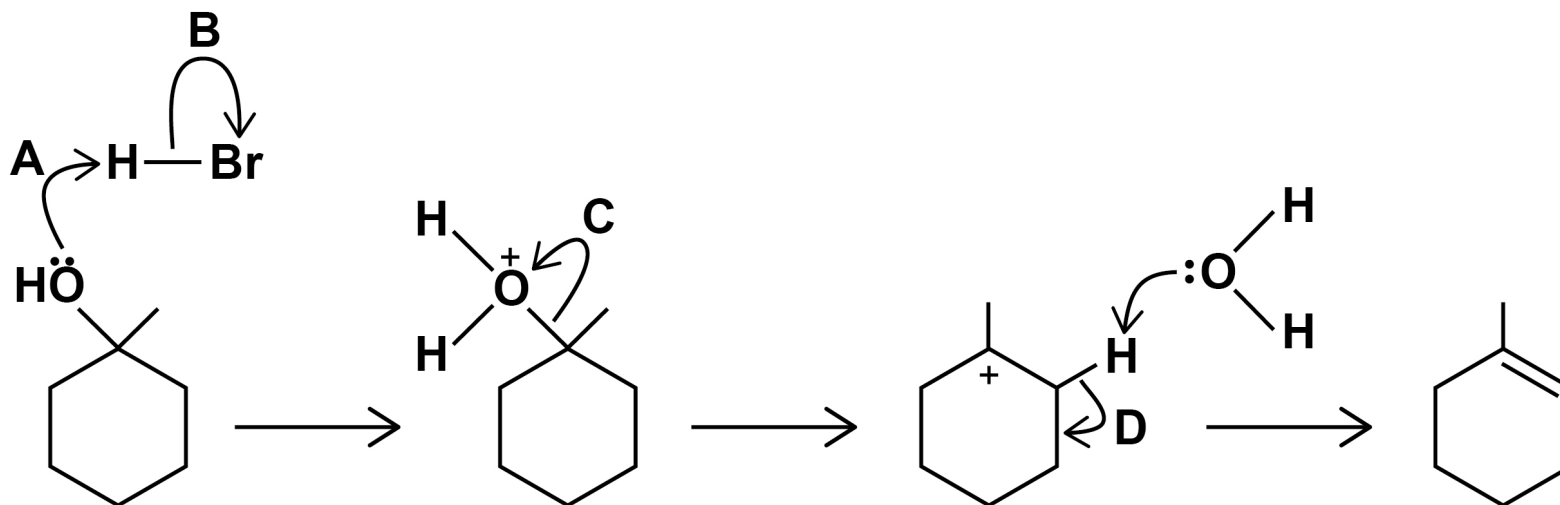
[Turn over]



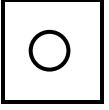
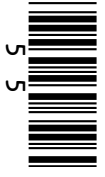


1 1

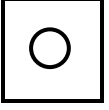
Which labelled curly arrow shows an INCORRECT movement of an electron pair?



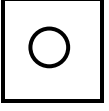
[1 mark]



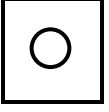
A



B



C



D

[Turn over]

1	2
---	---

A halogenoalkane reacts with ethanolic potassium hydroxide to form these alkenes by elimination:

- 2-ethylpent-1-ene
- *E*-3-methylhex-2-ene
- *Z*-3-methylhex-2-ene
- *E*-3-methylhex-3-ene
- *Z*-3-methylhex-3-ene

Which halogenoalkane would form these alkenes in this reaction? [1 mark]

A 1-bromo-2-ethylpentane

B 2-bromo-3-methylhexane

C 3-bromo-3-methylhexane

D 3-bromo-4-methylhexane



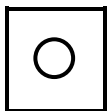
BLANK PAGE

[Turn over]

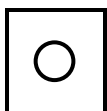
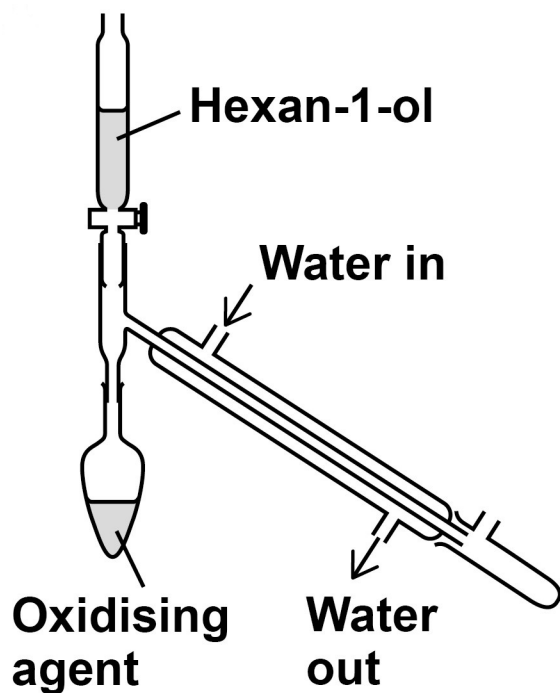


1 3

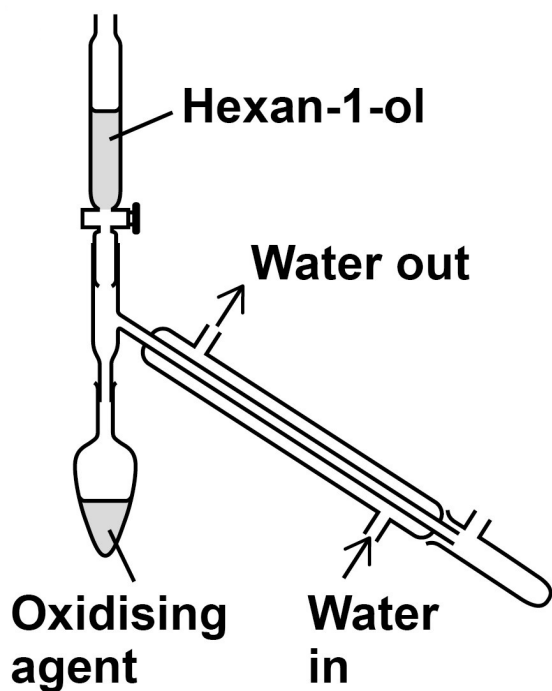
Which diagram shows the correct apparatus for the conversion of hexan-1-ol to hexanal? [1 mark]

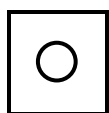


A

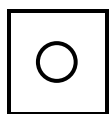
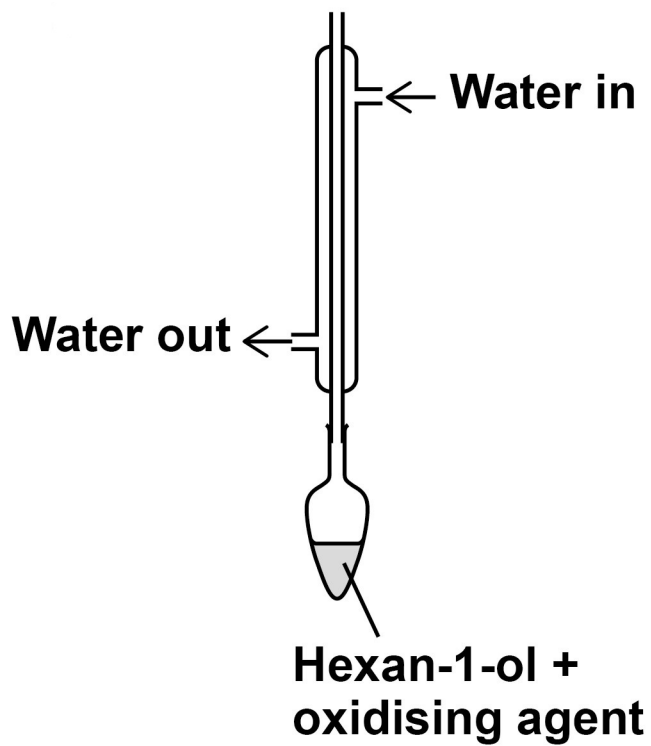


B

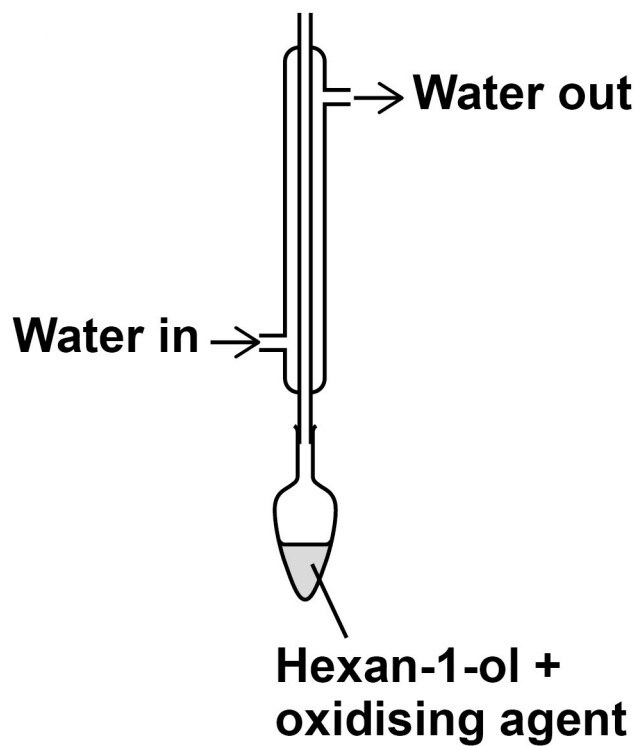




C



D



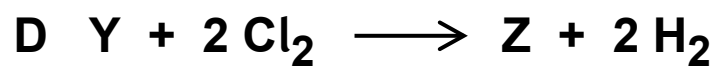
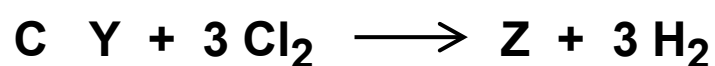
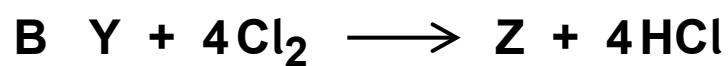
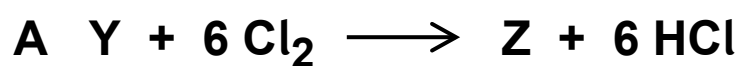
[Turn over]



1 4

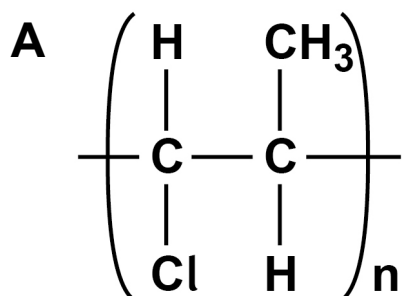
1,1-Dichloroethane (Y) reacts with chlorine to form hexachloroethane (Z).

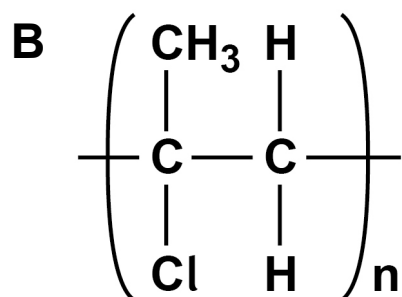
Which is the correct equation for this reaction?
[1 mark]

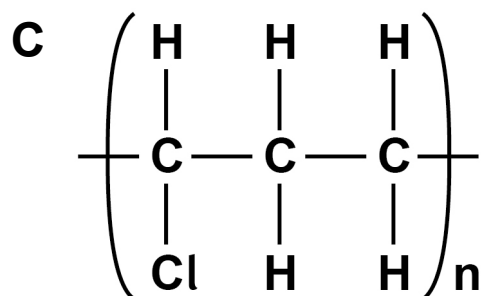


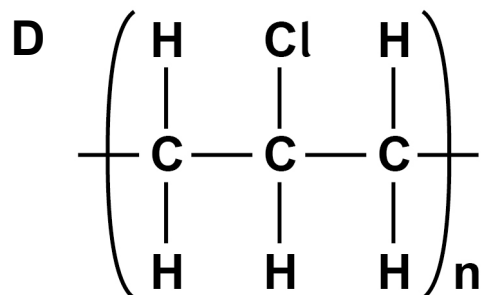
1 | 5

Which is the structure of poly(1-chloropropene)?
[1 mark]









[Turn over]

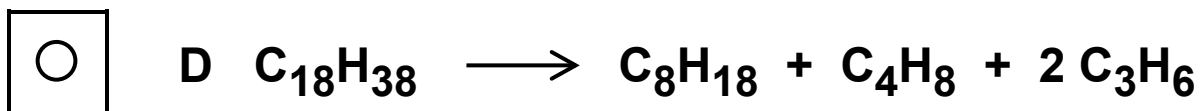
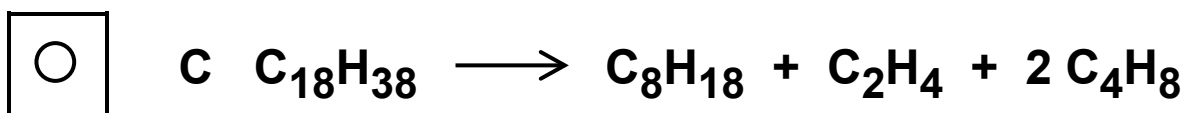
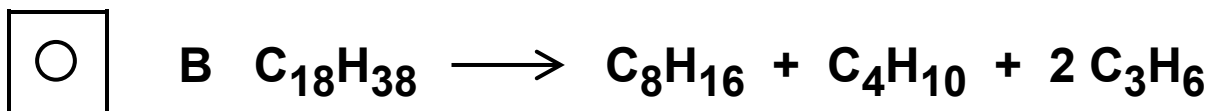
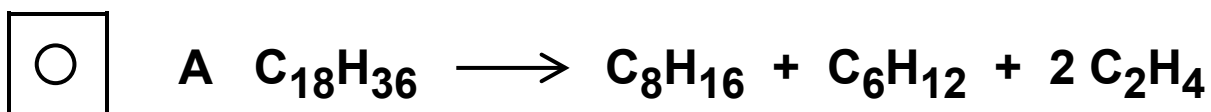


1 6

Octadecane is a straight-chain alkane containing 18 carbon atoms per molecule.

It is cracked to produce oct-1-ene and two other compounds.

Which equation represents this reaction? [1 mark]



17

Which of these alkanes has the highest boiling point?
[1 mark]

A decane

B hexane

C 2,3-dimethyloctane

D 2,3-dimethylbutane

[Turn over]



1 8

High resolution mass spectrometry can be used to determine the precise relative molecular mass of compounds.

Which compound has a precise relative molecular mass that is different from the precise relative molecular mass of butanone? [1 mark]

A but-3-en-1-ol

B cyclobutanol

C methylpropanal

D prop-2-enoic acid

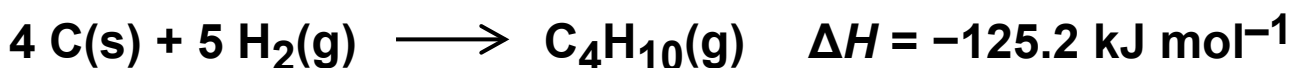
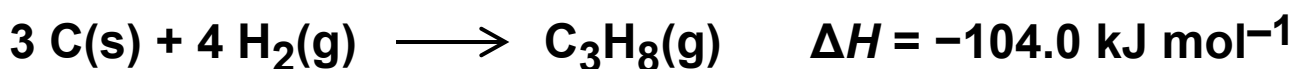
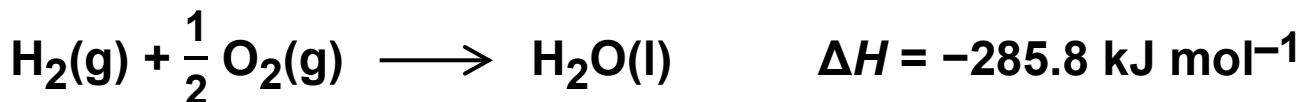


BLANK PAGE

[Turn over]



Use this information to answer Questions 19 and 20.



19

What is the enthalpy of combustion, in kJ mol^{-1} , of propane? [1 mark]

A -211.7

B -419.7

C -2220

D -2878



2	0
---	---

What is the enthalpy change, in kJ mol^{-1} , when butane reacts to form propane, hydrogen and carbon?

[1 mark]

A +21.2

B +17.5

C -17.5

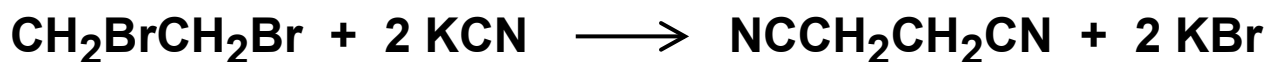
D -21.2

[Turn over]



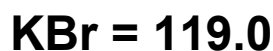
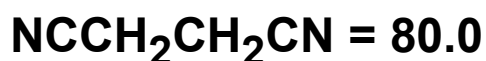
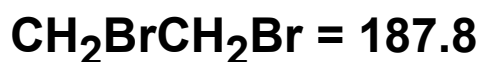
2	1
---	---

This is the equation for the conversion of 1,2-dibromoethane to butanedinitrile.



What is the percentage atom economy for the production of butanedinitrile in this reaction?

Relative formula masses, M_r



[1 mark]

A 100%

B 40.2%

C 31.6%

D 25.2%



2	2
---	---

A sample of cyclohexane contains 3.011×10^{24} atoms of carbon.

What is the mass of this sample?

The Avogadro constant, $L = 6.022 \times 10^{23} \text{ mol}^{-1}$
[1 mark]

A 70.0 g

B 71.7 g

C 420 g

D 430 g

END OF QUESTIONS

15



BLANK PAGE

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

Copyright information

For confidentiality purposes, all acknowledgements of third-party copyright material are published in a separate booklet. This booklet is published after each live examination series and is available for free download from www.aqa.org.uk.

Permission to reproduce all copyright material has been applied for. In some cases, efforts to contact copyright-holders may have been unsuccessful and AQA will be happy to rectify any omissions of acknowledgements. If you have any queries please contact the Copyright Team.

Copyright © 2024 AQA and its licensors. All rights reserved.

WP/M/CH/Jun24/7404/2/G4001/V3