AQA

Please write clearly in block capitals.

Centre number | | | | | | Candidate number | | | | |

Surname ______________________

Forename(s) ______________________

Candidate signature ______________________
I declare this is my own work.

AS CHEMISTRY

Paper 2 Organic and Physical Chemistry

Time allowed: 1 hour 30 minutes

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.
- 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 80.

Advice
You are advised to spend about 65 minutes on **Section A** and 25 minutes on **Section B**.

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

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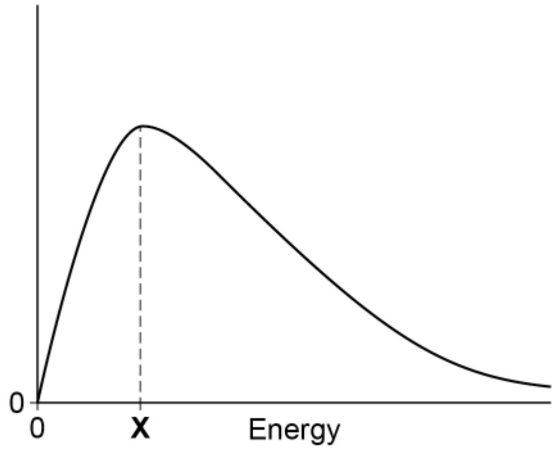
Section A

Answer **all** questions in this section.

0 1 **Figure 1** shows the Maxwell–Boltzmann distribution of molecular energies in a sample of gas.

Figure 1



0 1 . 1 Label the *y*-axis on **Figure 1**.

[1 mark]

0 1 . 2 State why the curve starts at the origin.

[1 mark]

____

____

0 1 . 3 State what **X** indicates on **Figure 1**.

[1 mark]

X indicates ____

____

0 1 . 4 Half of the gas molecules in the sample are removed.
The remaining gas molecules are kept at the same temperature.

Draw the new distribution of molecular energies for the remaining gas on **Figure 1**.

[2 marks]

5

Turn over ►

Do not write outside the box

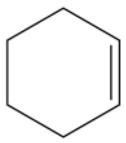
0 2 Alkenes react with bromine (Br_2)

0 2 . 1 Name and outline the mechanism for the reaction of cyclohexene with Br_2

[5 marks]

Name of mechanism ____________________

Outline of mechanism



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0 2 . 2 Explain why there is an attraction between a C=C double bond and Br_2

[3 marks]

0 2 . 3 Draw the skeletal formula of the halogenoalkane formed when buta-1,3-diene (CH_2=CHCH=CH_2) reacts with an excess of Br_2

[1 mark]

9

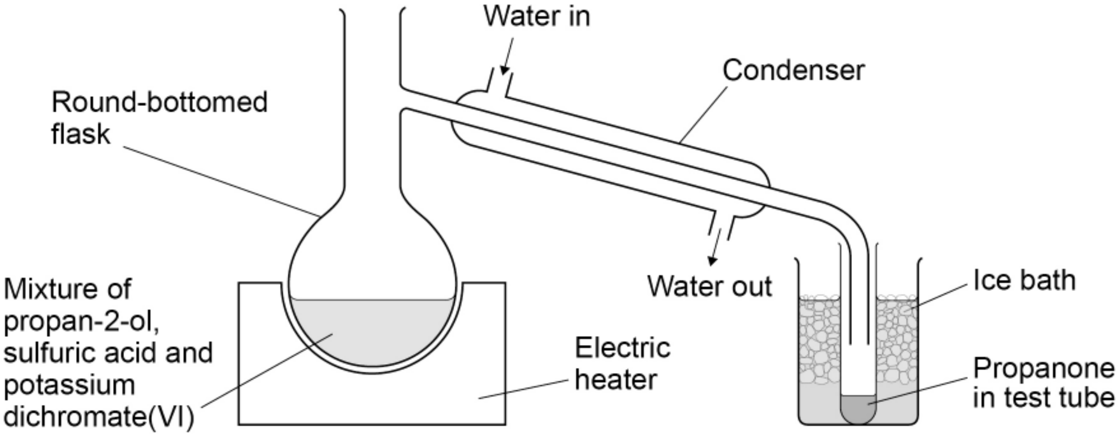
Turn over for the next question

0 3 Propanone can be made by reacting propan-2-ol with an excess of acidified potassium dichromate(VI).

The propanone is removed from the reaction mixture by distillation.

0 3 . 1 **Figure 2** shows the apparatus set up by a student to make propanone by this method. Suitable clamps are used to hold all the apparatus firmly in place.

Figure 2



There are **three** problems with the apparatus set up in **Figure 2**.

For each problem:

- identify the problem
- describe the issue it would cause
- suggest how the problem can be solved.

[6 marks]

Do not write outside the box

Turn over ►

Another student completes the experiment using apparatus that is set up correctly.

0 3 . 2 The student reacts 2.0 cm^3 of propan-2-ol ($CH_3CH(OH)CH_3$) with an excess of acidified potassium dichromate(VI).

The student obtains 0.954 g of propanone (CH_3COCH_3).

Calculate the percentage yield of propanone in this experiment.
Give your answer to the appropriate number of significant figures.

Density of propan-2-ol = 0.786 g cm^{-3}

[4 marks]

Percentage yield ______________________________

Do not write outside the box

0 3 . 3 Molecules of propan-2-ol and propanone each contain three carbon atoms.

Complete **Table 1** to suggest the shape and a bond angle around the central C atom in a molecule of each compound.

[2 marks]

Table 1

Compound	propan-2-ol $CH_3CH(OH)CH_3$	propanone CH_3COCH_3
Shape around central C atom		
Bond angle around central C atom		

0 3 . 4 Explain why propanone has a lower boiling point than propan-2-ol.

[3 marks]

15

Turn over for the next question

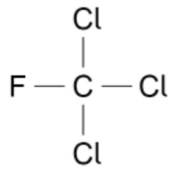
0 4 CFCs were used as refrigerants and in aerosols.

The scientists Rowland and Molina published research in 1974 to show that CFCs are responsible for the destruction of ozone molecules in the upper atmosphere.

A few years later, other scientists discovered that the concentration of ozone in the upper atmosphere was decreasing.

In 1987 there was an agreement by many countries to restrict the use of CFCs.

0 4 . 1 The molecule CFC-11 was commonly used as a refrigerant.



Use IUPAC rules to name CFC-11

[1 mark]

____

0 4 . 2 A molecule of CFC-11 breaks down in the upper atmosphere to form a chlorine free radical.

Give the equation for this reaction.

[1 mark]

____

0 4 . 3 A typical refrigerator contained 0.50 kg of CFC-11 (M_r = 137.5).

One molecule of CFC-11 causes the destruction of approximately 100 000 molecules of ozone.

Use these data to estimate the number of molecules of ozone that can be destroyed by 0.50 kg of CFC-11
Give your answer in standard form.

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

[2 marks]

Number of molecules of ozone ____________________

0 4 . 4 State the benefit to life on Earth of ozone in the upper atmosphere.

[1 mark]

____

____

____

0 4 . 5 Suggest **one** reason why the use of CFCs was not restricted until several years after Rowland and Molina published their research.

[1 mark]

____

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Do not write outside the box

0 4 . 6 CFC-11 is a greenhouse gas that can contribute to global warming.

State and explain how CFC-11 is able to contribute to global warming.

[2 marks]

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8

Turn over for the next question

Turn over ►

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0 5 This question is about poly(propene).

0 5 . 1 The three key steps in the manufacture of poly(propene) from crude oil are shown.

$$\text{crude oil} \xrightarrow{\text{step } \mathbf{1}} \text{naphtha} \xrightarrow{\text{step } \mathbf{2}} \text{propene} \xrightarrow{\text{step } \mathbf{3}} \text{poly(propene)}$$

Naphtha is a mixture of alkanes with 6 to 12 carbon atoms per molecule.

For each step, name the process and state briefly the purpose of the process that leads to the formation of poly(propene).

[6 marks]

Step **1**

Name ______________________________

Purpose ______________________________

____

____

Step **2**

Name ______________________________

Purpose ______________________________

____

____

Step **3**

Name ______________________________

Purpose ______________________________

____

____

Do not write outside the box

0 5 . 2 Poly(propene) is not biodegradable because it is unreactive.

Explain why poly(propene) is unreactive.

[1 mark]

0 5 . 3 Scientists are developing new polymers, including some that are biodegradable.

Suggest why it is beneficial for some polymers to be biodegradable.

[1 mark]

8

Turn over for the next question

0 6 This question is about two experiments on gases.

0 6 . 1 In the first experiment, liquid **Y** is injected into a sealed flask under vacuum.
The liquid vaporises in the flask.
Table 2 shows data for this experiment.

Table 2

Mass of **Y**	717 mg
Temperature	297 K
Volume of flask	482 cm^3
Pressure inside flask	51.0 kPa

Calculate the relative molecular mass of **Y**.

Show your working.

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

[5 marks]

Relative molecular mass of **Y** ____________________

Do not write outside the box

0 6 . 2 In the second experiment, another flask is used for a combustion reaction.

Method

- Remove all the air from the flask.
- Add 0.0010 mol of 2,2,4-trimethylpentane (C_8H_{18}) to the flask.
- Add 0.0200 mol of oxygen to the flask.
- Spark the mixture to ensure complete combustion.
- Cool the mixture to the original temperature.

The equation is

$$C_8H_{18}(g) + 12\frac{1}{2}O_2(g) \longrightarrow 8\,CO_2(g) + 9\,H_2O(l)$$

Calculate the amount, in moles, of gas in the flask after the reaction.

[2 marks]

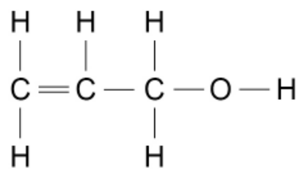
Amount of gas ______________________________ mol

7

Turn over for the next question

Do not write outside the box

0 7 Prop-2-en-1-ol is a natural chemical found in garlic. It is also used in the production of plasticisers.



0 7 . 1 Prop-2-en-1-ol can be prepared by reacting 3-chloroprop-1-ene with dilute aqueous sodium hydroxide.

Name the mechanism for this reaction.

[1 mark]

____

0 7 . 2 Prop-2-en-1-ol can also be formed from $HOCH_2CH_2CH_2OH$ in the presence of an acid catalyst.

$$HOCH_2CH_2CH_2OH \longrightarrow CH_2{=}CHCH_2OH + H_2O$$

Name and outline a mechanism for this reaction.

[4 marks]

Name of mechanism ____

Outline of mechanism

Do not write outside the box

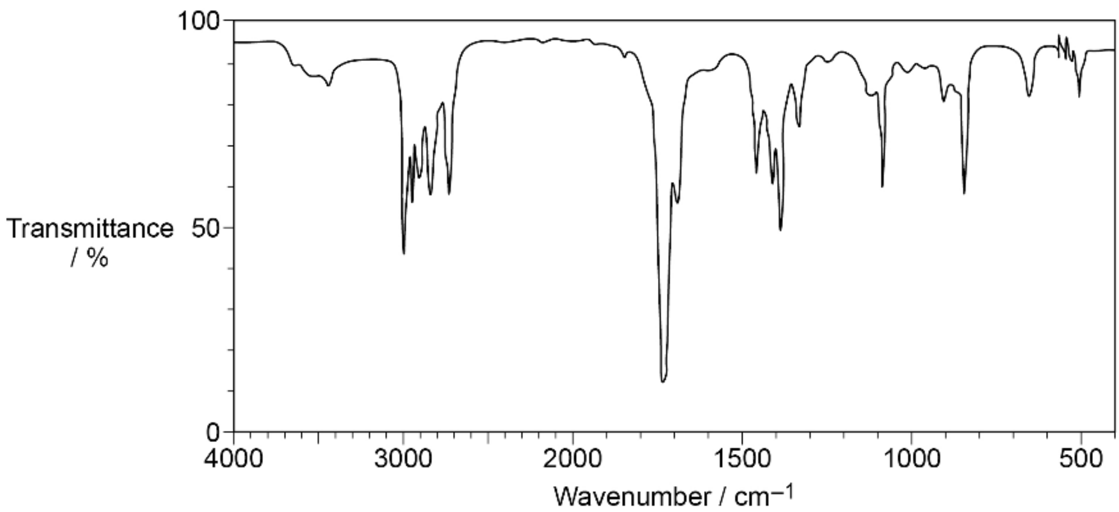
0 7 . 3 Prop-2-en-1-ol forms an addition polymer.

Draw the repeating unit of poly(prop-2-en-1-ol).

[1 mark]

0 7 . 4 **Figure 3** shows the infrared spectrum of a functional group isomer of prop-2-en-1-ol.

Figure 3



This isomer reacts with acidified potassium dichromate(VI) to form a green solution.

Draw the structure of this isomer.

[1 mark]

7

Turn over ►

Do not write outside the box

0 8 This question is about enthalpy changes.

0 8 . 1 Define the term enthalpy change.

[1 mark]

0 8 . 2 Propane undergoes complete combustion.

$$C_3H_8(g) + 5\,O_2(g) \longrightarrow 3\,CO_2(g) + 4\,H_2O(l) \qquad \Delta H = -2046\ \text{kJ mol}^{-1}$$

Table 3 shows some bond enthalpy data.

Table 3

Bond	C–H	C=O	O–H
Mean bond enthalpy / kJ mol^{-1}	412	743	463

The bond enthalpy for O=O is 496 kJ mol^{-1}

For $H_2O(l) \longrightarrow H_2O(g)$ ΔH = +41 kJ mol^{-1}

Use these data to calculate a value for the C–C bond enthalpy in propane.

[4 marks]

C–C bond enthalpy ____________________ kJ mol^{-1}

Do not write outside the box

0 8 . 3 Explain why the value given for the O=O bond enthalpy in Question **08.2** is **not** a mean value.

[1 mark]

____

____

____

6

Turn over for Section B

Section B

Answer **all** questions in this section.

Only **one** answer per question is allowed.
For each answer 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 9 Which alkene shows *E–Z* isomerism?

[1 mark]

A 2,3-dimethylbut-2-ene

B 4-methylpent-2-ene

C methylpropene

D pent-1-ene

1 0 A compound contains 40.0% carbon, 6.7% hydrogen and 53.3% oxygen by mass.

Which could be the molecular formula of this compound?

[1 mark]

A $C_2H_2O_2$

B C_2H_2O

C $C_2H_4O_2$

D C_2HO_2

Do not write outside the box

1 1 When driving a car, a legal limit for ethanol (M_r = 46.0) is 80 mg per 100 cm^3 of blood.

What is this concentration in mol dm^{-3}?

[1 mark]

A 1.74×10^{-1} ⬭

B 1.74×10^{-2} ⬭

C 1.74×10^{-3} ⬭

D 1.74×10^{-4} ⬭

1 2 Which is a propagation step in the chlorination of methane?

[1 mark]

A $H\bullet + Cl_2 \rightarrow HCl + Cl\bullet$ ⬭

B $Cl\bullet + CH_4 \rightarrow CH_3Cl + H\bullet$ ⬭

C $\bullet CH_3 + Cl\bullet \rightarrow CH_3Cl$ ⬭

D $\bullet CH_3 + Cl_2 \rightarrow CH_3Cl + Cl\bullet$ ⬭

1 3 Which compound is **not** formed by reacting 3-bromo-3-methylhexane with warm, ethanolic potassium hydroxide?

[1 mark]

A 2-ethylpent-1-ene ⬭

B 3-methylhex-1-ene ⬭

C 3-methylhex-2-ene ⬭

D 3-methylhex-3-ene ⬭

Turn over for the next question

Questions 14 to 16 refer to the reaction of 1-bromopropane with a solution of potassium cyanide in aqueous ethanol.

1 4 What is the organic product of this reaction?

[1 mark]

A propylamine ⬭

B butylamine ⬭

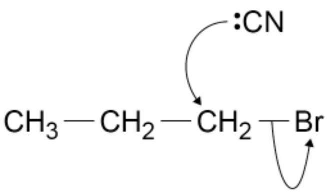
C propanenitrile ⬭

D butanenitrile ⬭

1 5 Which is the correct mechanism for the reaction?

[1 mark]

A



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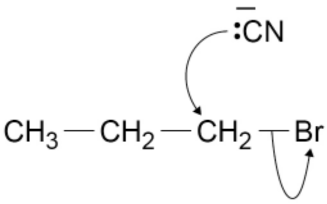
B



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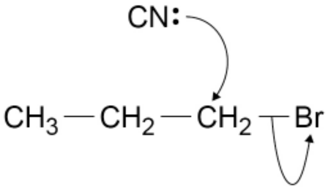
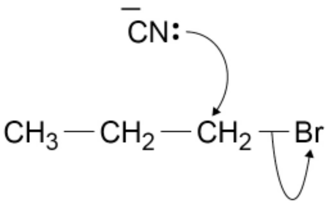


⬭

D



⬭

1 6 The reactions of 1-bromopropane and 1-chloropropane with potassium cyanide in aqueous ethanol occur at different rates under the same conditions.

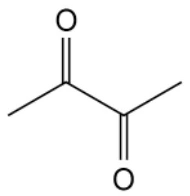
Which row correctly shows the compound that has a faster rate of reaction and the correct reason for this?

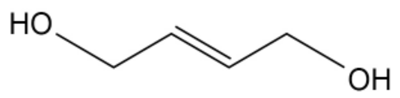
[1 mark]

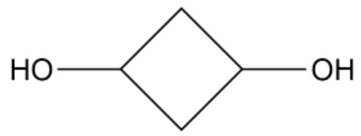
	Compound	Reason	
A	1-bromopropane	C–Br bond weaker than C–Cl bond	⬭
B	1-bromopropane	C–Br bond stronger than C–Cl bond	⬭
C	1-chloropropane	C–Br bond weaker than C–Cl bond	⬭
D	1-chloropropane	C–Br bond stronger than C–Cl bond	⬭

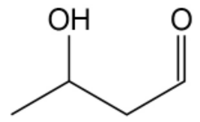
1 7 Which compound has a molecular formula that is different from the others?

[1 mark]

A  ⬭

B  ⬭

C  ⬭

D  ⬭

Turn over for the next question

Do not write outside the box

1 8 Which compound reacts with hydrogen bromide to give 2-bromo-3-methylbutane as the major product?

[1 mark]

A $(CH_3)_2C{=}CHCH_3$

B $(CH_3)_2C{=}CH_2$

C $CH_2{=}C(CH_3)CH_2CH_3$

D $(CH_3)_2CHCH{=}CH_2$

1 9 Which statement is **not** correct about the industrial production of ethanol from ethene at 300 °C?

$$C_2H_4(g) + H_2O(g) \rightleftharpoons C_2H_5OH(g) \qquad \Delta H = -46\ \text{kJ mol}^{-1}$$

[1 mark]

A The reaction is catalysed by an acid.

B The reaction has 100% atom economy.

C An increase in temperature decreases the equilibrium yield of ethanol.

D An increase in pressure increases the value of K_c

2 0 Which statement about the use of a catalyst in a reversible reaction is correct?

[1 mark]

A The activation energy for the reverse reaction is increased.

B The equilibrium constant increases.

C The rate of the reverse reaction increases.

D The enthalpy change for the forward reaction decreases.

Do not write outside the box

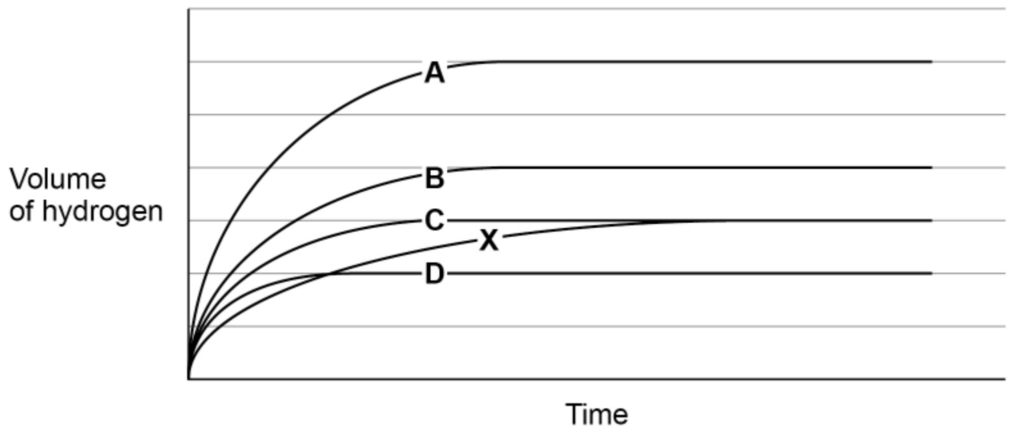
2 1 An excess of magnesium reacts with hydrochloric acid to form hydrogen gas.

Line **X** on the graph shows how the volume of hydrogen produced changes with time as magnesium reacts with 30 cm^3 of 1.0 mol dm^{-3} hydrochloric acid.

The reaction is repeated using 20 cm^3 of 2.0 mol dm^{-3} hydrochloric acid, with all other conditions the same.

Which line shows how the volume of hydrogen produced changes with time?

[1 mark]



A ⬭

B ⬭

C ⬭

D ⬭

Turn over for the next question

Do not write outside the box

2 2 Which statement is **not** correct about the pollutant sulfur dioxide?

[1 mark]

A It can be removed from car exhaust gases by a catalytic converter. ⬭

B It can be removed from power station flue gases by reaction with calcium oxide. ⬭

C It can cause respiratory problems. ⬭

D It can cause acid rain. ⬭

2 3 What is the percentage atom economy for the production of ethanol from glucose?

$$C_6H_{12}O_6 \rightarrow 2\,C_2H_5OH + 2\,CO_2$$

[1 mark]

A 25.6% ⬭

B 27.1% ⬭

C 51.1% ⬭

D 54.2% ⬭

15

END OF QUESTIONS

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ANSWER IN THE SPACES PROVIDED

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