



Please write clearly in block capitals.

Centre number 

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Candidate number 

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Forename(s)

Candidate signature \_\_\_\_\_

# AS CHEMISTRY

## Paper 2: Organic and Physical Chemistry

## Specimen materials (set 2)

1 hour 30 minutes

## Materials

For this paper you must have:

- the AS Chemistry Data Sheet/Periodic Table
- a ruler with millimetre measurements
- a 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 outside the box around each page or on blank pages.
- 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 maximum mark for this paper is 80.
- The AS Chemistry Data Sheet/Periodic Table is provided.

## Advice

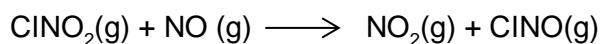
- You are advised to spend about 65 minutes on **Section A** and 25 minutes on **Section B**.

### Section A

Answer **all** questions in this section.

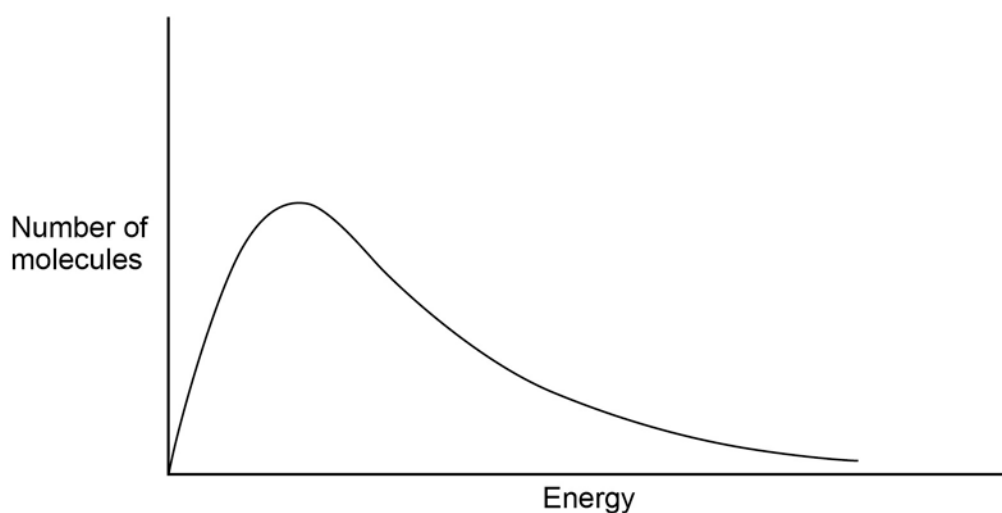
**0 1**

Nitryl chloride reacts with nitrogen monoxide according to the equation:



The Maxwell–Boltzmann distribution curve in **Figure 1** shows the distribution of molecular energies in 1 mol of this gaseous reaction mixture (sample **1**) at 320 K.

**Figure 1**



**0 1**

. **1** On the same axes, draw a curve for sample **1** at a lower temperature.

[2 marks]

**0 1**

. **2** Explain the effect that lowering the temperature would have on the rate of reaction.

[2 marks]

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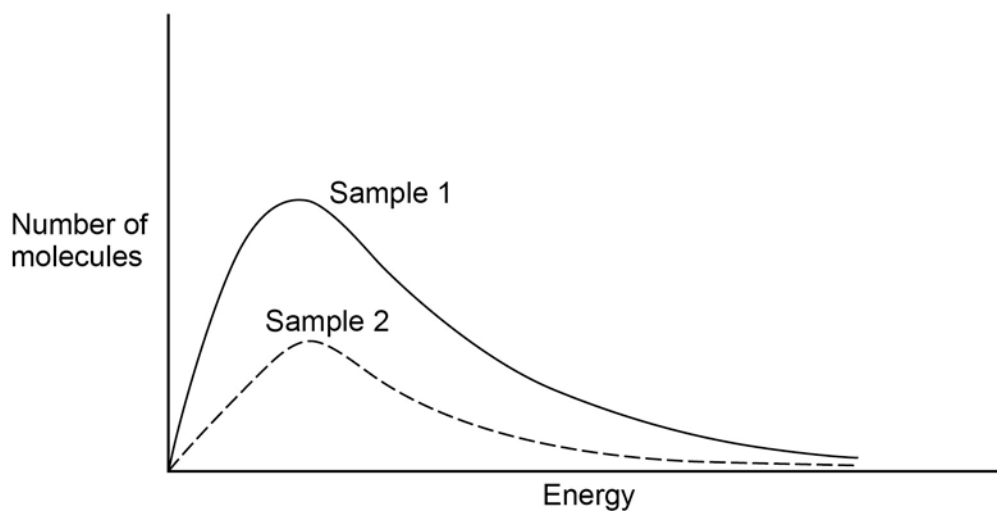
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- 0 1 . 3** A Maxwell–Boltzmann distribution curve was drawn for a second sample of the reaction mixture in the same reaction vessel. **Figure 2** shows the results.

**Figure 2**



Deduce the change that was made to the reaction conditions.

Explain the effect that this change has on the rate of reaction.

**[3 marks]**

Change \_\_\_\_\_

\_\_\_\_\_

Explanation \_\_\_\_\_

\_\_\_\_\_

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Avgas is an aviation fuel used in the internal combustion engines of helicopters. It consists of a large number of hydrocarbons, including a high proportion of hexane, which can exist as several isomers.

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Draw the skeletal formulae of **two** branched isomers of hexane.

[1 mark]

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State the type of isomerism shown by these branched isomers.

[1 mark]

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Safety signs on the fuselage of the helicopter state that the air inlets to the engine need to be cleaned out regularly.

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Write an equation for the combustion of hexane that would happen in the helicopter engine if the air inlets were partially blocked with debris.

[2 marks]

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Suggest how this partial blockage might affect the performance of the helicopter engine.

[1 mark]

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**Turn over for the next question**

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ANSWER IN THE SPACES PROVIDED**

**0 3**

Halogenoalkanes such as 1,1,2-trichloro-1,2,2-trifluoroethane were used as coolants in refrigerators until the late 1980s. Their use was then banned and alternative coolants were used instead.

**0 3****1**

Draw the displayed formula of 1,1,2-trichloro-1,2,2-trifluoroethane.

**[1 mark]****0 3****2**

1,1,2-Trichloro-1,2,2-trifluoroethane was banned for use as a refrigerant because it damaged the ozone layer.

Write **three** equations to show how this compound is involved in damaging the ozone layer.

**[3 marks]**

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**0 3****3**

State the role of chlorine atoms in the reactions in **03.2**.

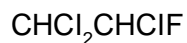
**[1 mark]**

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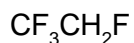
**0 3 . 4** Inevitably, some coolant escapes from refrigerators.

Deduce which of the following coolants, **A**, **B** or **C**, would cause least environmental damage to the atmosphere.

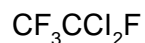
**[1 mark]**



**A**



**B**



**C**

Coolant \_\_\_\_\_

**0 3 . 5** Give the IUPAC name of compound **B** in **03.4**.

**[1 mark]**

\_\_\_\_\_

**0 3 . 6** The boiling point of iodomethane ( $\text{CH}_3\text{I}$ ) is higher than that of fluoromethane ( $\text{CH}_3\text{F}$ ) even though the electronegativity of iodine is less than that of fluorine.

Explain why iodomethane has the higher boiling point by considering the forces that act between  $\text{CH}_3\text{I}$  molecules and comparing these forces with the forces between the  $\text{CH}_3\text{F}$  molecules.

**[3 marks]**

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0	4
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A student was given unlabelled samples of pentan-1-ol, pent-1-ene, pentanoic acid and pentanal.

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Name the reagent(s) that the student could use to identify the sample that was pent-1-ene.

Describe the observation(s) that the student would make to confirm this.

[2 marks]

Reagent(s) \_\_\_\_\_

\_\_\_\_\_

Observation(s) \_\_\_\_\_

\_\_\_\_\_

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Name the reagent(s) that the student could use to identify the sample that was pentanoic acid.

Describe the observation(s) that the student would make to confirm this.

[2 marks]

Reagent(s) \_\_\_\_\_

\_\_\_\_\_

Observation(s) \_\_\_\_\_

\_\_\_\_\_

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Name the reagent(s) that the student could use to identify the sample that was pentanal.

Describe the observation(s) that the student would make to confirm this.

[2 marks]

Reagent(s) \_\_\_\_\_

\_\_\_\_\_

Observation(s) \_\_\_\_\_

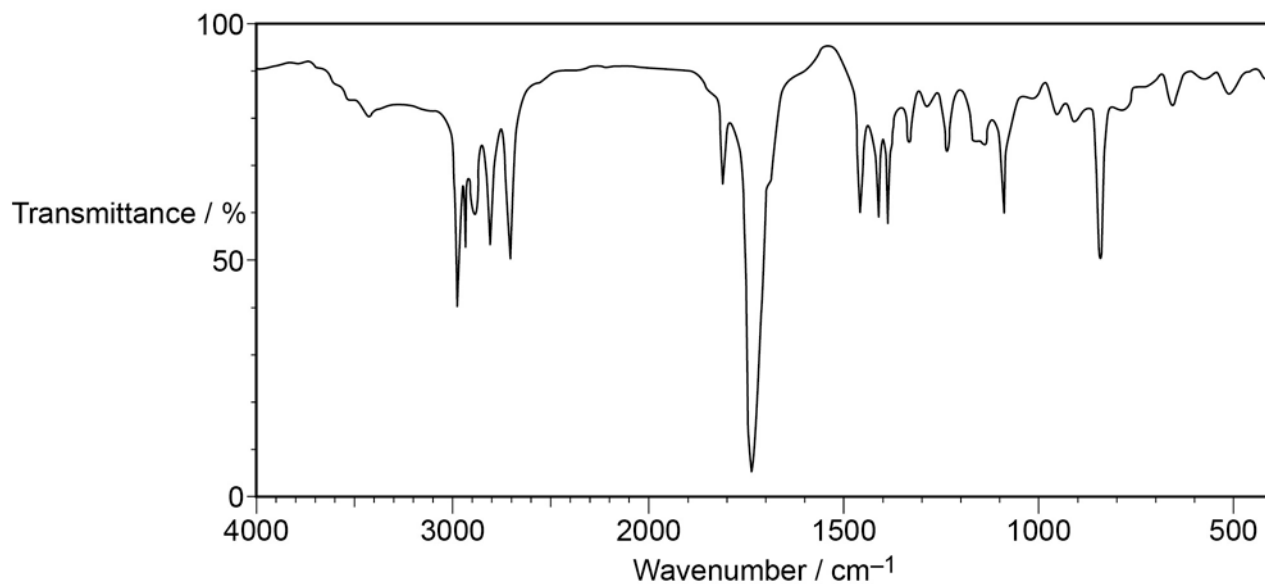
\_\_\_\_\_

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**0 4 . 4** The student deduced that the spectrum in **Figure 3** was that of pentanal.

**Figure 3**



Justify this deduction and suggest why this spectrum **cannot** be that of pentan-1-ol, pentanoic acid or pent-1-ene.

**[4 marks]**

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**Turn over for the next question**

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2-Methyl but-2-ene reacts with concentrated sulfuric acid to form two different products.

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Outline a mechanism for this reaction to show the formation of the major product.

**[4 marks]**

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Draw the structure of the minor product of this reaction.

**[1 mark]**

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Explain why the two products are formed in different amounts.

[2 marks]

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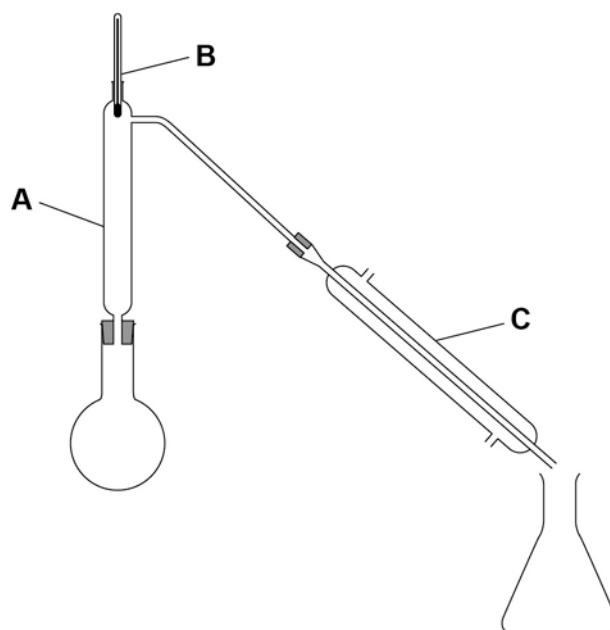
Turn over for the next question

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A group of students wanted to produce a biofuel to power the central heating system in their school. They collected scraps of fruits and vegetables from the kitchens and fermented them with yeast, in the absence of air, in order to produce ethanol. The aqueous mixture was filtered to remove the remaining solids.

The students then set up the apparatus shown in **Figure 4** and placed the aqueous mixture in the round bottomed flask.

**Figure 4**



0	6
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Describe how the students would use this apparatus to collect a sample of ethanol. Include in your answer the functions of the parts of the apparatus labelled **A**, **B** and **C**.  
[6 marks]

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**0 6 . 2** The students collected a 20 cm<sup>3</sup> sample of liquid and weighed it. The mass of the sample was 16 g.

The density of ethanol is 0.79 g cm<sup>-3</sup> and that of water 1.00 g cm<sup>-3</sup>.

Use these data to calculate the mass of ethanol in the sample collected.  
You should assume that the volume of the sample is equal to the sum of the volumes of water and ethanol.

**[2 marks]**

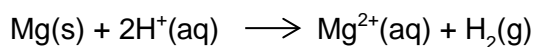
Mass of ethanol = \_\_\_\_\_ g

**8**

**Turn over for the next question**

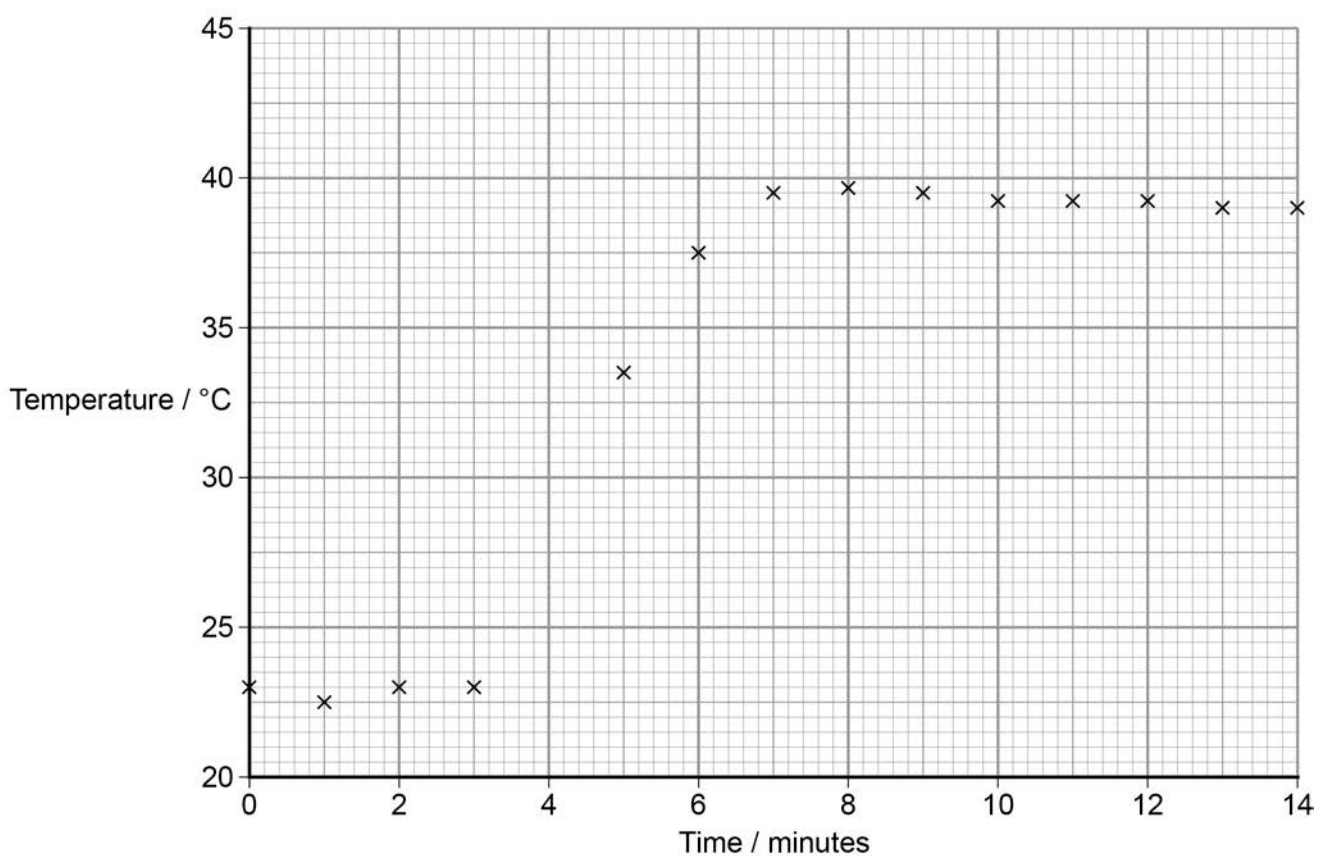
**0 7**

A student carried out a reaction between magnesium ribbon and aqueous trichloroethanoic acid in order to determine the enthalpy change. The equation for the reaction is shown:



The student measured the initial temperature of the trichloroethanoic acid and again every minute for 3 minutes before adding the magnesium ribbon at the fourth minute. The student continued to measure the temperature every minute for a further 10 minutes. The graph for these measurements is shown in **Figure 5**.

**Figure 5**



0	7	.	1
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The student used 240 mg of magnesium and 10.0 cm<sup>3</sup> of aqueous trichloroethanoic acid (an excess).

Use these data and information determined from **Figure 5** to calculate the enthalpy change, in kJ mol<sup>-1</sup>, for this reaction.

Show your working.

Give your answer to an appropriate precision.

(The specific heat capacity of water = 4.18 J K<sup>-1</sup> g<sup>-1</sup>)

[7 marks]

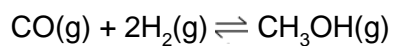
Enthalpy change = \_\_\_\_\_ kJ mol<sup>-1</sup>

7
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Turn over for the next question

0	8
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Methanol can be manufactured by the reaction of carbon monoxide with hydrogen



In an experiment, 0.73 mol of carbon monoxide was heated with 1.25 mol of hydrogen. An equilibrium mixture was formed that contained 0.43 mol of methanol.

0	8
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Calculate the amount, in moles, of each reactant present at equilibrium.

**[2 marks]**

Amount of carbon monoxide = \_\_\_\_\_ mol

Amount of hydrogen = \_\_\_\_\_ mol

0	8
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Write an expression for the equilibrium constant,  $K_c$ , for this reaction.

**[1 mark]**

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In another experiment at a different temperature, the equilibrium mixture contained 0.452 mol of carbon monoxide, 0.106 mol of hydrogen and 0.273 mol of methanol in a flask of volume  $9.40 \times 10^3 \text{ cm}^3$ .

**0 8 . 3**

Calculate the value of the equilibrium constant,  $K_c$ , at this temperature and state the units.

**[4 marks]**

$K_c =$  \_\_\_\_\_ Units = \_\_\_\_\_

**0 8 . 4**

The total pressure of this equilibrium mixture in the flask was 482.9 kPa.

Calculate the temperature, in  $^{\circ}\text{C}$ , of the equilibrium mixture.  
(The ideal gas constant  $R = 8.31 \text{ J mol}^{-1} \text{ K}^{-1}$ )

**[4 marks]**

Temperature = \_\_\_\_\_  $^{\circ}\text{C}$

**Turn over for the next question**

## 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.



0 9

Which of the following mechanisms does **not** occur in reactions of bromoethane?

[1 mark]

A Electrophilic addition

☐

B Elimination

☐

C Nucleophilic substitution

☐

D Radical substitution

☐

1 0

What is the empirical formula of 4-hydroxypent-2-ene?

[1 mark]

A  $C_5H_{12}O$

☐

B  $C_5H_{10}O$

☐

C  $CH_2O$

☐

D  $C_5H_9OH$

☐

1	1
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What is the total number of structural isomers with the molecular formula  $\text{C}_2\text{HBrClF}_3$ ?  
[1 mark]

**A**      2      ☐

**B**      3      ☐

**C**      4      ☐

**D**      5      ☐

1	2
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Which of the following contains the most chloride ions?

[1 mark]

**A**      15 cm<sup>3</sup> of  $3.40 \times 10^{-2} \text{ mol dm}^{-3}$  aluminium chloride solution      ☐

**B**      30 cm<sup>3</sup> of  $5.50 \times 10^{-2} \text{ mol dm}^{-3}$  calcium chloride solution      ☐

**C**      40 cm<sup>3</sup> of  $2.30 \times 10^{-2} \text{ mol dm}^{-3}$  hydrochloric acid      ☐

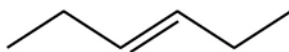
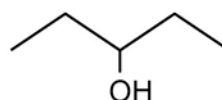
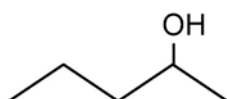
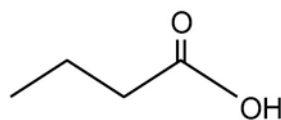
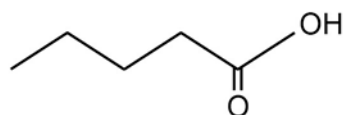
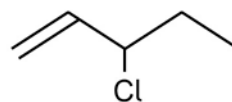
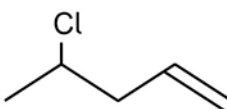
**D**      45 cm<sup>3</sup> of  $2.20 \times 10^{-2} \text{ mol dm}^{-3}$  sodium chloride solution      ☐

**Turn over for the next question**

1 3

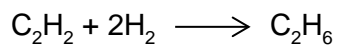
Which is a pair of functional group isomers?

[1 mark]

A ☐B ☐C ☐D ☐

1	4
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The equation for the hydrogenation of ethyne is



The experimental yield is 65.0%.

What is the mass in grams of ethane that can be produced from 16.20 g of hydrogen?  
[1 mark]

A 42.53 g

☐

B 78.98 g

☐

C 121.5 g

☐

D 527.7 g

☐

1	5
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Which molecule does **not** have a permanent dipole?

[1 mark]

A  $\text{CH}_3\text{Cl}$

☐

B  $\text{CHCl}_3$

☐

C  $\text{CF}_4$

☐

D  $\text{CHCl}_2\text{F}$

☐

Turn over for the next question

1	6
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Bromine exists as two isotopes  $^{79}\text{Br}$  and  $^{81}\text{Br}$ , which are found in almost equal abundance.

Which of the statements is correct?

[1 mark]

- A** The first ionisation energy of  $^{79}\text{Br}$  is less than the first ionisation energy of  $^{81}\text{Br}$  ☐
- B** The atomic radius of  $^{79}\text{Br}$  is less than the atomic radius of  $^{81}\text{Br}$  ☐
- C** The mass spectrum of  $\text{C}_3\text{H}_7\text{Br}$  has two molecular ion peaks at 122 and 124 ☐
- D**  $^{79}\text{Br}$  is more reactive than  $^{81}\text{Br}$  ☐

1	7
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Which of these species is **not** planar?

[1 mark]

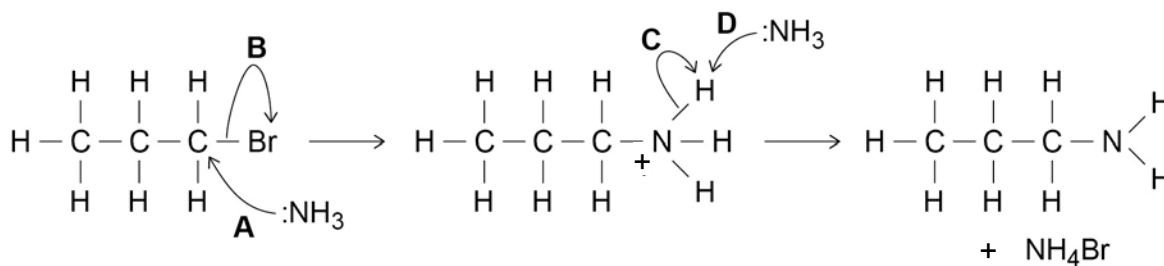
- A**  $\text{HCHO}$  ☐
- B**  $\text{CH}_3^+$  ☐
- C**  $\text{CH}_3\text{OH}$  ☐
- D**  $\text{C}_2\text{H}_4$  ☐

1 8

Which of the arrows, labelled **A**, **B**, **C** or **D** in the mechanism in **Figure 6**, is **not** correct?

[1 mark]

Figure 6

A ☐B ☐C ☐D ☐

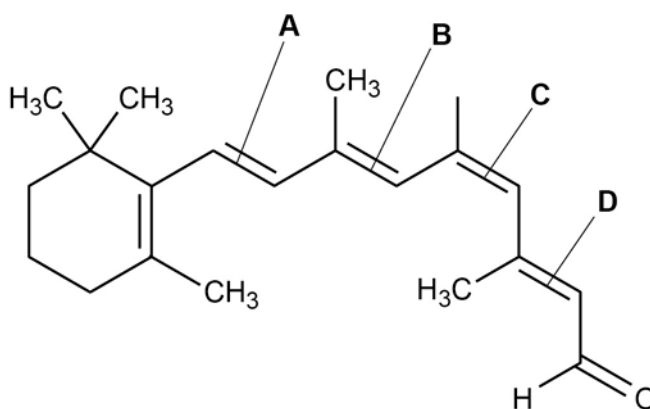
1 9

Z-Retinal, shown in **Figure 7**, is a component in vitamin A.

Which of the double bonds, labelled **A**, **B**, **C** or **D**, is responsible for the letter Z in the name?

[1 mark]

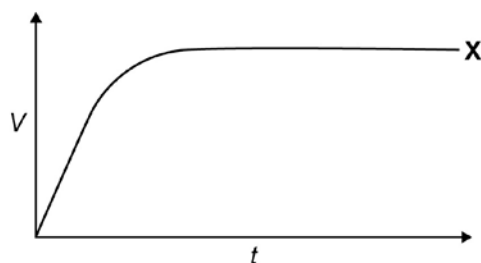
Figure 7

A ☐B ☐C ☐D ☐

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Line **X** in **Figure 8** represents the volume ( $V$ ) of gas formed with time ( $t$ ) in a reaction between an excess of magnesium and aqueous sulfuric acid.

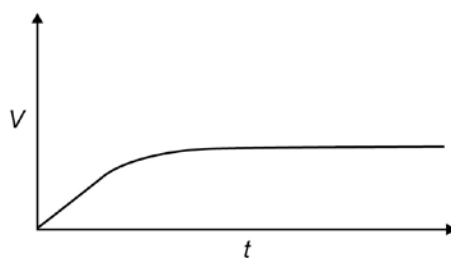
**Figure 8**



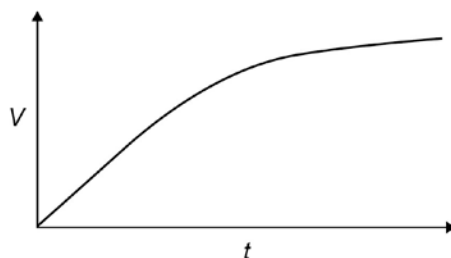
Which line represents the volume of hydrogen formed, at the same temperature and pressure, when the concentration of sulfuric acid has been halved?

[1 mark]

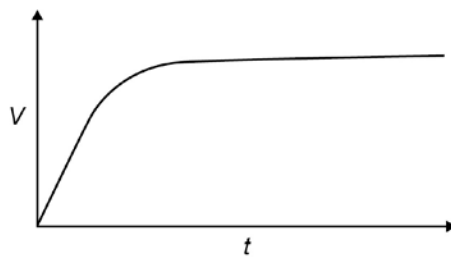
**A**



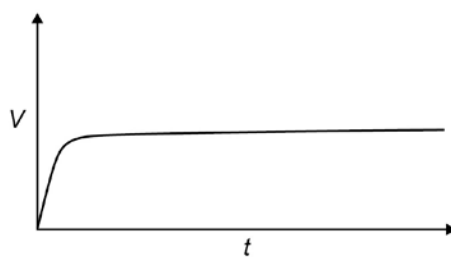
**B**



**C**



**D**





2	1
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The maximum uncertainty when weighing 0.250 g on a balance was 0.001 g.

What is the percentage uncertainty?

[1 mark]

- |          |      |                       |
|----------|------|-----------------------|
| <b>A</b> | 4.0% | <input type="radio"/> |
| <b>B</b> | 0.4% | <input type="radio"/> |
| <b>C</b> | 0.8% | <input type="radio"/> |
| <b>D</b> | 250% | <input type="radio"/> |

2	2
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Which species has the same number of electrons as the radical  $\bullet\text{CH}_3$ ?

[1 mark]

- |          |                 |                       |
|----------|-----------------|-----------------------|
| <b>A</b> | $\text{CH}_2$   | <input type="radio"/> |
| <b>B</b> | $\text{CH}_3^+$ | <input type="radio"/> |
| <b>C</b> | $\text{CH}_3^-$ | <input type="radio"/> |
| <b>D</b> | $\text{CH}_4^+$ | <input type="radio"/> |

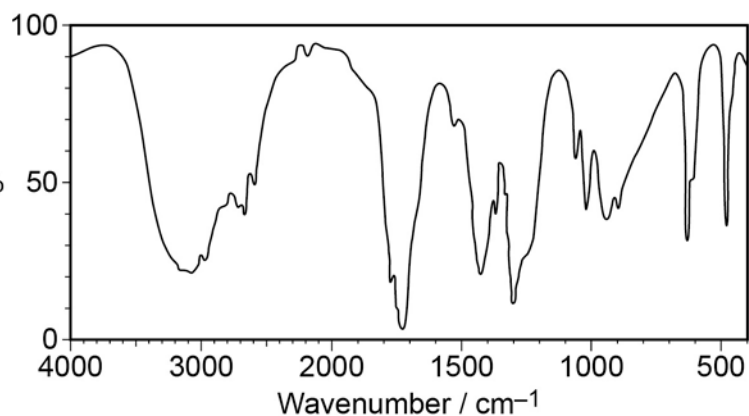
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**2 3**

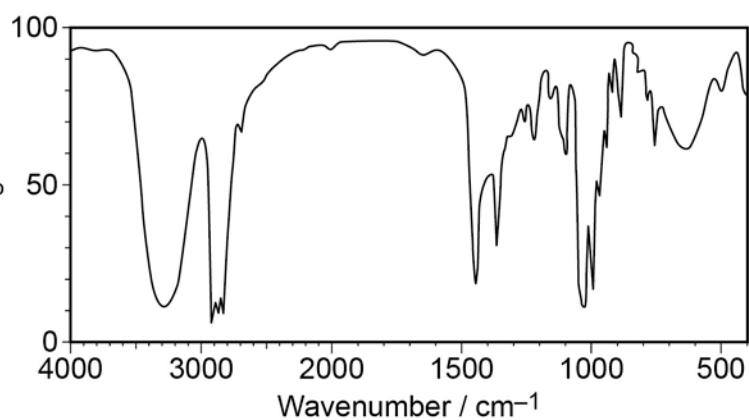
Which of these infrared spectra could represent a carboxylic acid?

**[1 mark]****A** ☐

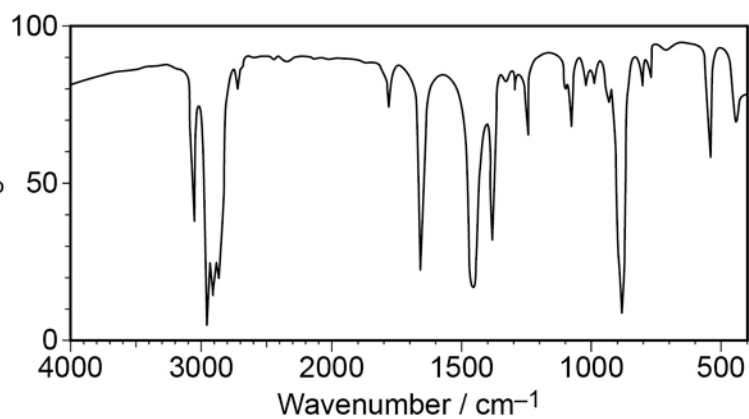
Transmittance / %

**B** ☐

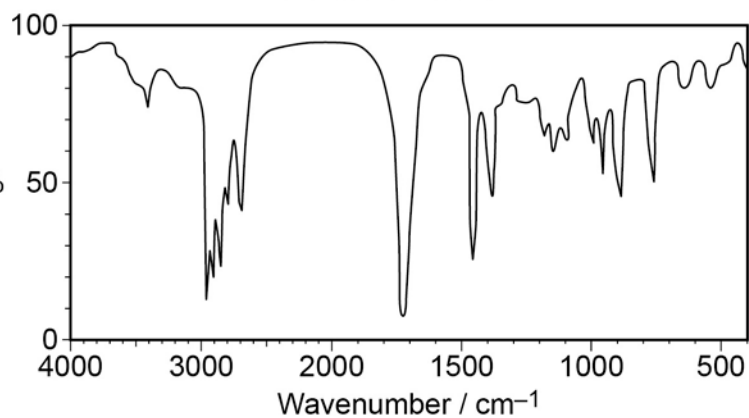
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**C** ☐

Transmittance / %

**D** ☐

Transmittance / %

**END OF QUESTIONS**

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ANSWER IN THE SPACES PROVIDED**

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