



Rewarding Learning

ADVANCED SUBSIDIARY (AS)
General Certificate of Education
2024

Centre Number

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Candidate Number

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Chemistry

Assessment Unit AS 2

assessing

Further Physical and Inorganic
Chemistry and an Introduction to
Organic Chemistry

MV24

[SCH24]

TUESDAY 21 MAY, MORNING

Time

1 hour 30 minutes, plus your additional time allowance.

Instructions to Candidates

Write your Centre Number and Candidate Number in the spaces provided at the top of this page.

Answer **all sixteen** questions in **Sections A and B**.

You must answer the questions in the spaces provided.

Do not write on blank pages.

Complete in black ink only.

Information for Candidates

The total mark for this paper is 90.

Quality of written communication will be assessed in Question **13(b)**.

The figures in brackets printed at the end of each question indicate the marks awarded to each question or part question.

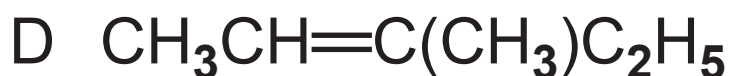
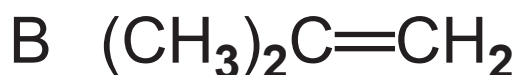
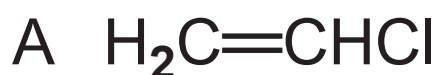
A Periodic Table of Elements, containing some data, is included with this question paper.

Section A

For each of the following questions, only **one** of the lettered responses (A–D) is correct.

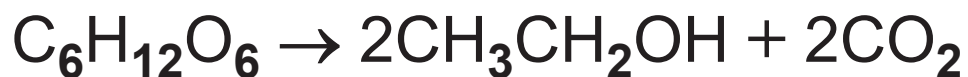
Select the correct response for each question and write the appropriate letter in the space provided.

1 Which one of the following exhibits E–Z isomerism? [1 mark]



Answer _____

2 Which one of the following is the atom economy for the production of ethanol by fermentation? [1 mark]



A 25.6%

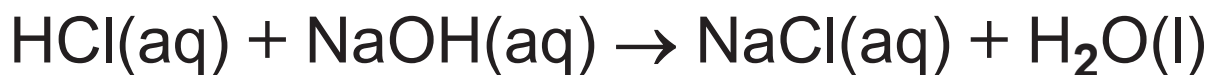
B 34.3%

C 51.1%

D 67.6%

Answer _____

- 3 When 10 cm^3 of 2.0 mol dm^{-3} hydrochloric acid is reacted with 10 cm^3 of 2.0 mol dm^{-3} sodium hydroxide solution, the temperature change is ΔT .



Which one of the following is the temperature change when the reaction is repeated with 50 cm^3 of each solution?

[1 mark]

A $\frac{1}{5} \times \Delta T$

B ΔT

C $5 \times \Delta T$

D $10 \times 2 \times \Delta T$

Answer _____

- 4 The equation for the reaction of propene with hydrogen bromide is shown below.



Which one of the following describes the mechanism for this reaction? [1 mark]

- A electrophilic addition
- B electrophilic substitution
- C nucleophilic addition
- D nucleophilic substitution

Answer _____

- 5 Which one of the following is the percentage yield of propanoic acid if 81.5 g are formed by the complete oxidation of 90.0 g of propan-1-ol? [1 mark]



A 73.4%

B 88.6%

C 89.5%

D 90.6%

Answer _____

6 Which one of the following is the catalyst used in the hydrogenation of alkenes?
[1 mark]

A iron

B manganese(IV) oxide

C nickel

D vanadium(V) oxide

Answer _____

7 Which one of the following reacts with ethanol to produce steamy fumes?
[1 mark]

A ammonia

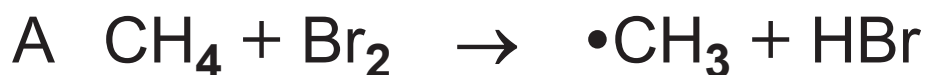
B hydrogen chloride

C phosphorus(V) chloride

D sodium

Answer _____

8 Which one of the following equations correctly shows a propagation step in the photochemical radical substitution reaction of methane with bromine? [1 mark]



Answer _____

9 Which one of the following shows the products for the reaction of magnesium with steam? [1 mark]

A magnesium hydroxide and hydrogen

B magnesium hydroxide and oxygen

C magnesium oxide and hydrogen

D magnesium oxide and oxygen

Answer _____

10 Which one of the following is the major product in the reaction between but-1-ene and hydrogen bromide? [1 mark]

A 1-bromobutane

B 2-bromobutane

C 1,1-dibromobutane

D 1,2-dibromobutane

Answer _____

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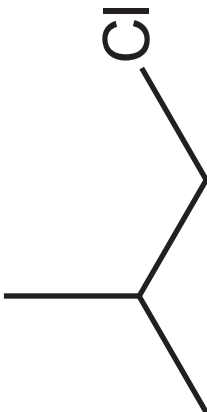
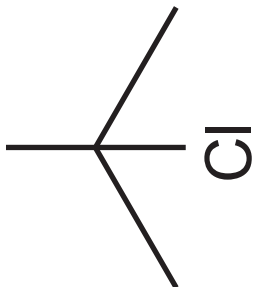
(Questions continue overleaf)

Section B

Answer **all six** questions in this section

11 Halogenoalkanes are reactive organic molecules.

(a) There are four structural isomers with the formula C_4H_9Cl . Complete the table opposite to give information about these isomers. [5 marks]

IUPAC name	Skeletal formula	Classification
1-chlorobutane		Primary
		Primary
		Secondary
2-chloro-2-methylpropane		

(b) 2-chloro-2-methylpropane reacts with aqueous potassium hydroxide.

(i) State the IUPAC name of the organic product of this reaction. [1 mark]

(ii) Draw the mechanism for the reaction of 2-chloro-2-methylpropane with aqueous potassium hydroxide. [4 marks]

(c) The progress of the reaction between 2-chloro-2-methylpropane and aqueous potassium hydroxide can be monitored using infrared spectroscopy.

(i) Explain why organic molecules absorb infrared radiation. [1 mark]

(ii) Describe how the infrared spectrum of 2-chloro-2-methylpropane is different from that of the purified product of the reaction in part **(b)**. [1 mark]

(d) Complete the following table, outlining reactions of 1-chlorobutane with different reagents. [4 marks]

Reagent	Conditions	Reaction type	Structure of organic product
Potassium hydroxide	Reflux in ethanolic solution		
Ammonia	Ammonia in ethanol, heat in sealed tube		$\text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_2\text{NH}_2$
Potassium cyanide	Reflux in ethanolic solution	Substitution	

12 Enthalpy changes may be determined using average bond enthalpy values and by Hess's Law.

(a) Define the following terms:
[2 marks for each]

(i) Average bond enthalpy

(ii) Hess's Law

(b) The equation for the thermal decomposition of barium nitrate is given below.



The table opposite shows some enthalpy changes which are involved in the determination of the enthalpy of decomposition of barium nitrate.

(i) Write an equation for the enthalpy of formation of nitrogen dioxide.
[2 marks]

Enthalpy change	Equation	ΔH /kJ mol ⁻¹
Enthalpy of formation of barium nitrate	$\text{Ba(s)} + \text{N}_2(\text{g}) + 3\text{O}_2(\text{g}) \rightarrow \text{Ba}(\text{NO}_3)_2(\text{s})$	-988.0
Enthalpy of formation of barium oxide	$\text{Ba(s)} + \frac{1}{2}\text{O}_2(\text{g}) \rightarrow \text{BaO(s)}$	-558.1
Enthalpy of formation of nitrogen dioxide		+33.2

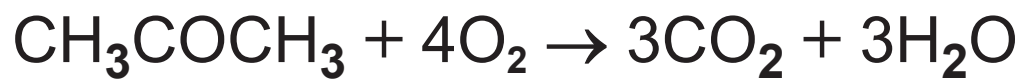
(ii) Using Hess's Law, calculate a value for the enthalpy change for the thermal decomposition of barium nitrate per mole of barium nitrate. Give your answer to 3 significant figures. [4 marks]

Answer _____ kJ mol⁻¹

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(Questions continue overleaf)

(c) The complete combustion of propanone is represented by the equation below:



$$\Delta H = -1821 \text{ kJ mol}^{-1}$$

Calculate the average bond enthalpy of the C=O bond. [4 marks]

Bond	Average bond enthalpy /kJ mol ⁻¹
C—H	412
C—C	348
O—H	463
O=C	496

Answer _____ kJ mol⁻¹

13 Organic compounds undergo a wide range of reactions.

(a) But-1-ene can undergo addition polymerisation.

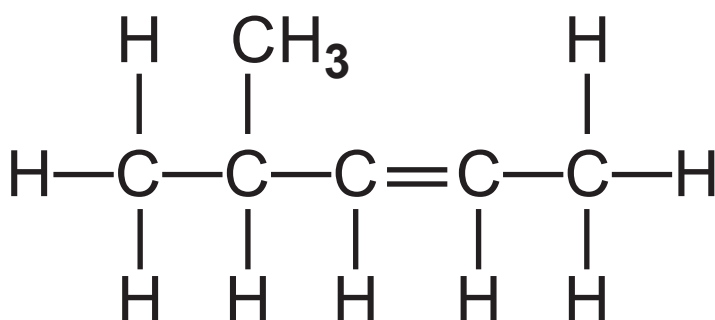
Draw the structure of the polymer formed from but-1-ene, showing three repeating units. [1 mark]

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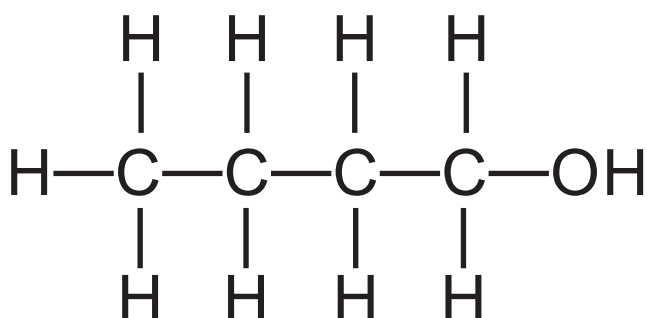
(Questions continue overleaf)

(c) The structures of two organic compounds, labelled **A** and **B**, are shown below. Compound **A** reacts with hydrogen and compound **B** reacts with acidified potassium dichromate(VI) solution.

A



B



(i) Write the empirical formula of compound **A**. [1 mark]

(ii) State the IUPAC names of compounds **A** and **B**. [2 marks]

A _____

B _____

(iii) State the IUPAC name of the compound formed when **A** reacts with hydrogen. [1 mark]

(iv) State the type of reaction which occurs when compound **B** reacts with acidified potassium dichromate(VI) solution. [1 mark]

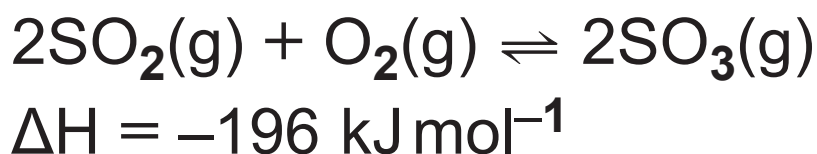
(v) Draw the structural formula of another alcohol, which is an isomer of compound **B**, that would **not** react with acidified potassium dichromate(VI) solution. Explain your answer. [2 marks]

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(Questions continue overleaf)

14 Sulfuric acid is manufactured by the Contact process.

One reaction in this process involves the conversion of sulfur dioxide to sulfur trioxide according to the following equation:



(a) This reaction can reach dynamic equilibrium. Define the term **dynamic equilibrium**. [2 marks]

(b) Write an expression for K_c for the reaction (opposite) and state its units. [2 marks]

Units: _____

(c) State and explain the effect of increasing the pressure on the equilibrium yield of sulfur trioxide. [3 marks]

(d) On the axes below, draw an enthalpy level diagram for this reaction. Label the axes and the enthalpy change (ΔH).
[3 marks]



(e) The sulfur trioxide produced in the Contact process is absorbed into 98% sulfuric acid to produce oleum ($\text{H}_2\text{S}_2\text{O}_7$). The oleum is then diluted by dissolving it in water to produce sulfuric acid.

Write an equation for the reaction between oleum and water to produce sulfuric acid. [1 mark]

15 (a) Catalytic converters convert unreacted hydrocarbons, such as ethane, to less harmful products.

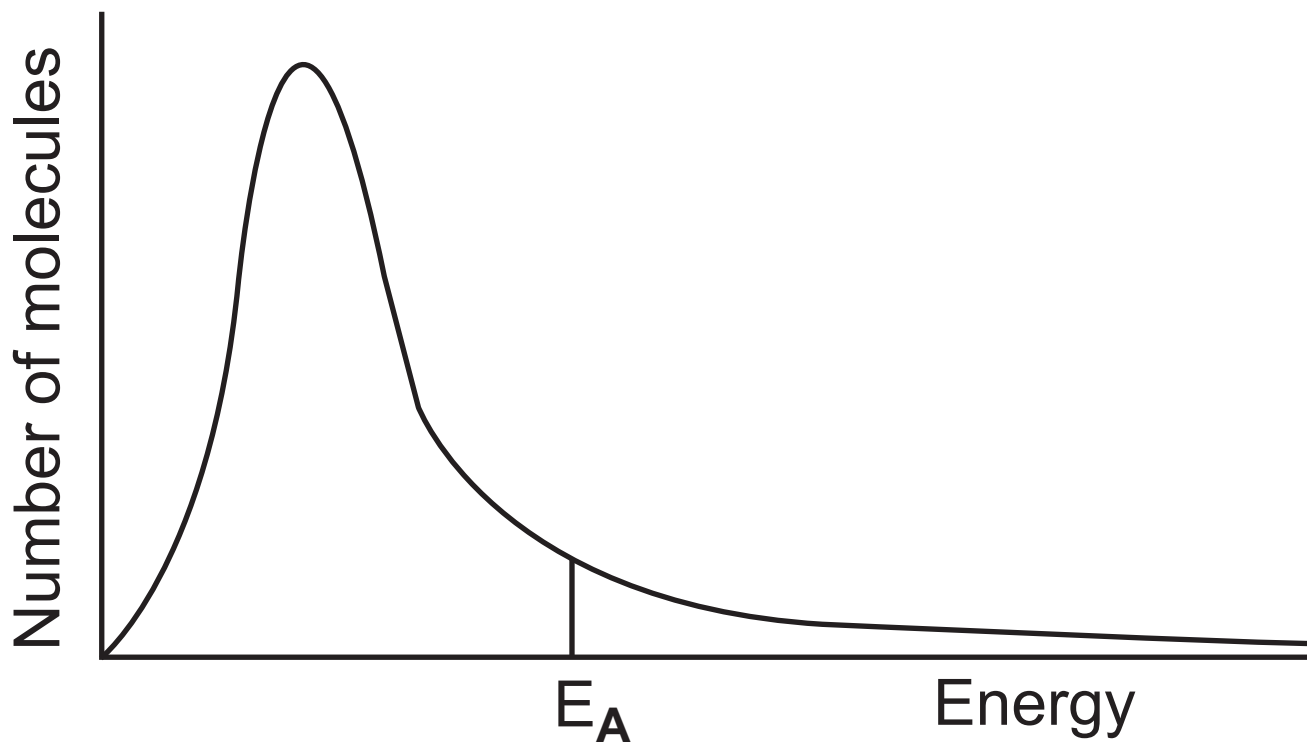
Calculate the total volume, in dm^3 , of gaseous products formed when 11.85 kg of ethane were reacted with excess nitrogen(IV) oxide in a catalytic converter.
[3 marks]

The molar gas volume is 24 dm^3 .



Answer _____ dm^3

(b) The Maxwell–Boltzmann distribution of molecular energies for a mixture of ethane and nitrogen(IV) oxide at 300 K is shown below.



(i) With reference to the graph, explain how the catalyst increases the rate of this chemical reaction. [3 marks]

(ii) Sketch on the graph the distribution of molecular energies you would expect to obtain at 500 K. [2 marks]

(c) Alkanes can be replaced as fuels by hydrogen or by alcohols, such as ethanol.

The table on page 42 compares the use of hydrogen and ethanol as fuels.

(i) Write an equation for the complete combustion of one mole of ethanol. [2 marks]

Fuel	Enthalpy of combustion /kJ mol⁻¹	Energy evolved per gram /kJ	Energy evolved per cm³ /kJ	State at room temperature and pressure
Hydrogen	-286	143	0.012	gas
Ethanol	-1367			liquid

(ii) Calculate the molar mass of ethanol.
[1 mark]

Answer _____ g mol⁻¹

(iii) Calculate the energy evolved per gram for ethanol. [1 mark]

Answer _____ kJ

(iv) Calculate the energy evolved per cm^3 for ethanol. The density of ethanol is 0.79 g cm^{-3} . [2 marks]

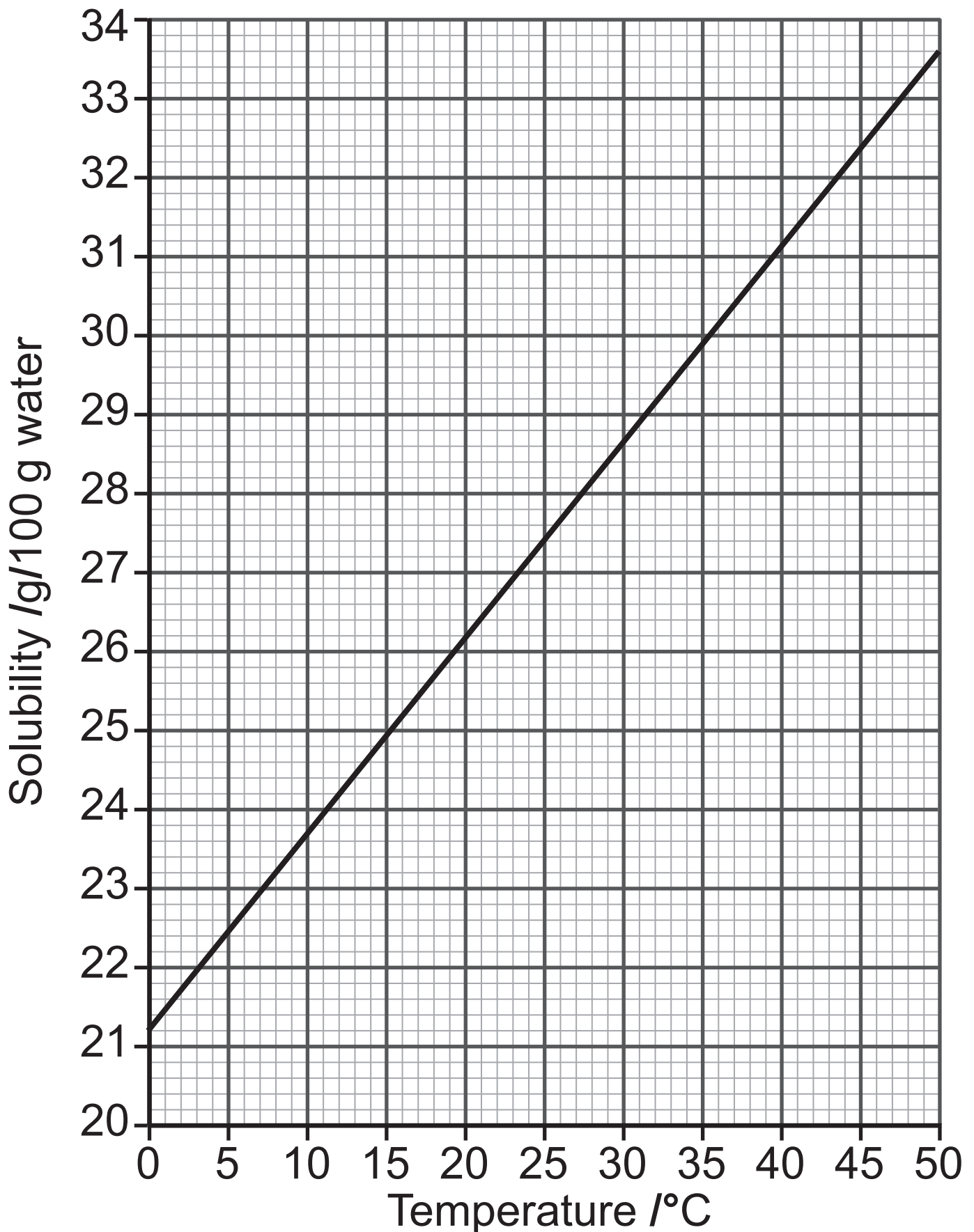
Answer _____ kJ

(v) Suggest one environmental advantage of using hydrogen as a fuel rather than ethanol. [1 mark]

16 The solubility of Group II compounds in water varies greatly.

(a) Explain what is meant by the term **solubility**. [1 mark]

(b) The graph below shows the solubility of magnesium sulfate at different temperatures.



- (i) Calculate the mass of solid that would crystallise when a saturated solution of magnesium sulfate in 2 kg of water is cooled from 30°C to 20°C.
[2 marks]

Answer _____ g

- (ii) Magnesium sulfate is formed when magnesium reacts with sulfuric acid. Write an equation for this reaction.
[1 mark]
-

(c) Group II metals react with water to form metal hydroxides.

(i) Write an equation for the reaction of calcium with water. [1 mark]

(ii) State the trend in solubility of the Group II hydroxides. [1 mark]

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(Questions continue overleaf)

(d) The table below shows the decomposition temperatures of the Group II carbonates.

Group II carbonate	Decomposition temperature /°C
magnesium carbonate	540
calcium carbonate	900
strontium carbonate	1290
barium carbonate	1360

(i) Write an equation for the decomposition of strontium carbonate. [1 mark]

(ii) State and explain the trend in the thermal stability of the Group II carbonates. [3 marks]

**This is the end of the
question paper**

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