A

AQA

Surname _____

Other Names _____

Centre Number _____

Candidate Number _____

Candidate Signature _____

I declare this is my own work.

AS

CHEMISTRY

Paper 2 Organic and Physical Chemistry

7404/2

Thursday 21 May 2020 Morning

Time allowed: 1 hour 30 minutes

At the top of the page, write your surname and other names, your centre number, your candidate number and add your signature.

[Turn over]

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 1-chloropropane.**

0 1 . 1 **Define the term standard enthalpy of formation. [2 marks]**

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[Turn over]

0 1 . 2 The equation for a reaction used to manufacture 1-chloropropane is

$$3\ CH_3CH_2CH_2OH(l) + PCl_3(l) \rightarrow 3\ CH_3CH_2CH_2Cl(l) + H_3PO_3(s)$$

The enthalpy change for this reaction, ΔH, is –114 kJ mol^{-1}

TABLE 1 contains some standard enthalpy of formation data.

TABLE 1

Substance	$PCl_3(l)$	$CH_3CH_2CH_2Cl(l)$	$H_3PO_3(s)$
$\Delta_f H^{\ominus}$ / kJ mol^{-1}	–339	–130	–972

Calculate a value for the standard enthalpy of formation of propan-1-ol using the enthalpy change for the reaction and data from TABLE 1. [3 marks]

Standard enthalpy of formation

_____ kJ mol^{-1}

[Turn over]

0 1 . 3 **1-chloropropane can also be produced by the reaction between propane and chlorine in the presence of ultraviolet light.**

State why ultraviolet light is needed for this reaction to occur.

Give an equation for each propagation step in the formation of 1-chloropropane from propane. [3 marks]

Why ultraviolet light is needed

Propagation step 1

Propagation step 2

0 1 . 4 **The C–Cl bond in 1-chloropropane is polar because carbon and chlorine have different electronegativities.**

Define the term electronegativity. [1 mark]

_____

_____

_____

_____

_____

[Turn over]

0 1 . 5 **Ammonia reacts with 1-chloropropane to form propylamine.**

Name and outline the mechanism for this reaction. [5 marks]

Name of mechanism

Outline of mechanism

0 2 **A student investigates the effect of temperature on the rate of reaction between sodium thiosulfate solution and dilute hydrochloric acid.**

$$Na_2S_2O_3(aq) + 2\,HCl(aq) \rightarrow 2\,NaCl(aq) + SO_2(g) + S(s) + H_2O(l)$$

The student mixes the solutions together in a flask and places the flask on a piece of paper marked with a cross.

The student records the time for the cross to disappear. The cross disappears because the mixture becomes cloudy.

TABLE 2 shows the student's results.

TABLE 2

Temperature / °C	22	31	36	42	49	54
Time, t, for cross to disappear / s	87	48	36	26	44	12
$\frac{1}{t}$ / s^{-1}	0.0115	0.0208	0.0278	0.0385	0.0227	

0 2 . 1 The student uses a stopwatch to measure the time. The stopwatch shows each time to the nearest 0.01 s

Suggest why the student records the times to the nearest second and not to the nearest 0.01 s [1 mark]

0 2 . 2 The rate of reaction is proportional to $\frac{1}{t}$

Complete TABLE 2. [1 mark]

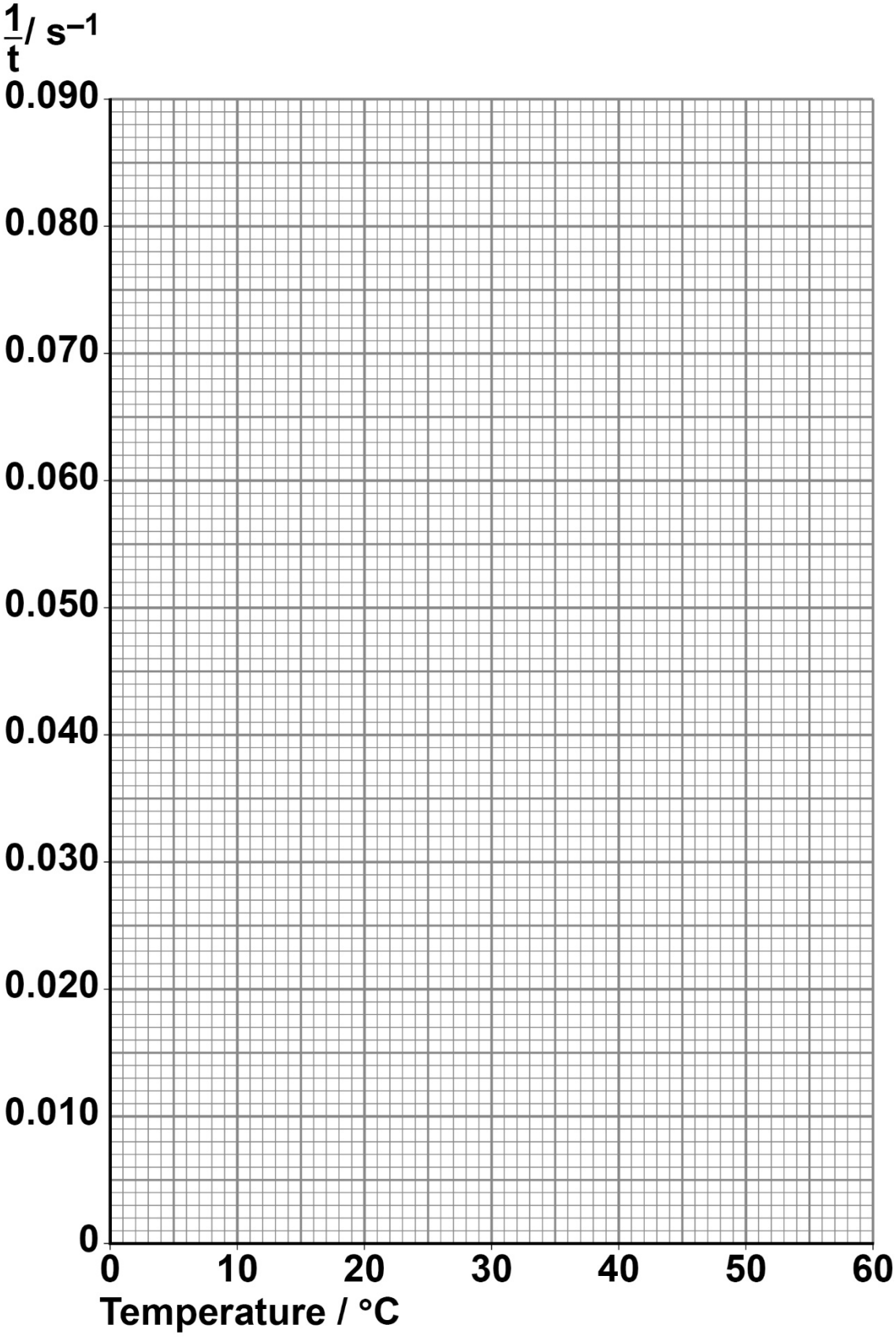
0 2 . 3 Plot the values of $\frac{1}{t}$ against temperature on FIGURE 1 on the opposite page.

Draw a line of best fit. [2 marks]

0 2 . 4 Use your line of best fit to estimate the time for the cross to disappear at 40 °C
Show your working. [1 mark]

Time _____ s

FIGURE 1


1/t / s−1
0.090
0.080
0.070
0.060
0.050
0.040
0.030
0.020
0.010
0
0
10
20
30
40
50
60
Temperature / °C

0 2 . 5 **Suggest, by considering the products of this reaction, why small amounts of reactants are used in this experiment. [1 mark]**

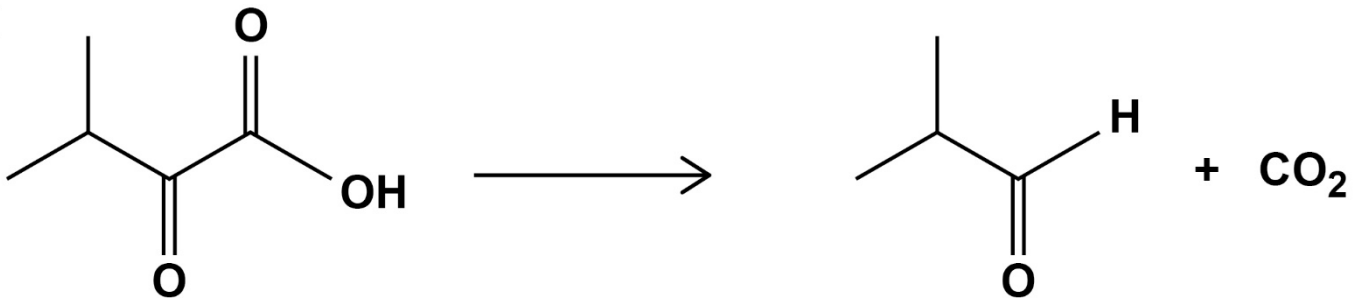
0 2 . 6 **The student could do the experiment at lower temperatures using an ice bath.**

Suggest why the student chose NOT to carry out experiments at temperatures in the range 1–10°C [1 mark]

7

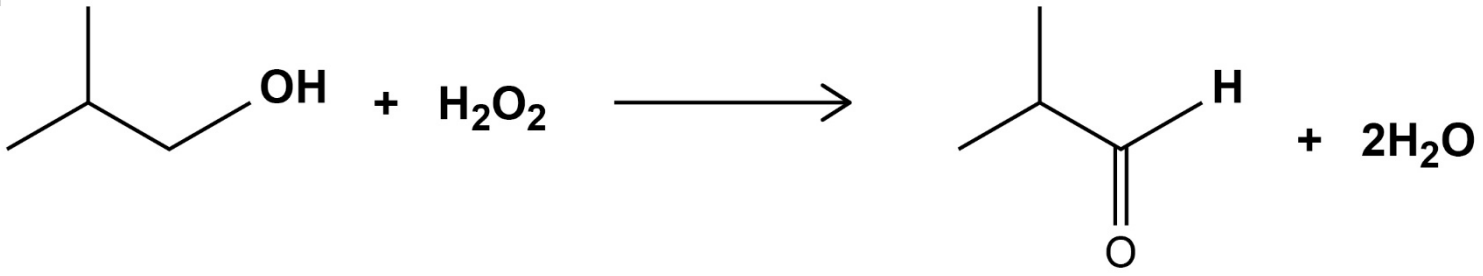
0 3 **A student investigates two experimental methods of making methylpropanal. The equations for these two methods are shown.**

METHOD 1



M_r = 116.0 M_r = 72.0

METHOD 2



M_r = 74.0 M_r = 72.0

In each method, the student uses 1.00 g of organic starting material.

The yield of methylpropanal obtained using each method and other data are included in TABLE 3.

TABLE 3

	Method 1	Method 2
Yield of methylpropanal / mg	552	778
Percentage yield		80.0%
Percentage atom economy	62.1%	

Calculate the percentage yield for Method 1, on page 21.

Calculate the percentage atom economy for Method 2, on page 23.

State the importance of percentage yield and percentage atom economy when choosing the method used to make a compound. [6 marks]

[Turn over]

REPEAT OF TABLE 3

	Method 1	Method 2
Yield of methylpropanal / mg	552	778
Percentage yield		80.0%
Percentage atom economy	62.1%	

% yield _____

Importance of percentage yield

_____

_____

_____

_____

[Turn over]

REPEAT OF TABLE 3

	Method 1	Method 2
Yield of methylpropanal / mg	552	778
Percentage yield		80.0%
Percentage atom economy	62.1%	

% atom economy _____

Importance of percentage atom economy

_____

_____

_____

_____

[Turn over]

6

0 4 **This question is about pentan-2-ol and pent-1-ene.**

0 4 . 1 **The boiling point of pentan-2-ol is 119 °C**
The boiling point of pent-1-ene is 30 °C

Explain why pentan-2-ol has a higher boiling point than pent-1-ene. [3 marks]

0 4 . 2 **Pent-1-ene is formed by the elimination of water from pentan-2-ol.**

State the reagent and condition for this reaction.

Outline the mechanism for this reaction.
[5 marks]

Reagent _____

Condition _____

Outline of mechanism

0 5 **Explain the differences between structural isomerism and stereoisomerism. Use examples to show how compounds with the molecular formula C_4H_8 exhibit stereoisomerism and the three types of structural isomerism. [6 marks]**

6

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[Turn over]

0 6 **This question is about poly(chloroethene), commonly known as PVC.**

0 6 . 1 **Give an equation, showing structural formulas, for the conversion of chloroethene into poly(chloroethene). [3 marks]**

0 6 . 2 **State what you would observe if bromine water was added to poly(chloroethene). Explain this observation. [2 marks]**

Observation _____

_____

Explanation _____

_____

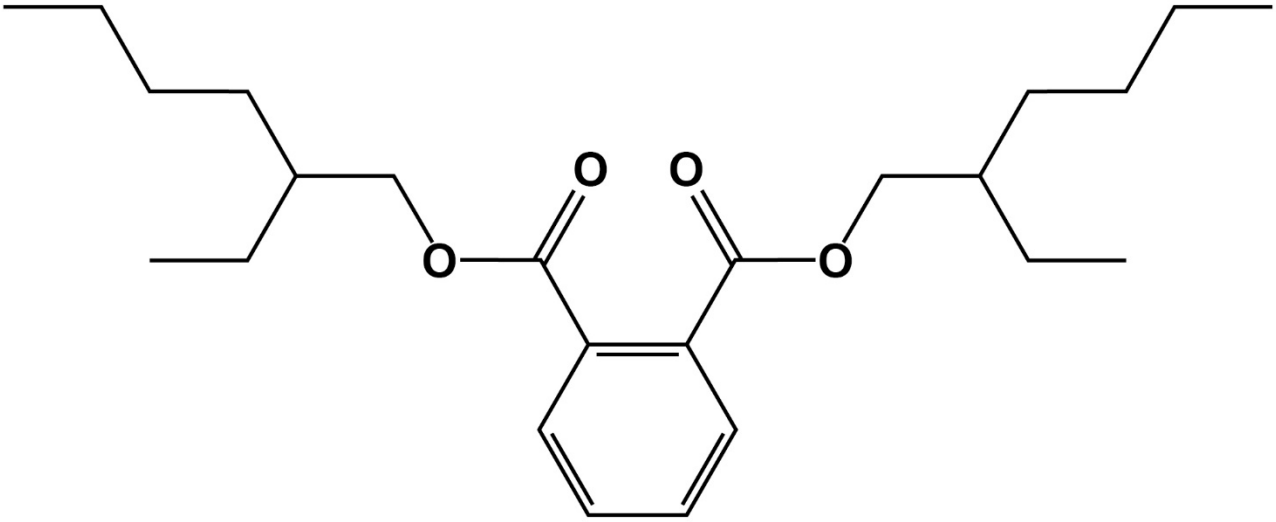
_____

_____

_____

[Turn over]

0 6 . 3 **Plasticisers are often added during the manufacture of PVC. The structure of the plasticiser DEHP is shown.**



Deduce the molecular formula of DEHP and state why a plasticiser is added to PVC.
[2 marks]

Molecular formula

Why a plasticiser is added

[Turn over]

7

0 7 **This question is about ethanedioic acid ($H_2C_2O_4$) which is a dicarboxylic acid.**

0 7 . 1 **Draw the skeletal formula of ethanedioic acid. [1 mark]**

0 7 . 2 **Ethanedioic acid is formed by the oxidation of ethane-1,2-diol ($HOCH_2CH_2OH$).**

State suitable reagent(s) and a condition for this reaction. [2 marks]

Reagent(s) _____

_____

_____

Condition _____

_____

_____

[Turn over]

0 7 . 3 **Ethanedioic acid reacts with an excess of sodium hydroxide to form sodium ethanedioate.**

$$H_2C_2O_4\,(aq) + 2\,NaOH\,(aq) \rightarrow Na_2C_2O_4\,(aq) + 2\,H_2O\,(l)$$

A student mixes 10.0 cm^3 of 0.400 mol dm^{-3} ethanedioic acid with 50.0 cm^3 of 0.200 mol dm^{-3} sodium hydroxide.

Show that the sodium hydroxide is in excess.

Calculate the mass, in mg, of sodium ethanedioate that can be formed in this reaction. [5 marks]

Mass of sodium ethanedioate

_____ **mg**

[Turn over]

8

0 8 **Hydrogen gas can be made by reacting ethanol with steam in the presence of a catalyst.**

$$C_2H_5OH(g) + H_2O(g) \rightleftharpoons 2\,CO(g) + 4\,H_2(g)$$

0 8 . 1 **Give an expression for K_c for this equilibrium.**

State its units. [2 marks]

K_c

Units of K_c _____

0 8 . 2 **TABLE 4 shows the amount of each substance in an equilibrium mixture in a container of volume 750 cm^3**

TABLE 4

Substance	$C_2H_5OH(g)$	$H_2O(g)$	$CO(g)$	$H_2(g)$
Amount of substance / mol	0.0750	0.156	0.110	0.220

Calculate K_c [3 marks]

K_c _____

[Turn over]

0 8 . 3 **The pressure of the equilibrium mixture was increased by reducing the volume of the container at constant temperature.**

Predict the effect of increasing the pressure on the equilibrium yield of hydrogen. Explain your answer.

Predict the effect of increasing the pressure on the value of K_c [4 marks]

Effect on equilibrium yield of hydrogen

Explanation

Effect on value of K_c

[Turn over]

9

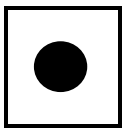
SECTION B

Answer ALL questions in this section.

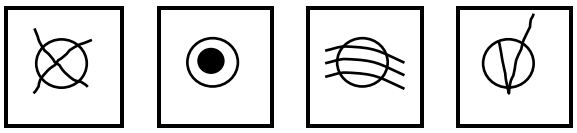
Only ONE answer per question is allowed.

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

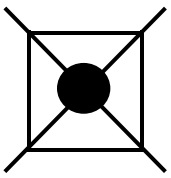
CORRECT METHOD



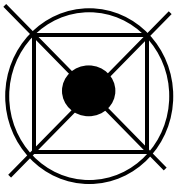
WRONG METHODS



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 statement is correct about thermal cracking? [1 mark]**

○ **A A pressure between 100 and 200 kPa is used.**

○ **B Aromatic hydrocarbons are the major products.**

○ **C C–C bonds are broken.**

○ **D Zeolite catalysts are used.**

[Turn over]

1 0 **Which statement is NOT correct about ozone? [1 mark]**

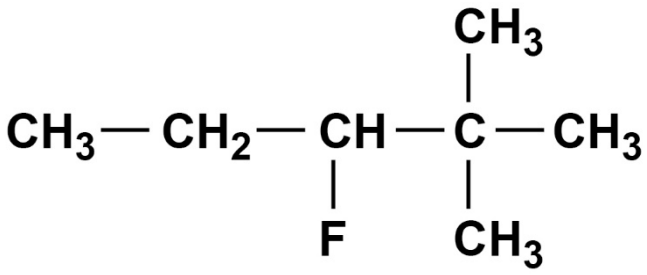
○ **A** **It absorbs harmful ultraviolet radiation in the upper atmosphere.**

○ **B** **It decomposes to form oxygen.**

○ **C** **Its decomposition is catalysed by chlorine molecules.**

○ **D** **Ozone holes are regions of the upper atmosphere where there is a reduced concentration of ozone.**

1 1 **What is the IUPAC name for this compound?**



[1 mark]

○ **A 2-dimethyl-3-fluoropentane**

○ **B 2,2-dimethyl-3-fluoropentane**

○ **C 3-fluoro-2,2-dimethylpentane**

○ **D 3-fluoro-2-dimethylpentane**

[Turn over]

1 2 **What is the IUPAC name of the major product of the reaction between 2-ethylbut-1-ene and hydrogen bromide? [1 mark]**

○ **A 1-bromo-2-ethylbutane**

○ **B 2-bromo-2-ethylbutane**

○ **C 2-bromo-2-methylpentane**

○ **D 3-bromo-3-methylpentane**

1 3 **Which can be used to distinguish between these two compounds?**

$(CH_3)_2CHCH_2CHO$ and $(CH_3)_3CCHO$

[1 mark]

○ **A Acidified potassium dichromate(VI)**

○ **B Fingerprint region of infrared spectrum**

○ **C M_r value in high resolution mass spectrometry**

○ **D Tollens' reagent**

[Turn over]

1 4 **An excess of methane reacts with chlorine in the presence of ultraviolet radiation.**

What are the main products of this reaction? [1 mark]

○ **A** CCl_4 **and** H_2

○ **B** CCl_4 **and** HCl

○ **C** CH_3Cl **and** H_2

○ **D** CH_3Cl **and** HCl

1 5 **In which reaction does the inorganic reagent act initially as an electrophile? [1 mark]**

○ **A** **bromoethane with ethanolic potassium hydroxide**

○ **B** **chloroethane with aqueous sodium hydroxide**

○ **C** **ethane with chlorine**

○ **D** **ethene with concentrated sulfuric acid**

[Turn over]

1 6 **What is the empirical formula of a hydrocarbon that contains 90% carbon by mass? [1 mark]**

○ **A** C_2H_3

○ **B** C_3H_2

○ **C** C_3H_4

○ **D** C_4H_3

1 7 **Which compound has the lowest relative molecular mass? [1 mark]**

○ **A ethanoic acid**

○ **B 1-fluoropropane**

○ **C propanenitrile**

○ **D propylamine**

[Turn over]

1 8 **Which statement is correct about the production and use of ethanol as a biofuel? [1 mark]**

○ **A** **Biofuel ethanol is produced by the fermentation of glucose in the presence of yeast and air.**

○ **B** **Biofuel ethanol is purified by fractional distillation.**

○ **C** **No carbon dioxide is released when biofuel ethanol is burned.**

○ **D** **Biofuel ethanol burns with a cleaner flame than ethanol made by hydration of ethene.**

1 9 **What is the minimum volume of 0.0500 mol dm^{-3} aqueous bromine needed to react completely with 0.0200 g of buta-1,3-diene?**

(M_r of buta-1,3-diene = 54.0)

[1 mark]

○ **A 7.40 cm^3**

○ **B 14.8 cm^3**

○ **C 29.6 cm^3**

○ **D 67.5 cm^3**

[Turn over]

2 0 **Which statement about the molecules in a sample of a gas is correct? [1 mark]**

○ **A At a given temperature they all move at the same speed.**

○ **B At a given temperature their average kinetic energy is constant.**

○ **C As temperature increases, there are more molecules with the most probable energy.**

○ **D As temperature decreases, there are fewer molecules with the mean energy.**

2 1 **Some enthalpy change data are shown.**

$C(s) + 2\ H_2(g) \rightarrow CH_4(g) \quad \Delta H = -75\ kJ\ mol^{-1}$

$H_2(g) \rightarrow 2\ H(g) \quad \Delta H = +436\ kJ\ mol^{-1}$

What is the enthalpy change, in kJ mol^{-1}, for the following reaction?

$CH_4(g) \rightarrow C(s) + 4\ H(g)$

[1 mark]

○ **A –947**

○ **B –361**

○ **C +361**

○ **D +947**

[Turn over]

2 2 **The temperature changed from 21.8 °C to 19.2 °C during a calorimetry experiment.**

The uncertainty of each reading of the thermometer is ±0.1 °C

What is the percentage uncertainty in the temperature change? [1 mark]

○ **A 0.5%**

○ **B 1.0%**

○ **C 3.8%**

○ **D 7.7%**

2 3 An experiment is done to determine the enthalpy of combustion of a fuel using a calorimeter containing water.

b = mass of fuel burned / g
w = mass of water heated / g
ΔT = temperature rise of water / K
M_r = relative molecular mass of fuel
c = specific heat capacity of water / J K^{-1} g^{-1}

Which expression gives the enthalpy of combustion (in J mol^{-1}), assuming there is no heat loss? [1 mark]

○ A $-\dfrac{c\,w\,\Delta T\,M_r}{b}$

○ B $-\dfrac{c\,b\,\Delta T M_r}{w}$

○ C $-\dfrac{c\,b\,w\,M_r}{\Delta T}$

○ D $-\dfrac{c\,b\,w\,\Delta T}{M_r}$

15

END OF QUESTIONS

Additional page, if required.
Write the question numbers in the left-hand margin.

Additional page, if required.
Write the question numbers in the left-hand margin.

Additional page, if required.
Write the question numbers in the left-hand margin.

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Write the question numbers in the left-hand margin.

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For Examiner's Use	
Question	Mark
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Section B	
TOTAL	