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AS Level Chemistry A

H032/01 Breadth in chemistry

Friday 26 May 2017 – Morning

Time allowed: 1 hour 30 minutes

You must have:
- the Data Sheet for Chemistry A (sent with general stationery)

You may use:
- a scientific or graphical calculator

First name									
Last name									
Centre number						Candidate number				

INSTRUCTIONS
- Use black ink. HB pencil may be used for graphs and diagrams only.
- Complete the boxes above with your name, centre number and candidate number.
- Answer **all** the questions.
- Write your answer to each question in the space provided. If additional space is required, you should use the lined page(s) at the end of this booklet. The question number(s) must be clearly shown.
- Do **not** write in the barcodes.

INFORMATION
- The total mark for this paper is **70**.
- The marks for each question are shown in brackets **[ ]**.
- This document consists of **24** pages.

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SECTION A

You should spend a maximum of 25 minutes on this section.

Answer **all** the questions.

Write your answer to each question in the box provided.

1 Which ion has a different number of electrons from the other three ions?

A Ga^{3+}

B Cl^{-}

C S^{2-}

D Ca^{2+}

Your answer ☐ **[1]**

2 An organic compound has the composition by mass:

C, 53.33 %; H, 11.11%; O, 35.56%.

What is the empirical formula of the organic compound?

A $C_4H_8O_2$

B $C_4H_{10}O_2$

C C_2H_4O

D C_2H_5O

Your answer ☐ **[1]**

3 Samples of four hydrocarbons are completely burnt under the same conditions of temperature and pressure.

Which sample produces the greatest volume of CO_2?

A 0.4 mol C_2H_6

B 0.3 mol C_3H_8

C 0.2 mol C_4H_{10}

D 0.1 mol C_5H_{12}

Your answer ☐ **[1]**

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4 Which reaction produces the smallest atom economy of $BaCl_2$?

A $BaCl_2 \cdot 2H_2O \rightarrow BaCl_2 + 2H_2O$

B $BaO + 2HCl \rightarrow BaCl_2 + H_2O$

C $BaCO_3 + 2HCl \rightarrow BaCl_2 + CO_2 + H_2O$

D $Ba + 2HCl \rightarrow BaCl_2 + H_2$

Your answer ☐ **[1]**

5 The burette readings from a titration are shown below.

Final reading / cm^3	24.95
Initial reading / cm^3	5.00

The burette used has an uncertainty of ±0.05 cm^3 in each reading.

What is the percentage uncertainty of the resulting titre?

A 0.20%

B 0.25%

C 0.45%

D 0.50%

Your answer ☐ **[1]**

6 Which element has atoms with the greatest number of singly occupied orbitals?

A C

B Cl

C Ca

D Ga

Your answer ☐ **[1]**

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7 Which compound has polar molecules?

A OCl_2

B BCl_3

C CCl_4

D SCl_6

Your answer ☐ **[1]**

8 Which element has the highest melting point?

A silicon

B phosphorus

C sulfur

D chlorine

Your answer ☐ **[1]**

9 What is the best explanation for the trend in boiling points down the halogens group?

A The covalent bonds become stronger.

B The hydrogen bonds become stronger.

C The permanent dipole–dipole interactions become stronger.

D The induced dipole–dipole interactions (London forces) increase.

Your answer ☐ **[1]**

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10 Which silver compound is insoluble in concentrated $NH_3(aq)$?

A $AgNO_3$

B $AgCl$

C AgBr

D AgI

Your answer ☐ **[1]**

11 $50.0\,cm^3$ of $1.00\,mol\,dm^{-3}$ NaOH is neutralised by $50.0\,cm^3$ of $1.00\,mol\,dm^{-3}$ HNO_3.
The temperature increases by 6.0 °C.

The experiment is repeated using:
$25.0\,cm^3$ of $1.00\,mol\,dm^{-3}$ NaOH and $25.0\,cm^3$ of $1.00\,mol\,dm^{-3}$ HNO_3.

What is the increase in temperature in the second experiment?

A 1.5 °C

B 3.0 °C

C 6.0 °C

D 12.0 °C

Your answer ☐ **[1]**

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12 The table shows standard enthalpy changes of combustion, $\Delta_c H$.

Substance	$\Delta_c H$ / kJ mol^{-1}
C(s)	–393.5
$H_2(g)$	–285.8
$C_4H_{10}(g)$	–2876.5

What is the enthalpy change for the following reaction?

$$4C(s) + 5H_2(g) \rightarrow C_4H_{10}(g)$$

A –2197.2 kJ mol^{-1}

B –126.5 kJ mol^{-1}

C +126.5 kJ mol^{-1}

D +2197.2 kJ mol^{-1}

Your answer ☐ **[1]**

13 The reversible reaction below is allowed to reach equilibrium.

$$H_2(g) + I_2(g) \rightleftharpoons 2HI(g) \qquad \Delta H = -9.4\,\text{kJ mol}^{-1}$$

Which change in conditions would be expected to shift the equilibrium position towards the products?

A decrease the pressure

B decrease the temperature

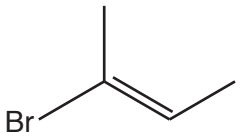
C increase the pressure

D increase the temperature

Your answer ☐ **[1]**

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14 What is the systematic name of the compound below?



A *E*-2-bromobut-2-ene

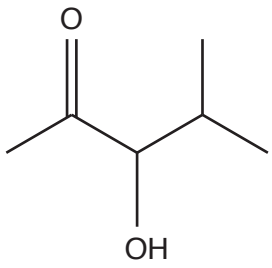
B *Z*-2-bromobut-2-ene

C *E*-1,2-dimethyl-1-bromoethene

D *Z*-1,2-dimethyl-1-bromoethene

Your answer ☐ **[1]**

15 The skeletal formula of an organic compound is shown below.



What is the molecular formula of the organic compound?

A $C_6H_{10}O_2$

B $C_6H_{11}O_2$

C $C_6H_{12}O_2$

D $C_6H_{13}O_2$

Your answer ☐ **[1]**

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16 How many structural isomers have the molecular formula C_5H_{12}?

A 2

B 3

C 4

D 5

Your answer ☐ **[1]**

17 Which organic compound has the lowest boiling point?

A 2,3,4-trimethylpentane

B 2,3-dimethylhexane

C 2-methylheptane

D octane

Your answer ☐ **[1]**

18 Which alcohol reacts with an acid catalyst to form *E* and *Z* stereoisomers?

A pentan-3-ol

B pentan-1-ol

C 2-methylbutan-2-ol

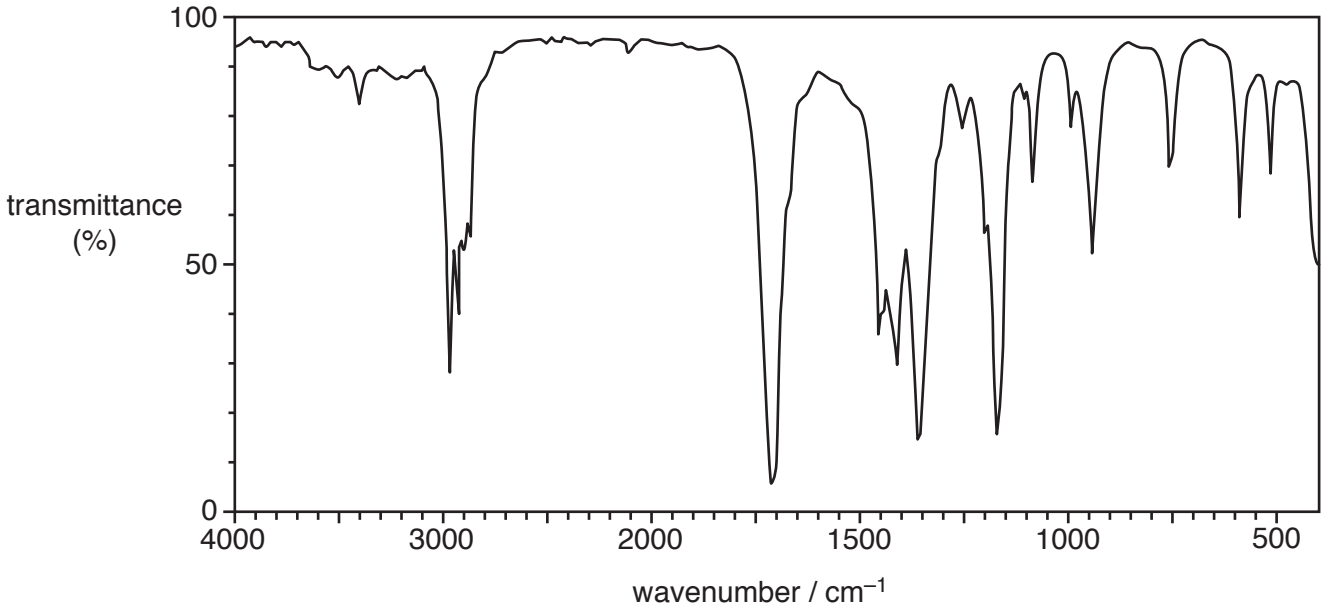
D 2,2-dimethylpropan-1-ol

Your answer ☐ **[1]**

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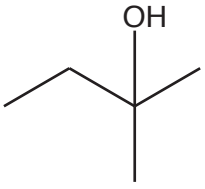
19 An alcohol **A** is heated under reflux with sulfuric acid and potassium dichromate(VI).

The organic compound formed produces the infrared spectrum below.

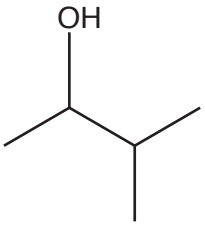


Which compound could be alcohol **A**?

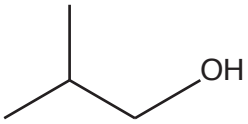
A



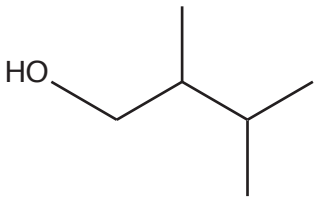
B



C



D



Your answer ☐ **[1]**

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20 Which alcohol is **not** likely to have a fragment ion at $m/z = 43$ in its mass spectrum?

A $CH_3CH_2CH(OH)CH_3$

B $CH_3CH_2CH_2CH_2OH$

C $CH_3CH(OH)CH_2CH_2CH_3$

D $(CH_3)_2CHCH_2OH$

Your answer ☐ **[1]**

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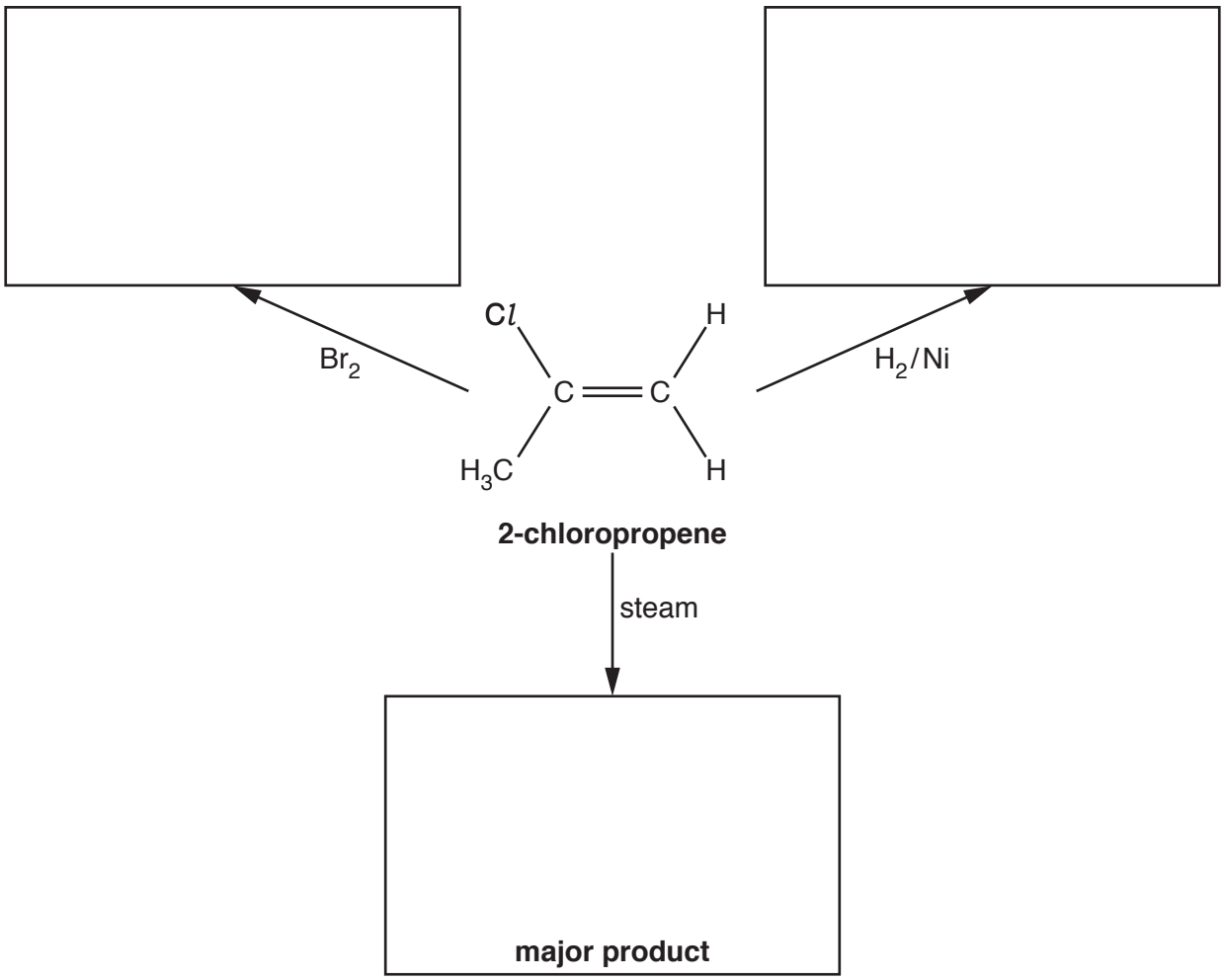
SECTION B

Answer **all** the questions.

21 This question is about 2-chloropropene, C_3H_5Cl.

(a) Three reactions of 2-chloropropene are shown in the flowchart below.

(i) Complete the flowchart to show the organic products formed in the reactions.



[3]

(ii) The reaction of 2-chloropropene with steam requires a catalyst.

State a suitable catalyst for this reaction.

..... **[1]**

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(b) 2-chloropropene can be polymerised to form poly(2-chloropropene).

(i) Write a balanced equation for the formation of this polymer.

The equation should include the structure of the repeat unit of the polymer.

[2]

(ii) After their useful life, waste polymers can be disposed of by combustion.

State **one** particular problem with disposal of poly(2-chloropropene) by combustion.

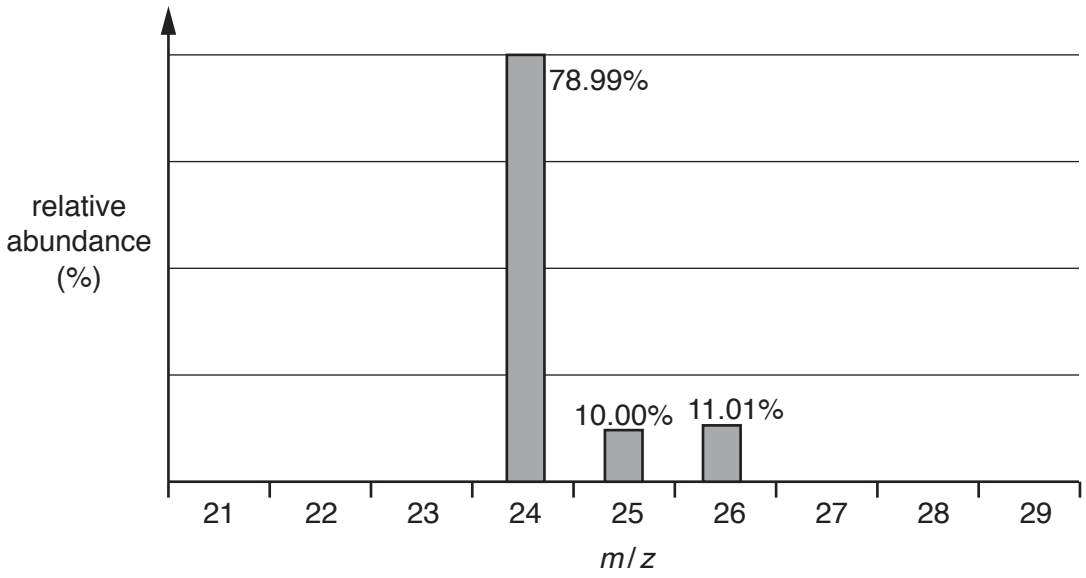
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..... **[1]**

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22 This question is about elements from the s-block and p-block of the periodic table.

(a) A sample of magnesium is analysed by mass spectrometry. The mass spectrum is shown below.



(i) The species causing the peaks in the mass spectrum are 1+ ions of magnesium.

Complete the table to show the number of protons, neutrons and electrons in each **1+ ion** of magnesium.

m/*z*	protons	neutrons	electrons
24			
25			
26			

[2]

(ii) Calculate the relative atomic mass of the magnesium in the sample.

Give your answer to **two** decimal places.

relative atomic mass = ... **[2]**

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(b) **B** and **C** are ionic compounds of two different Group 1 elements.
The molar masses of **B** and **C** are both approximately 140 g mol^{-1}.

A student dissolves **B** and **C** in water in separate test tubes and analyses the solutions.

The observations are shown below.

Test	Observation	
	B(aq)	**C(aq)**
Addition of HNO_3(aq) followed by $BaCl_2$(aq)	bubbles no change	no change white precipitate

Use this information and the observations to identify the formulae of **B** and **C**.

Explain your reasoning.

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(c) **Fig. 22.1** shows first ionisation energies for elements across Period 3.

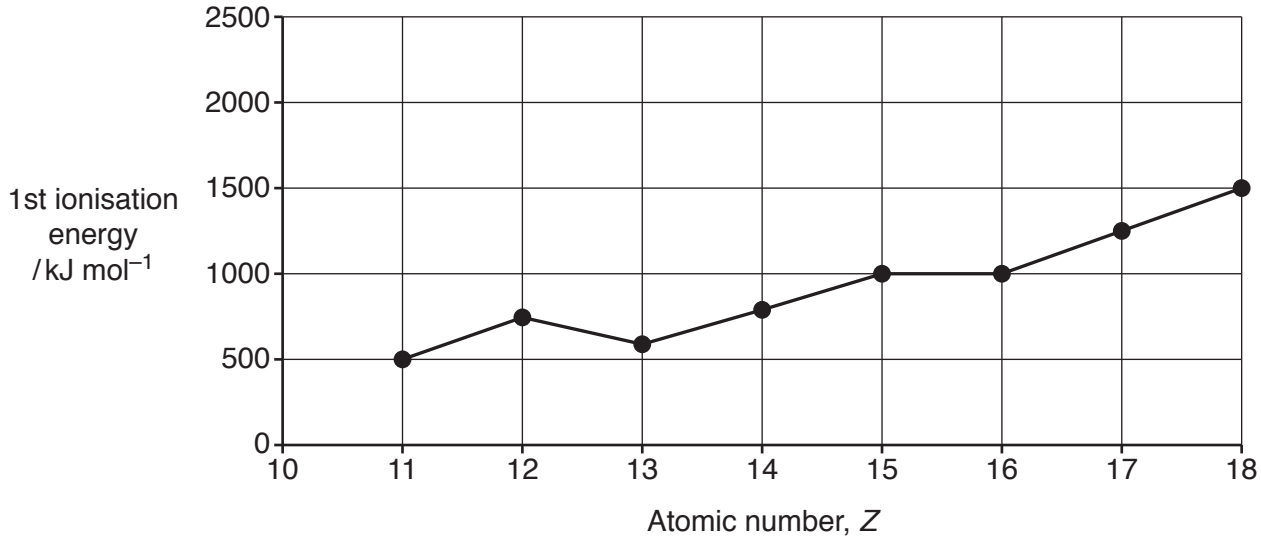


Fig. 22.1

(i) Add a point to **Fig. 22.1** for the first ionisation energy of the element with $Z = 10$. **[1]**

(ii) Estimate the energy required to form **one** $Na^+(g)$ ion from one Na(g) atom.

Give your answer in kJ, in standard form, and to **two** significant figures.

energy = ... kJ **[1]**

(iii) Explain why the first ionisation energies in **Fig. 22.1** show a general increase across Period 3 (Na–Ar).

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..... **[3]**

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(iv) Explain why the general increase in first ionisation energies across Period 3 is **not** followed for Mg (Z = 12) to Al (Z = 13).

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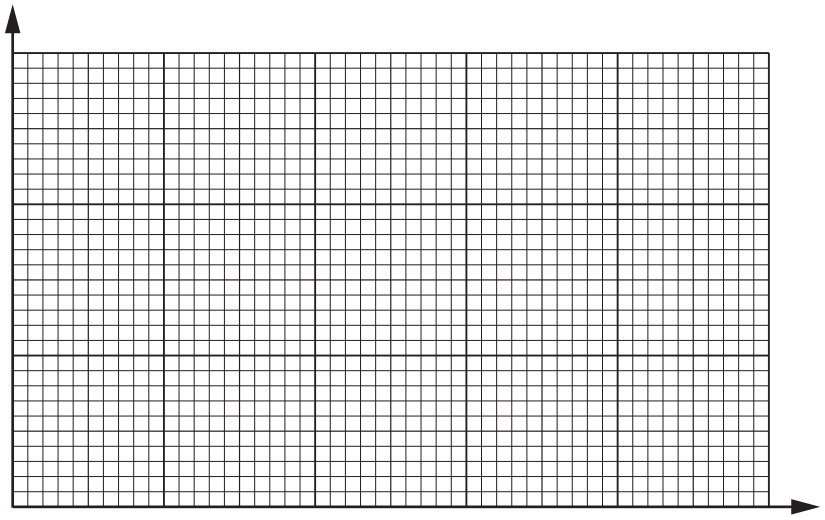
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23 Methanol can be prepared industrially by reacting carbon monoxide with hydrogen in the presence of a copper catalyst. This is a reversible reaction.

$$CO(g) + 2H_2(g) \rightleftharpoons CH_3OH(g)$$

(a) Using the Boltzmann distribution model, explain why the rate of a reaction increases in the presence of a catalyst.

You are provided with the axes below, which should be labelled.



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..... **[4]**

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(b) The reaction for the production of methanol in the presence of the copper catalyst is carried out at 200–300 °C.

Explain why use of the catalyst reduces energy demand and benefits the environment.

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..... **[2]**

(c) A chemist investigates the equilibrium that produces methanol:

$$CO(g) + 2H_2(g) \rightleftharpoons CH_3OH(g)$$

The chemist mixes CO(g) with $H_2(g)$ and leaves the mixture to react until equilibrium is reached.
The equilibrium mixture is analysed and found to contain the following concentrations.

Substance	**Concentration /mol dm^{-3}**
CO(g)	0.310
$H_2(g)$	0.240
$CH_3OH(g)$	0.260

Calculate the numerical value of K_c for this equilibrium.

Give your answer to an **appropriate** number of significant figures.

K_c = ... dm^2 mol^{-6} **[2]**

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24 Ethanoic acid, CH_3COOH, is the main dissolved acid in vinegar.

(a) Ethanoic acid is a weak acid.

What is meant by *acid* and *weak acid*?

.....

.....

..... **[1]**

(b) Aluminium is reacted with ethanoic acid.

(i) The unbalanced equation for the reaction is shown below.

Balance the equation.

……. $Al(s)$ + ……. $CH_3COOH(aq) \rightarrow$ ……. $(CH_3COO)_3Al(aq)$ + …… $H_2(g)$

[1]

(ii) This reaction is a redox reaction.

Deduce which element has been oxidised and which element has been reduced, and state the changes in oxidation number.

Element oxidised: ..... oxidation number change: from ..... to .....

Element reduced: ..... oxidation number change: from ..... to .....

[2]

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(c) A student plans to determine the concentration, in mol dm^{-3}, of CH_3COOH in a bottle of vinegar. The student will carry out a titration with aqueous barium hydroxide, $Ba(OH)_2(aq)$.

The student's method is outlined below.

- Dilute 10.0 cm^3 of vinegar from the bottle with distilled water and make the solution up to 250.0 cm^3.
- Add the diluted vinegar to the burette.
- Titrate 25.0 cm^3 volumes of 0.0450 mol dm^{-3} $Ba(OH)_2$ with the diluted vinegar.

The mean titre of the diluted vinegar is 25.45 cm^3.

The reaction in the student's titration is shown below.

$$2CH_3COOH(aq) + Ba(OH)_2(aq) \rightarrow (CH_3COO)_2Ba(aq) + 2H_2O(l)$$

(i) Calculate the concentration, in mol dm^{-3}, of CH_3COOH in the original bottle of vinegar.

Show your working.

concentration of CH_3COOH = ... mol dm^{-3} **[4]**

(ii) Suggest **one** assumption that the student has made that might mean that their calculated concentration of ethanoic acid in the vinegar is invalid.

Predict, with a reason, how the experimental result would differ from the actual concentration of CH_3COOH if the assumption were **not** correct.

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..... **[2]**

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25 This question is about alkenes.

(a) The combustion of ethene is shown in **equation 25.1** below.

$C_2H_4(g) + 3O_2(g) \rightarrow 2CO_2(g) + 2H_2O(g)$ $\Delta H = -1318$ kJ mol^{-1} **equation 25.1**

(i) Explain, in terms of bond breaking and bond forming, why a reaction can be exothermic.

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..... **[1]**

(ii) Average bond enthalpies are shown in the table.

Bond	Average bond enthalpy /kJ mol^{-1}
O–H	+464
O=O	+498
C–H	+413
C=O	+805

Calculate the average bond enthalpy of the C=C bond.
Use the average bond enthalpies in the table and **equation 25.1**.

average bond enthalpy = ... kJ mol^{-1} **[3]**

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(b) An alkene **D** is a liquid at room temperature and pressure but can easily be vaporised.

When vaporised, 0.1881 g of **D** produces 82.5 cm^3 of gas at 101 kPa and 373 K.

Determine the molar mass and molecular formula of alkene **D**.

Show all your working.

molar mass = ... g mol^{-1}

molecular formula = ... **[5]**

END OF QUESTION PAPER

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ADDITIONAL ANSWER SPACE

If additional space is required, you should use the following lined page(s). The question number(s) must be clearly shown in the margin(s).

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