

Please write clearly in block capitals.

Centre number

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Candidate number

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Surname *StemUp Model Solution*

Forename(s)

Candidate signature

I declare this is my own work.

INTERNATIONAL AS CHEMISTRY (9620)

Unit 2: Organic 1 and Physical 1

Thursday 9 January 2025 07:00 GMT Time allowed: 1 hour 30 minutes

Materials

For this paper you must have:

- the Periodic Table/Data Sheet, provided as an insert
- 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 70.

For Examiner's Use	
Question	Mark
1	
2	
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8	
9	
TOTAL	



J A N 2 5 C H O 2 0 1

Answer **all** questions in the spaces provided.

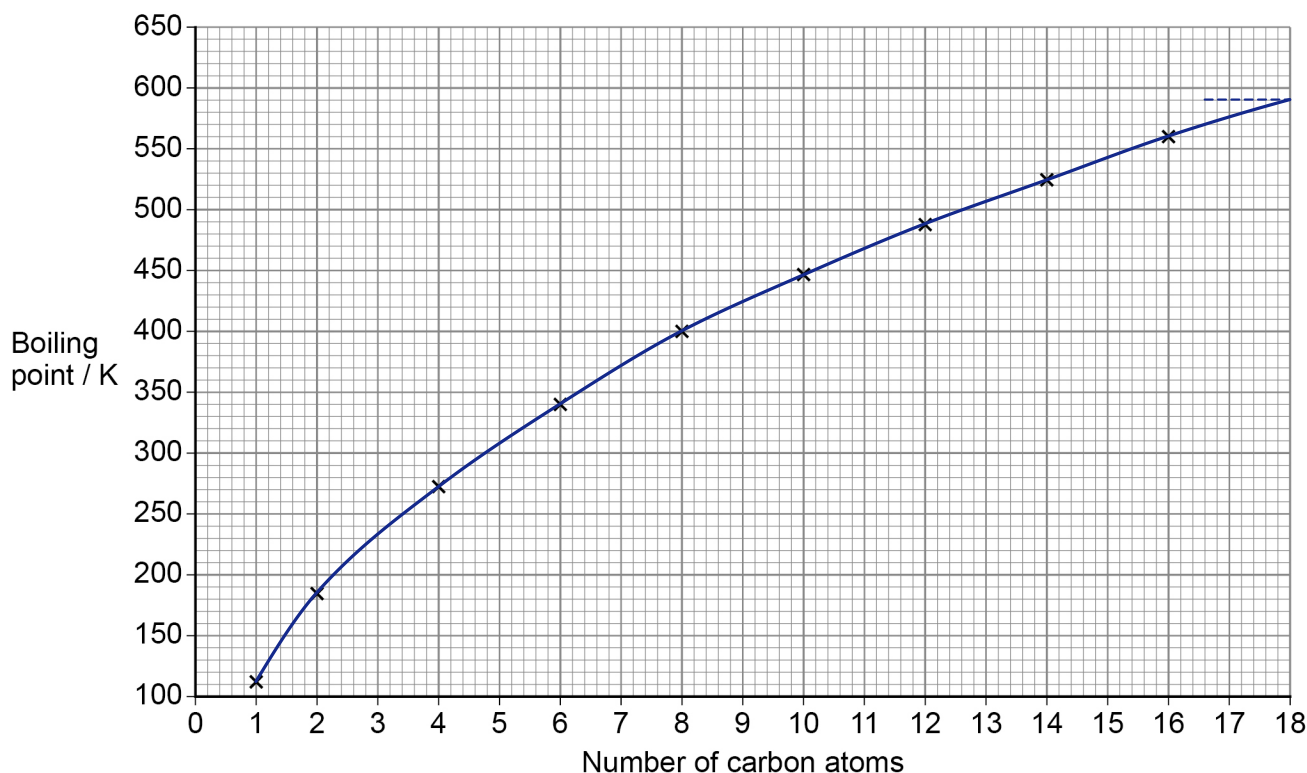
0 1

This question is about hydrocarbons.

Figure 1 shows a graph of the boiling points of some straight chain alkanes.

Octadecane ($C_{18}H_{38}$) is a straight chain alkane.

Figure 1



0 1 . 1

Draw a line of best fit on **Figure 1**.

Continue the line to determine a value for the boiling point of octadecane.

[2 marks]

Boiling point of octadecane 590 K

0 1 . 2

Name a process that can be used to separate octadecane from a mixture of alkanes.

[1 mark]

Fractional distillation



Alkanes are burned in air in internal combustion engines of cars.

0 1 . 3

Identify **two** toxic gases that are formed in internal combustion engines of cars.

Write **one** equation to show how **both** toxic gases can be removed by a catalytic converter in these cars.

Identify the catalyst used in the catalytic converter.

[3 marks]

Toxic gases Carbon monoxide (CO) and nitrogen monoxide (NO)

Equation



Catalyst Platinum (Pt)

0 1 . 4

Write an equation for the complete combustion of octadecane ($\text{C}_{18}\text{H}_{38}$)

[1 mark]



0 1 . 5

Write an equation for the cracking of one molecule of octadecane to give one molecule of decane ($\text{C}_{10}\text{H}_{22}$), one molecule of pentene and one other product.

[1 mark]



8

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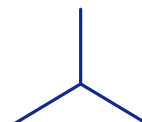
0 2

This question is about isomers.

0 2 . 1

Compounds **D** and **E** have the molecular formula C_4H_{10} **D** has a higher boiling point than **E**.Draw the skeletal formula of **D** and the skeletal formula of **E**.

[2 marks]

D**E**

0 2 . 2

Compounds **F** and **G** have the molecular formula C_4H_8 Bromine water turns colourless when added to **F** but there is no visible change with **G**.Draw a structure for **F** and a structure for **G**.

[2 marks]

F**G**

0 2 . 3

Define stereoisomerism

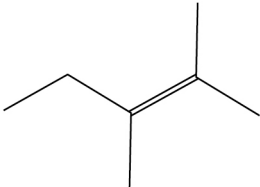
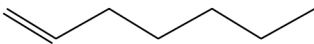
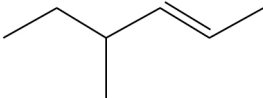
[1 mark]

*Compounds with the same structural formula but a different
arrangement of atoms (bonds) in space.*



0 2 . 4 Table 1 shows the skeletal formulas of three isomeric alkenes.

Table 1

A	B	C
		

Tick (✓) **one** box to choose the alkene, **A**, **B** or **C**, that can show *E-Z* isomerism.

[1 mark]

A

☐

B

☐

C

☒

0 2 . 5 Draw the structure of *Z*-5-methylhex-2-ene.

[1 mark]

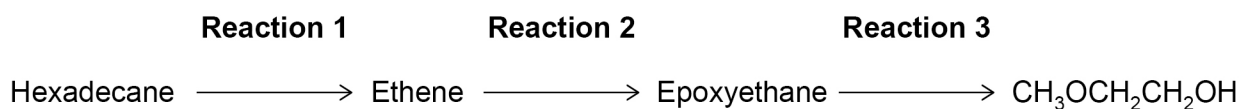


Z-5-methylhex-2-ene

0 3

A reaction sequence starting from hexadecane ($C_{16}H_{34}$) is shown in **Figure 2**.

Figure 2



0 3 . 1

In **Reaction 1** the only products are octane (C_8H_{18}) and ethene.

Write an equation using molecular formula for **Reaction 1**.

[1 mark]



0 3 . 2

Write an equation for **Reaction 2**.

Show the displayed formula of epoxyethane in your answer.

[1 mark]



0 3 . 3

Name the catalysts used in **Reaction 1** and in **Reaction 2**.

[2 marks]

Catalyst in **Reaction 1** Zeolite (aluminosilicate)

Catalyst in **Reaction 2** Silver (Ag)

0 3 . 4

Identify the substance that reacts with epoxyethane in **Reaction 3**.

[1 mark]



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0 4

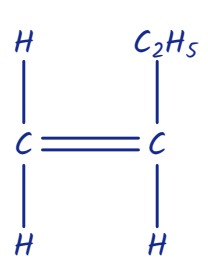
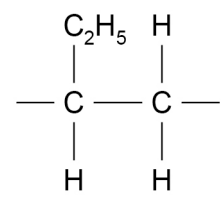
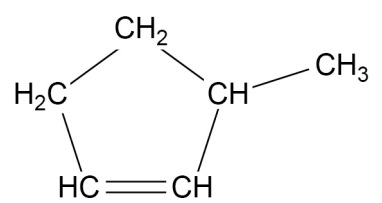
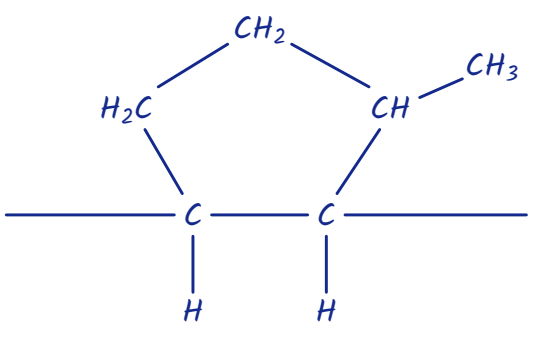
This question is about polymers.

0 4 . 1

Complete **Table 2** to show the

- structure of the monomer used to form polymer **K**
- repeating unit of the polymer formed from monomer **L**

[2 marks]**Table 2**

Monomer	Repeating unit of the polymer
Structure of the monomer used to form polymer K 	Polymer K 
Monomer L 	Repeating unit of the polymer formed from monomer L 

0 4 . 2

State why polymer **K** in Question **04.1** is not biodegradable.**[1 mark]**

Its carbon chain has strong, non-polar C-C bonds, which are not attacked or broken down by enzymes or bacteria.



0 4 . 3

Table 3 shows data from the analysis of a hydrocarbon.

Table 3

Element	% by mass
Carbon	88.9
Hydrogen	11.1

The mass spectrum of the hydrocarbon gives $M_r = 54.0$

Calculate the empirical formula **and** the molecular formula of the hydrocarbon.
Show your working.

[3 marks]

$$C: 88.9 \div 12.0 = 7.41 \qquad H: 11.1 \div 1.0 = 11.1$$

$$C: 7.41 \div 7.41 = 1 \qquad H: 11.1 \div 7.41 = 1.5$$

$$C : H = 1 : 1.5 = 2 : 3, \text{ so empirical formula} = C_2H_3$$

$$M_r \text{ of } C_2H_3 = 27.0 \qquad 54.0 \div 27.0 = 2$$

$$\text{molecular formula} = 2 \times C_2H_3 = C_4H_6$$

Empirical formula C_2H_3

Molecular formula C_4H_6

6

Turn over ►



0 5

This question is about rates of reaction of halogenoalkanes.

0 5 . 1

Define rate of reaction.

[1 mark]

The change in concentration of a reactant or product per unit time.

A student investigates the reactivity of halogenoalkanes.

- The student adds a halogenoalkane to ethanol and sodium hydroxide solution in a test tube.
- The student warms the mixture in the test tube at approximately 60 °C
- The halogenoalkane is hydrolysed.

0 5 . 2

Suggest how the student should heat the test tube safely.

[1 mark]

Stand the test tube in a water bath at 60 °C, not a naked flame, as ethanol is flammable.

Nitric acid and silver nitrate solution are added to the test tube in Question **05.2** to form a precipitate.

The time for a precipitate to appear is recorded.

The experiment is repeated with other halogenoalkanes.

The rate of reaction for each halogenoalkane is calculated and the results are shown in **Table 4**.

Table 4

Halogenoalkane	Rate of formation of precipitate / s ⁻¹
1	0.0042
2	0.0054
3	0.0087

0 5 . 3

State the halogenoalkane that reacts in the shortest time.

[1 mark]

Halogenoalkane 3



Samples of 1-chloropropane, 1-bromopropane and 1-iodopropane are tested in this experiment.

0 5 . 4

Suggest why 1-iodopropane has the fastest reaction rate.

[1 mark]

The C-I bond is the weakest (lowest bond enthalpy) of the C-Cl, C-Br and C-I bonds, so it breaks most easily.

0 5 . 5

Explain why these reactions are slower at a lower temperature. You must refer to particles in your answer.

[2 marks]

At a lower temperature, fewer particles have energy greater than or equal to the activation energy, E_a .

So there are fewer successful collisions (collisions with $E \geq E_a$) per unit time.

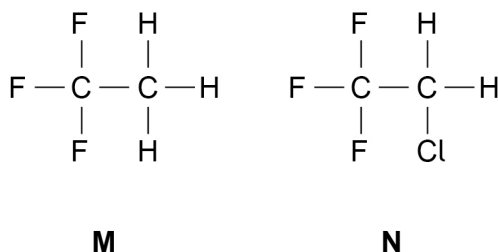
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0 6

Compounds **M** and **N** are gaseous organic compounds.

0 6 . 1

Calculate the percentage by mass of fluorine in **M** ($M_r = 84.0$).
Give your answer to 3 significant figures.

[1 mark]

$$\% \text{ F} = (3 \times 19.0) \div 84.0 \times 100 = 67.857 = 67.9\%$$

Percentage by mass of fluorine 67.9%

0 6 . 2

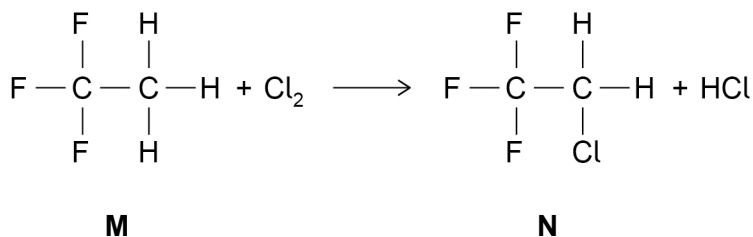
Suggest why **M** does not damage the ozone layer.

[1 mark]

M contains no chlorine atoms, so no chlorine radicals form (the C-F bond is too strong to be broken by UV light).



M can be converted to **N** in the presence of chlorine and ultraviolet light.



0 6 . 3

Name the mechanism for this reaction.

[1 mark]

Free-radical substitution

0 6 . 4

2.64 g of **M** ($M_r = 84.0$) are reacted with chlorine.
The percentage yield of **N** is 93.0%

Calculate the mass, in g, of **N** formed in this reaction.

[3 marks]

$$\text{amount of M} = 2.64 \div 84.0 = 0.0314 \text{ mol}$$

$$M_r \text{ of N (CF}_3\text{CH}_2\text{Cl)} = 118.5$$

$$\text{theoretical mass of N} = 0.0314 \times 118.5 = 3.72 \text{ g}$$

$$\text{actual mass of N} = 3.72 \times 93.0 \div 100 = 3.46 \text{ g}$$

Mass of **N** 3.46 g

0 6 . 5

A sample of **M** and chlorine are reacted in a sealed 10 dm³ container at a given temperature and in the presence of ultraviolet light.

State why the rate of reaction will increase if the reaction is repeated in a 5 dm³ container.

[1 mark]

The same number of particles are in a smaller volume, so the concentration (pressure) is higher and collisions are more frequent.

Turn over ►



0 7

This question is about alkenes and halogenoalkanes.

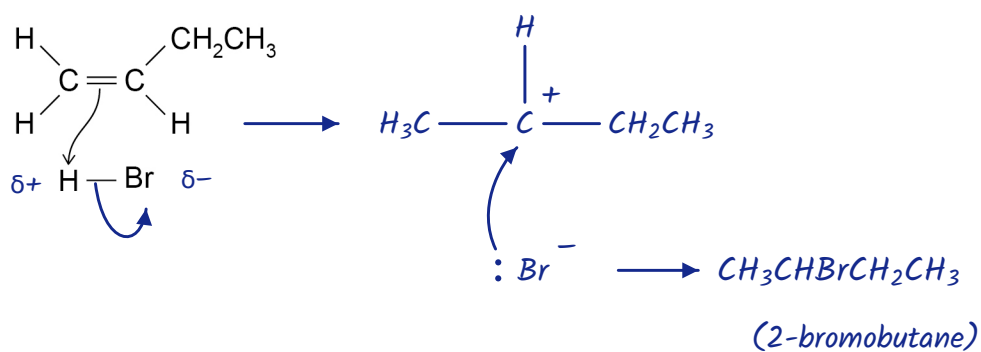
0 7 . 1

Alkenes react with hydrogen halides to produce halogenoalkanes.

Name and complete the mechanism to show the major product formed in the reaction between but-1-ene and hydrogen bromide.

[4 marks]Name of mechanism Electrophilic addition

Mechanism



Halogenoalkanes can react under different conditions to make products with different functional groups.

0 7 . 2

Give the meaning of functional group as applied to an organic molecule.

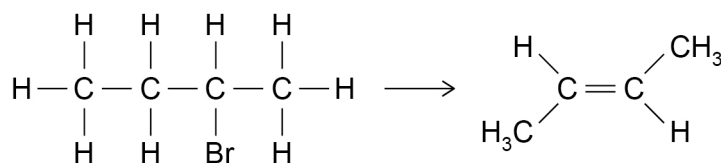
[1 mark]

An atom or group of atoms in an organic molecule that is responsible for the chemical reactions of that molecule.

0 7 . 3

Give the reagent and **one** condition required for the following change.

[2 marks]



Reagent *Potassium hydroxide (KOH)*

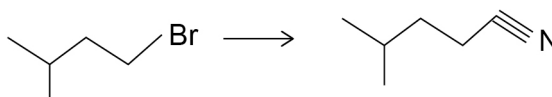
Condition *Dissolved in ethanol (ethanolic solvent), heat*

0 7 . 4

Give the reagent and **one** condition required for the following change.

Use IUPAC rules to name the organic product.

[3 marks]



Reagent *Potassium cyanide (KCN)*

Condition *Aqueous ethanol (solvent), heat*

IUPAC name of product *4-methylpentanenitrile*

10

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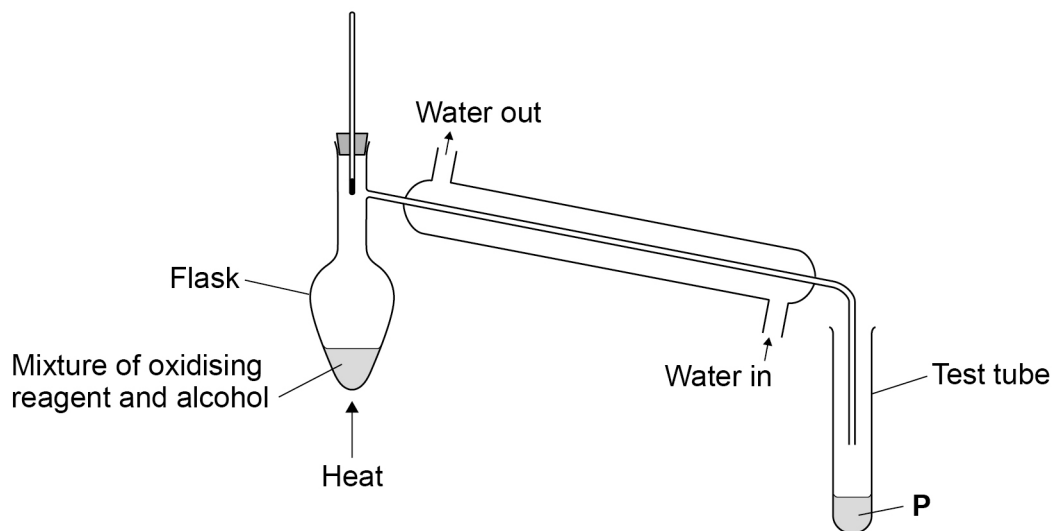


0 8

This question is about alcohols and their oxidation products.

Figure 3 shows the equipment that can be used to oxidise alcohols.

Figure 3



0 8 . 1

Suggest one way to increase the yield of product **P** collected in the test tube in **Figure 3**.

[1 mark]

Place the test tube in a beaker of ice (an ice bath) so that more of P condenses.

0 8 . 2

Name the practical technique used to obtain **P**.

State the reagent (or combination of reagents) used in the flask to oxidise the alcohol.

Describe the colour change observed in this reaction.

[3 marks]

Practical technique *Distillation*

Reagent(s) *Potassium dichromate(VI) and sulfuric acid, $K_2Cr_2O_7/H_2SO_4$*

Colour change *Orange to green*



0 8 . 3

The carboxylic acid functional group can be identified by its reaction with aqueous NaHCO_3

Give the observation when propanoic acid reacts with aqueous NaHCO_3

Write an equation for this reaction.

[2 marks]

Observation Effervescence (bubbles of CO_2 gas)

Equation



0 8 . 4

Identify the organic product of the reaction of 2-methylbutanal with Fehling's solution.

State what is observed in this reaction.

[2 marks]

Organic product 2-methylbutanoic acid, $\text{CH}_3\text{CH}_2\text{CH}(\text{CH}_3)\text{COOH}$

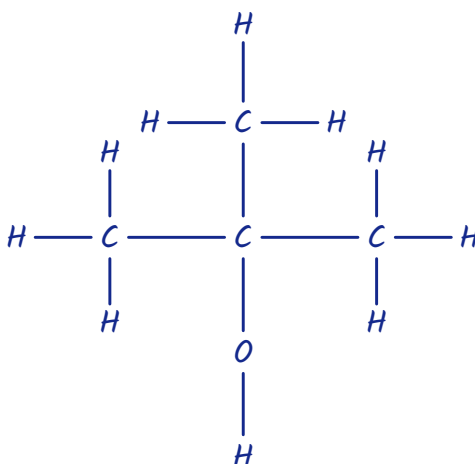
Observation Blue solution forms a brick-red precipitate

0 8 . 5

An alcohol with molecular formula $\text{C}_4\text{H}_{10}\text{O}$ does **not** react with the oxidising reagents used in this question.

Draw the displayed formula of this alcohol.

[1 mark]

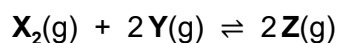


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0 9

This question is about the equilibrium



0 9 . 1

A student adds 2.0 mol of X_2 to 3.0 mol of Y .

The mixture is placed in a sealed container at a given temperature to reach equilibrium.

The equilibrium mixture contains 1.5 mol of X_2 Complete **Table 5** to show the amount, in mol, of each substance at equilibrium.**[2 marks]****Table 5**

	X_2	Y	Z
Initial amount / mol	2.0	3.0	0.0
Equilibrium amount / mol	1.5	2.0	1.0

0 9 . 2

The student repeats the experiment with different amounts of X_2 and Y at a different temperature.At equilibrium, the concentration of $\text{X}_2 = 0.150 \text{ mol dm}^{-3}$ and the concentration of $\text{Y} = 0.0520 \text{ mol dm}^{-3}$ At this temperature, the value of the equilibrium constant, $K_c = 290 \text{ mol}^{-1} \text{ dm}^3$ Write the expression for the equilibrium constant, K_c Calculate the concentration of Z , in mol dm^{-3} , at equilibrium.**[3 marks]**

$$K_c = \frac{[\text{Z}]^2}{[\text{X}_2][\text{Y}]^2}$$

Calculation $[\text{Z}]^2 = K_c \times [\text{X}_2] \times [\text{Y}]^2 = 290 \times 0.150 \times 0.0520^2$

$$[\text{Z}]^2 = 0.1176$$

$$[\text{Z}] = \sqrt{0.1176} = 0.343$$

Concentration of Z 0.343 mol dm^{-3} 

Table 6 shows the value of the equilibrium constant (K_c) at different temperatures.

Table 6

Temperature / K	K_c / mol ⁻¹ dm ³
300	780
500	160
700	55

0 9 . 3

State how the equilibrium concentration of **Z** changes as the temperature increases.

Explain your answer.

[3 marks]

Change in equilibrium concentration of **Z** *Decreases*

Explanation *K_c decreases as temperature increases, so the forward reaction is exothermic (the reverse reaction is endothermic).*

Equilibrium shifts left to oppose the higher temperature, so less Z forms.

0 9 . 4

The student repeats the experiment under different conditions.

Complete **Table 7** to state the effect on the value of equilibrium constant (K_c) and the position of the equilibrium when

- a catalyst is added
- the volume of the container is increased.

[2 marks]

Table 7

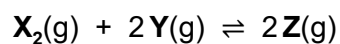
	Effect on K_c	Effect on position of equilibrium
Catalyst is added	<i>No change</i>	<i>No change</i>
Volume of the container is increased	<i>No change</i>	<i>Shifts to the left</i>

Question 9 continues on the next page

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The equilibrium is repeated here.



At 300 K, the value of the equilibrium constant, $K_c = 780 \text{ mol}^{-1} \text{ dm}^3$

0 9 . 5

Calculate a value for the equilibrium constant (K_c) for the reverse reaction at 300 K and give the units for this K_c

[2 marks]

$$K_c (\text{reverse}) = 1 \div 780 = 1.28 \times 10^{-3}$$

$$\text{units: } 1 \div (\text{mol}^{-1} \text{ dm}^3) = \text{mol dm}^{-3}$$

$$K_c \quad 1.28 \times 10^{-3}$$

$$\text{Units} \quad \text{mol dm}^{-3}$$

12

END OF QUESTIONS



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