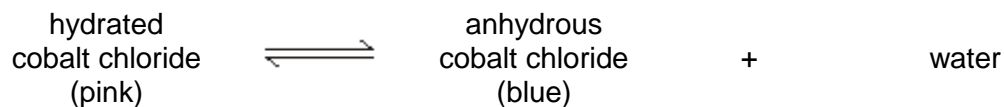


4-6 Chemistry /5-6 Trilogy – Rate and extent of chemical change

- 1.0** A student heated hydrated cobalt chloride.
The word equation shows the reaction.



- 1.1** The student recorded some observations from this experiment.
Suggest **two** observations the student may have written down.

[2 marks]

- 1.2** The student added anhydrous cobalt chloride to water and measured the temperature rise.
The student's results are shown in the table below.

	Trial 1	Trial 2	Trial 3
Temperature rise in °C	9.5	9.2	9.2

Calculate the mean temperature rise.

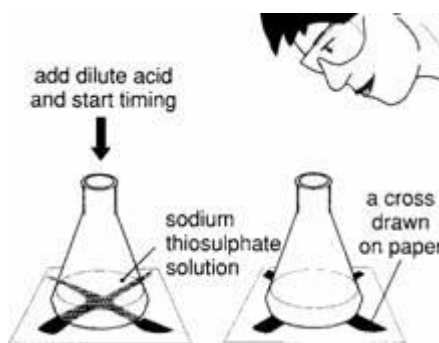
[1 mark]

Temperature = _____ °C

- 1.3** During the reaction in **1.2**, the temperature increased.
Name the type of reaction that causes the temperature to rise.

[1 mark]

- 2.0** A student investigated the effect of temperature on the rate of reaction.
Figure 1 below shows the apparatus the student used.



- 2.1** Name a piece of apparatus which could be used to measure the volume of the acid.

[1 mark]

- 2.2** The reaction forms a precipitate.
 When should the student stop timing the reaction?

[1 mark]

- 2.3** State the dependent and independent variables in the investigation.

[2 marks]

Dependent _____

Independent _____

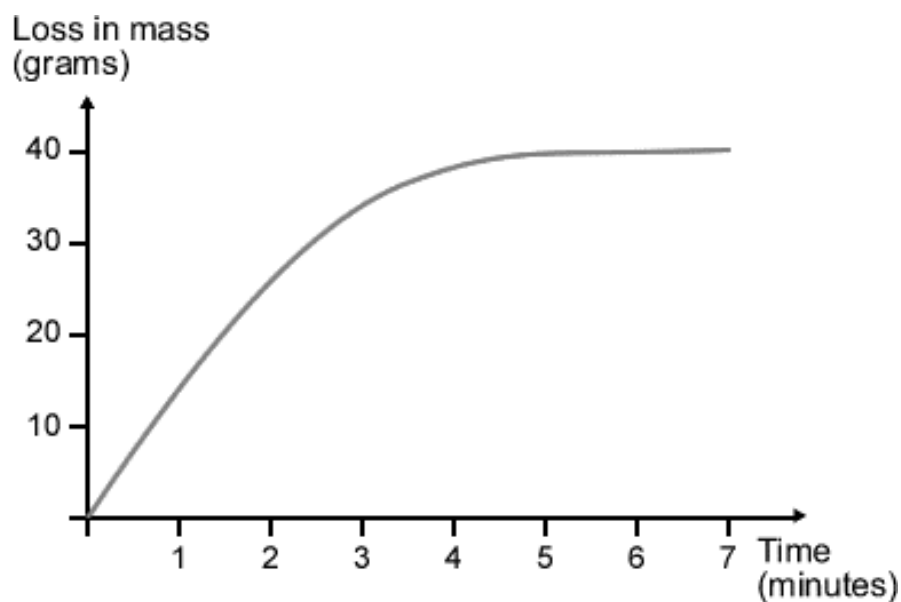
- 2.4** The student only carried out each test once.
 Explain why repeating the experiment would improve the results.

[1 mark]

- 2.5** Describe how a preliminary investigation could be used to find an appropriate temperature range.

[2 marks]

- 2.6** Another student used a different experiment to investigate the rate of reaction. This student measured the loss of mass every minute. The student's results are shown in **Graph 1** below:



Add labels to the graph to show:

- when the reaction is complete
- when the rate of reaction is fastest
- when half the reactants have been used up.

[3 marks]

3.0 A student investigated how the concentration of hydrochloric acid affected the rate of reaction between hydrochloric acid (HCl) and magnesium ribbon to produce magnesium chloride (MgCl₂) and hydrogen (H₂).

3.1 Complete and balance the equation for the reaction:

[2 marks]

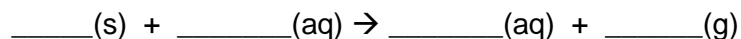


Figure 2 below shows the apparatus the student used.

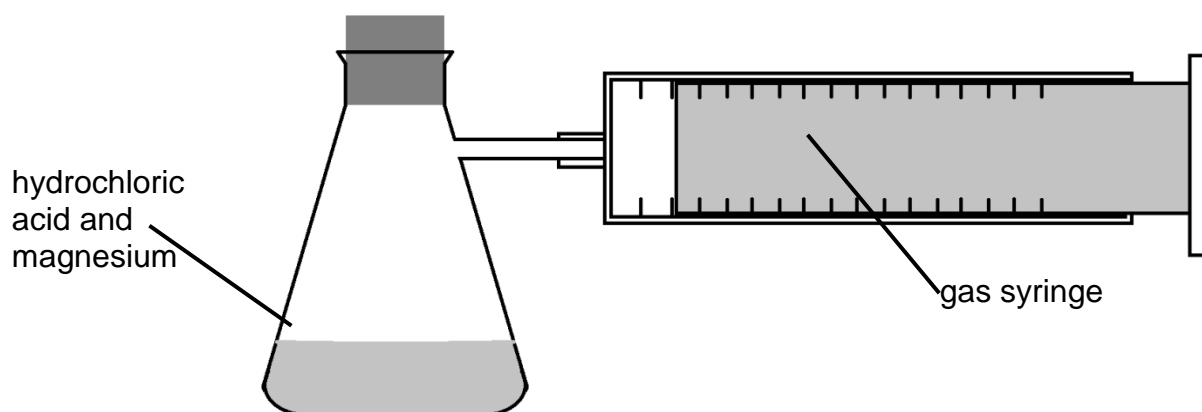


Table 1 shows the results of the experiment.

Table 1

Concentration of hydrochloric acid in mol/dm ³	Time taken for 30 cm ³ of hydrogen to be produced in s				Mean rate of reaction in cm ³ /s
	Trial 1	Trial 2	Trial 3	Mean	
0.4	158	150	154	154	0.19
0.8	77	77	74	76	0.39
1.2	68	51	49		
1.6	37	39	38	38	0.79
2.0	30	29	31	30	1.00

- 3.2** Calculate the rate of reaction when 1.2 mol/dm^3 hydrochloric acid is added to magnesium.

Use the equation below.

$$\text{mean rate of reaction} = \frac{\text{volume of gas in cm}^3}{\text{mean time taken in s}}$$

[3 marks]

Mean rate of reaction = _____ cm^3/s

- 3.3** Give **two** variables which the student should control during this investigation.

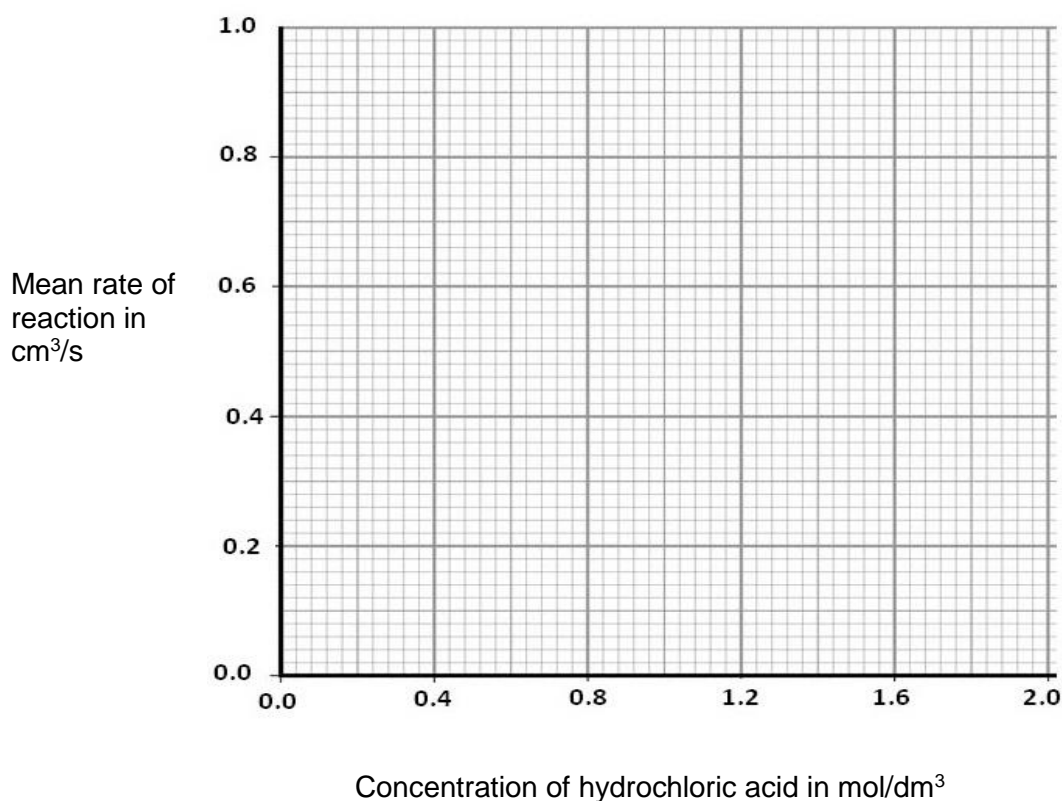
[2 marks]

- 3.4** On **Figure 3**, use the results from **Table 1** to

- plot a graph of rate of reaction and concentration of acid
- draw a best fit line.

[3 marks]

Figure 3



- 3.5** Using the idea of particle collisions, explain why the reaction rate is faster when the concentration of the acid is greater.

[2 marks]

- 3.6** The student used magnesium ribbon.
State a change that could be made to the magnesium to speed up the reaction.

[1 mark]

- 3.7** Explain in terms of the particles why the change you gave in **3.6** would increase the speed of reaction.

[1 mark]

4.0 This question is about reversible reactions and chemical equilibrium.

4.1 Reversible reactions can reach equilibrium in a closed system.
What is meant by a **closed system**?

[1 mark]

4.2 Explain why a reaction seems to have finished when a reversible reaction reaches equilibrium.

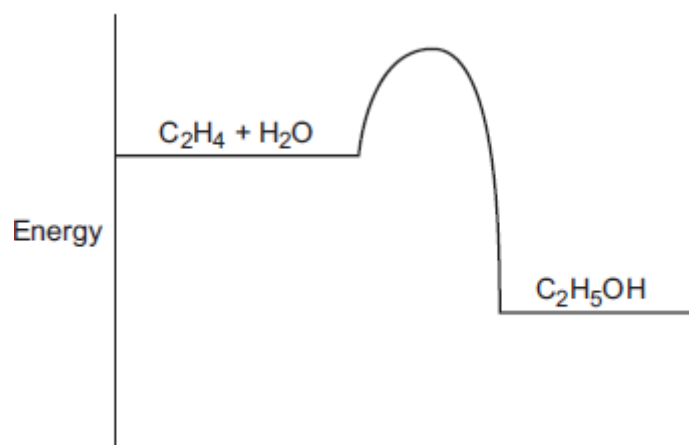
[2 marks]

Ethanol can be produced in a reversible reaction from ethene and steam.
The equation for the reaction is:



Figure 4 shows the reaction profile for the reaction.

Figure 4



4.3 How does the diagram show that the reaction is exothermic?

[1 mark]

4.4 A catalyst can be used for the reaction.

Indicate on **Figure 4**:

- the reaction profile for a catalysed reaction
- the activation energy for a catalysed reaction.

[2 marks]

4.5 State what is meant by **activation energy**.

[1 mark]

4.6 Give one similarity and one difference in the energy transfer for the back reaction to form ethene and water from ethanol.

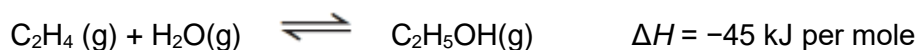
[2 marks]

Similarity: _____

Difference: _____

4.7 A company manufactures ethanol ($\text{C}_2\text{H}_5\text{OH}$).

The reaction for the process is:



The temperature and pressure can be changed to increase the yield of ethanol at equilibrium.

The forward reaction is exothermic.

The conditions used in the process are:

- 60 atmospheres pressure
- 200 °C
- phosphoric acid catalyst.

Explain why these conditions are used in this process.

Use the equation and your knowledge of reversible reactions.

Consider **both** yield **and** rate of reaction in your answer.

[6 marks]

[illegible]

MARK SCHEME

Qu No.		Extra Information	Marks
1.1	(Solid) changes from pink to blue		1
	Droplets of water / steam		1
1.2	9.3 °C		1
1.3	Exothermic		1

Qu No.		Extra Information	Marks
2.1	Measuring cylinder	Allow burette/pipette	1
2.2	When the cross cannot be seen through the solution	Ignore when the solution is cloudy	1
2.3	(Dependent) Time taken for the cross to disappear		1
	(Independent) Temperature		1
2.4	To check the results, So you know the readings are accurate, To eliminate/ignore anomalous results.	Allow to improve reliability.	1
2.5	Two temperatures are suggested that constitute a range		1
	Understanding demonstrated that an appropriate range will allow a pattern or trend to be seen in the results		1
2.6	<p style="text-align: center;">Graph 1</p> <p>A: Reaction is complete B: Reaction is fastest C: Half the reactants have been used up.</p>	<p>A: Must be after graph levels off</p> <p>B: Any point on straight line up before it changes gradient</p> <p>C: When loss of mass is 20g</p>	<p>1</p> <p>1</p> <p>1</p>

Qu No.		Extra Information	Marks
3.1	Formulae in correct place		1
	Correct balancing	Allow 2 marks for $\text{Mg(s)} + 2\text{HCl(aq)} \rightarrow \text{MgCl}_2(\text{aq}) + \text{H}_2(\text{g})$	1
3.2	(49+51)/2		1
	(mean =) 50	Allow 2 marks for 50 without working	1
	(30/50 =) 0.60	Allow 2 marks for 0.54 where anomaly has been included in mean	1
3.3	Any two from: <ul style="list-style-type: none"> • volume of acid • temperature (of acid) • length of magnesium (ribbon) 	Do not allow concentration of acid Allow mass of magnesium ribbon	2
3.4	All points plotted correctly	$\pm \frac{1}{2}$ small square Allow 1 mark for 4 plotted correctly Allow ecf for anomalous point at (1.2,0.54)	2
	Best fit straight line	Should not be influenced by anomaly	1
3.5	Particles must collide in order to react		1
	Collision frequency increases as concentration increases		1
3.6	Cut it up or increase the surface area	Allow grind it up or make a powder Do not accept make it smaller or use a smaller piece	1
3.7	Reference to particle theory eg more collisions between acid ions/particles and atoms/particles of magnesium		1

Qu No.		Extra Information	Marks
4.1	Nothing can enter and nothing can leave the reaction	Allow sealed reaction vessel	1
4.2	At equilibrium the forward and backward reactions have same rate		1
	So there is no (overall) change in quantities of reactants and products		1
4.3	The products are at a lower energy level than the reactants	Accept products have less energy or less energy at the end than the beginning	1
4.4	Pathway drawn from reactants to products, below original pathway		1
	Indication of activation energy from reactant level to highest point on catalysed reaction pathway		1
4.5	Minimum amount of energy needed by particles to react		1
4.6	<i>Similarity</i> Same amount of energy transferred	Allow 45 kJ of energy transferred (given in 4.7 below)	1
	<i>Difference</i> Endothermic reaction	Allow energy taken in by reaction	1

4.7		
Level 3:	A detailed and coherent explanation is given, which demonstrates a broad understanding of the key scientific ideas. The response makes logical links between the points raised and uses sufficient examples to support these links.	5-6
Level 2:	An explanation is given which demonstrates a reasonable understanding of the key scientific ideas. Links are made but may not be fully articulated and / or precise.	3-4
Level 1:	Simple statements are made which demonstrate a basic understanding of some of the relevant ideas. The response may fail to make logical links between the points raised.	1-2
	No relevant content	0
Indicative content		
60 atmospheres pressure <ul style="list-style-type: none"> high pressure gives a high yield of ethanol too high a pressure causes risk of explosion high pressure costly to maintain a high pressure will cause the rate to be higher 2 moles of gas become 1 (or fewer moles of gas in products) 200 °C <ul style="list-style-type: none"> high temperature increases the rate of reaction optimum temperature (forward reaction is exothermic so) a high yield of ethanol requires a low temperature but too low a temperature causes the rate of reaction to be too slow Phosphoric acid catalyst <ul style="list-style-type: none"> a catalyst speeds up the reaction a phosphoric acid catalyst allows a lower temperature to be used (saving energy and causing a higher yield) phosphoric acid catalyst increases the rate of reaction equally in both reactions Others <ul style="list-style-type: none"> compromise conditions unreacted ethene and steam is recycled 		