GCSE
CHEMISTRY

Chemistry Test 3: Energy changes and The rate and extent of chemical change (Higher)

Total number of marks: 34

0 3 This question is about rate of reaction.

A student investigated the rate of the reaction between magnesium and dilute hydrochloric acid.

The equation for the reaction is:

$$Mg(s) + 2HCl(aq) \rightarrow MgCl_2(aq) + H_2(g)$$

The student determined the rate of production of hydrogen gas.

0 3 . 2 What **two** pieces of measuring apparatus could the student use to find the rate of production of hydrogen gas?

[2 marks]

1 gas syringe

2 stopwatch

Table 2 shows the results of the investigation.

Table 2

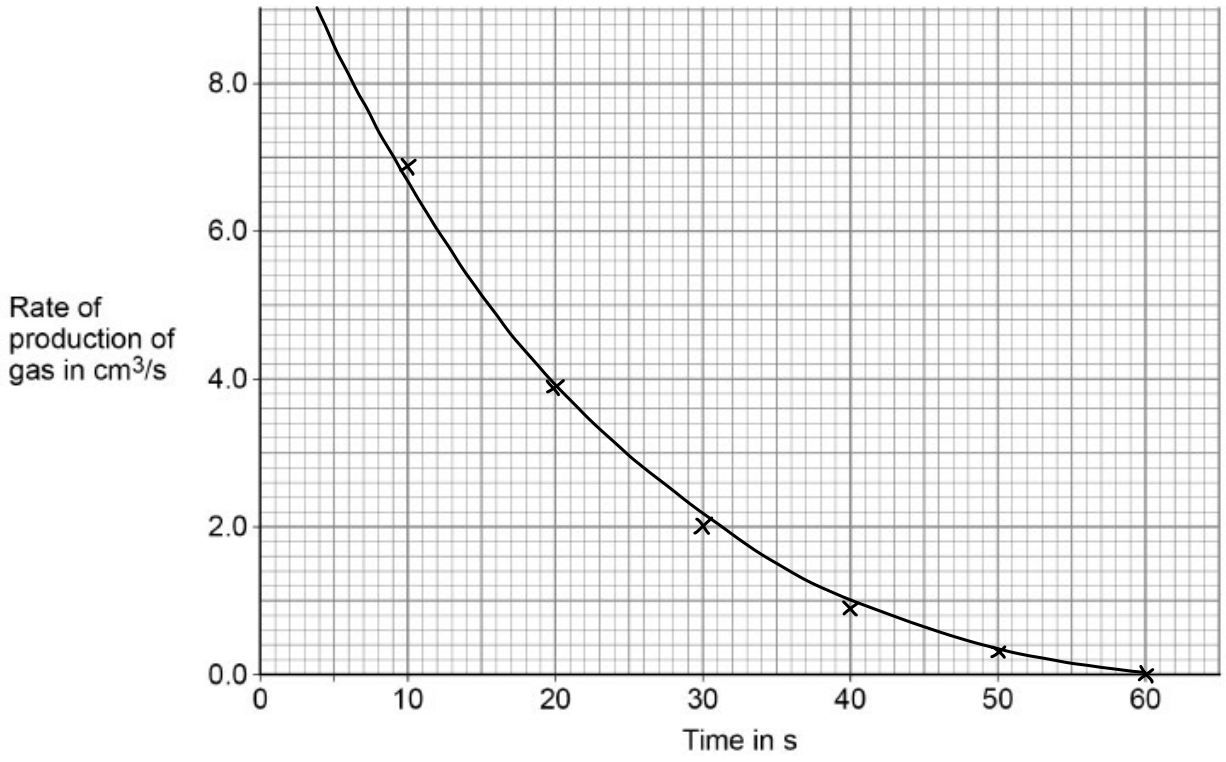
Time in s	Rate of production of gas in cm^3/s
10	6.9
20	3.9
30	2.0
40	0.9
50	0.3
60	0.0

0 3 . 3 Plot the data from **Table 2** on **Figure 3**.

You should draw a line of best fit.

[3 marks]

Figure 3



0 3 . 4 Give **three** conclusions that can be drawn about the rate of reaction between magnesium and dilute hydrochloric acid in this investigation.

Use data from **Figure 3** and **Table 2**.

[3 marks]

1 the rate of reaction is fastest between 0 and 10 second

2 the rate of reaction decreases between 0 and 60 seconds

3 all of the acid has reacted by 60 seconds

0 3 . 5 The student repeated the investigation using dilute hydrochloric acid at a higher temperature.

All the other variables were kept the same.

Which **two** statements are correct?

[2 marks]

Tick (✓) **two** boxes.

- More bubbles were produced in the first 10 seconds. ✓
- The activation energy for the reaction was higher.
- The magnesium was used up more quickly. ✓
- The reaction finished at the same time.
- The total volume of gas collected was greater.

0 5 Some students investigated the energy changes occurring in the reaction between potassium hydrogencarbonate and hydrochloric acid.

The equation for the reaction is:

$$KHCO_3(s) + HCl(aq) \rightarrow KCl(aq) + CO_2(g) + H_2O(l)$$

This is the method used.

1. Measure 50 cm^3 hydrochloric acid into a glass beaker.
2. Measure the temperature of the hydrochloric acid.
3. Measure a given mass of potassium hydrogencarbonate.
4. Add the potassium hydrogencarbonate to the hydrochloric acid.
5. Stir until all the potassium hydrogencarbonate has reacted.
6. Record the lowest temperature reached.
7. Repeat three more times, using the same mass of potassium hydrogencarbonate.

Each student used a different mass of potassium hydrogencarbonate.

0 5 . 1 The method described will not give very accurate results.

Suggest **one** change to the apparatus that would improve the accuracy of the results.

Give a reason for your answer.

[2 marks]

Using a polystyrene cup instead of a glass beaker to minimise energy transfer to the surroundings.

0 5 . 2 The students controlled the volume of the hydrochloric acid.

Give **one** other control variable the students should use.

concentration of hydrochloric acid

[1 mark]

Table 3 shows one student's results.

Table 3

	Trial 1	Trial 2	Trial 3	Trial 4
Initial temperature in °C	21.2	21.1	21.0	21.1
Final temperature in °C	15.6	15.4	15.6	16.6
Temperature decrease in °C	5.6	5.7	5.4	4.5

0 5 . 3 Calculate the mean temperature decrease for the results shown in **Table 3**.

Ignore any anomalous results.

Give your answer to 1 decimal place.

Give the uncertainty in your answer.

[3 marks]

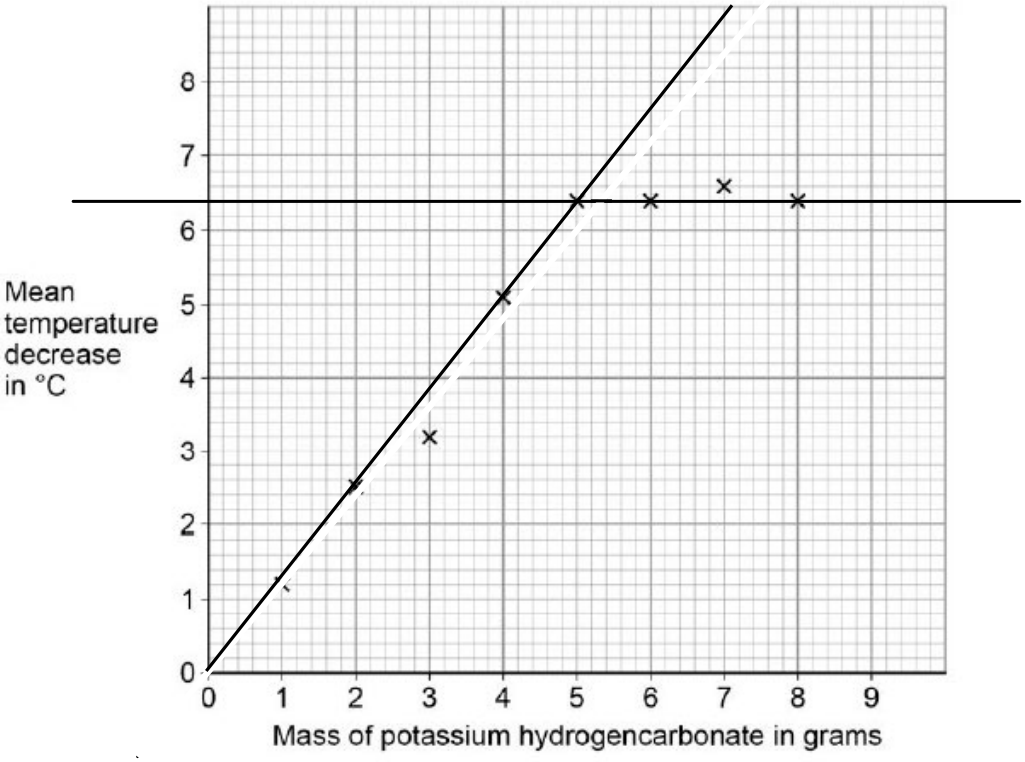
$\frac{5.6 + 5.7 + 5.4}{3} = 5.5667$

$\simeq 5.6$

Mean = 5.6 °C ± 0.2 °C

Figure 4 shows the students' results.

Figure 4



0 5 . 4 Draw **two** intersecting straight lines of best fit on **Figure 4**.

[2 marks]

0 5 . 5 Explain why the graph has this shape.

Use data from the graph.

From 0 to 5.0 g of potassium hydrogencarbonate, the hydrochloric acid is reacting to produce potassium chloride so the temperature decreases (because the reaction is endothermic). At 5.0 g the reaction stops because all of the acid has reacted and the potassium hydrogencarbonate is in excess, so the temperature stops decreasing. **[3 marks]**

0 5 . 6 Suggest a possible reason for the anomalous points.

Do **not** include errors in measuring.

[1 mark]

not all of the potassium hydrogencarbonate had dissolved due to poor stirring.

0 9 This question is about methanol.

0 9 . 1 Methanol is broken down in the body during digestion.

What type of substance acts as a catalyst in this process?

[1 mark]

Tick **one** box.

- Amino acid ☐
- Enzyme ☑
- Ester ☐
- Nucleotide ☐

In industry, methanol is produced by reacting carbon monoxide with hydrogen.

The equation for the reaction is:

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

0 9 . 2 How many moles of carbon monoxide react completely with 4.0×10^3 moles of hydrogen?

[1 mark]

Tick **one** box.

- 1.0×10^3 moles ☐
- 2.0×10^3 moles ☑
- 4.0×10^3 moles ☐
- 8.0×10^3 moles ☐

0 9 . 3 The reaction is carried out at a temperature of 250 °C and a pressure of 100 atmospheres.

The forward reaction is exothermic.

Explain what happens to the yield of methanol if a temperature higher than 250 °C is used.

[2 marks]

The yield of methanol would decrease because the backwards reaction is endothermic so the equilibrium would move to the left in order to oppose the increase in temperature.

0 9 . 4 A pressure of 100 atmospheres is used instead of atmospheric pressure.

The higher pressure gives a greater yield of methanol **and** an increased rate of reaction.

Explain why.

[4 marks]

There are less moles on the right side of the equation (1 vs 3) so increasing the pressure moves the equilibrium to the right in order to decrease the pressure. Increased pressure means there are more molecules in a given volume so more frequent successful collisions.

A catalyst is used in the reaction to produce methanol from carbon monoxide and hydrogen.

0 9 . 5 Explain how a catalyst increases the rate of a reaction.

[2 marks]

It provides an alternative route for the reaction, one with a lower activation energy, so less energy is needed for the reaction to take place.

0 9 . 6 Suggest why a catalyst is used in this industrial process.

Do **not** give answers in terms of increasing the rate of reaction.

[1 mark]

carbon monoxide and hydrogen do not usually react together so a catalyst is needed to start the reaction.

0 9 . 7 Suggest the effect of using the catalyst on the equilibrium yield of methanol.

[1 mark]

no effect