

# Rates of Reaction 5

Name: \_\_\_\_\_

Class: \_\_\_\_\_

Date: \_\_\_\_\_

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Time: **56 minutes**

Marks: **56 marks**

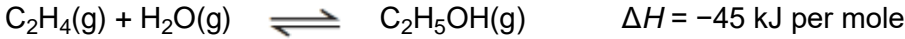
Comments:

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1.

A company manufactures ethanol (C<sub>2</sub>H<sub>5</sub>OH).

The reaction for the process is:



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

(a) Explain what is meant by equilibrium.

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(3)

(b) (i) How would increasing the temperature change the **yield** of ethanol at equilibrium?  
Give a reason for your answer.

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(2)

(ii) How would increasing the pressure change the **yield** of ethanol at equilibrium?  
Give a reason for your answer.

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(2)

(c) A catalyst is added to increase the rate of the reaction.

Explain how adding a catalyst increases the rate of a chemical reaction.

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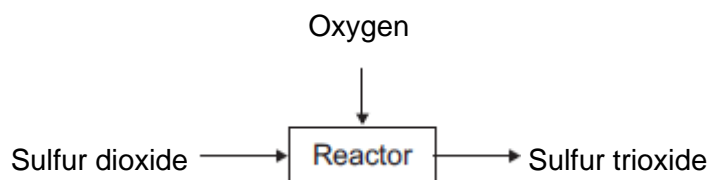
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(2)

(Total 9 marks)

2.

(a) The figure below represents the reaction of sulfur dioxide with oxygen.



(i) Complete the word equation for the reaction of sulfur dioxide with oxygen.

sulfur dioxide + \_\_\_\_\_ → \_\_\_\_\_

(1)

(ii) Draw a ring around the correct answer to complete the sentence.

Sulfur dioxide (SO<sub>2</sub>) is

- a compound.
- an element.
- a mixture.

(1)

(b) The reactants are gases.

When the pressure of the gases is increased, the reaction gets faster.

Complete the sentence.

When the pressure of the gases is increased,

the frequency of the collisions \_\_\_\_\_ .

(1)

(c) The particles need energy to react.

Complete the sentence.

The minimum amount of energy that particles need to react is called

the \_\_\_\_\_ energy.

(1)

(d) Give **one** way of increasing the rate of the reaction other than changing the pressure.

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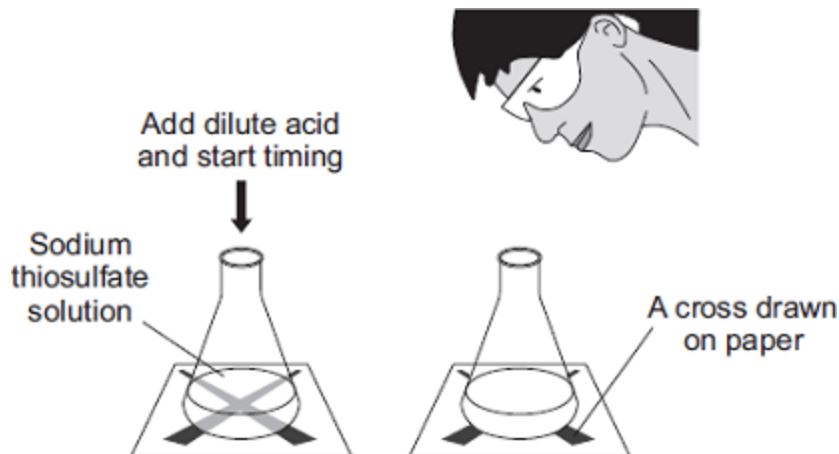
(1)

(Total 5 marks)

3.

Sodium thiosulfate solution reacts with hydrochloric acid. As the reaction takes place the solution slowly turns cloudy.

The diagram shows a method of measuring the rate of this reaction.



A student used this method to study how changing the concentration of the sodium thiosulfate solution alters the rate of this reaction.

The student used different concentrations of sodium thiosulfate solution. All the other variables were kept the same.

The results of the experiments are shown on the graph below.

(a) (i) Draw a line of best fit on the graph.

(1)

(ii) Suggest **two** reasons why all of the points do not lie on the line of best fit.

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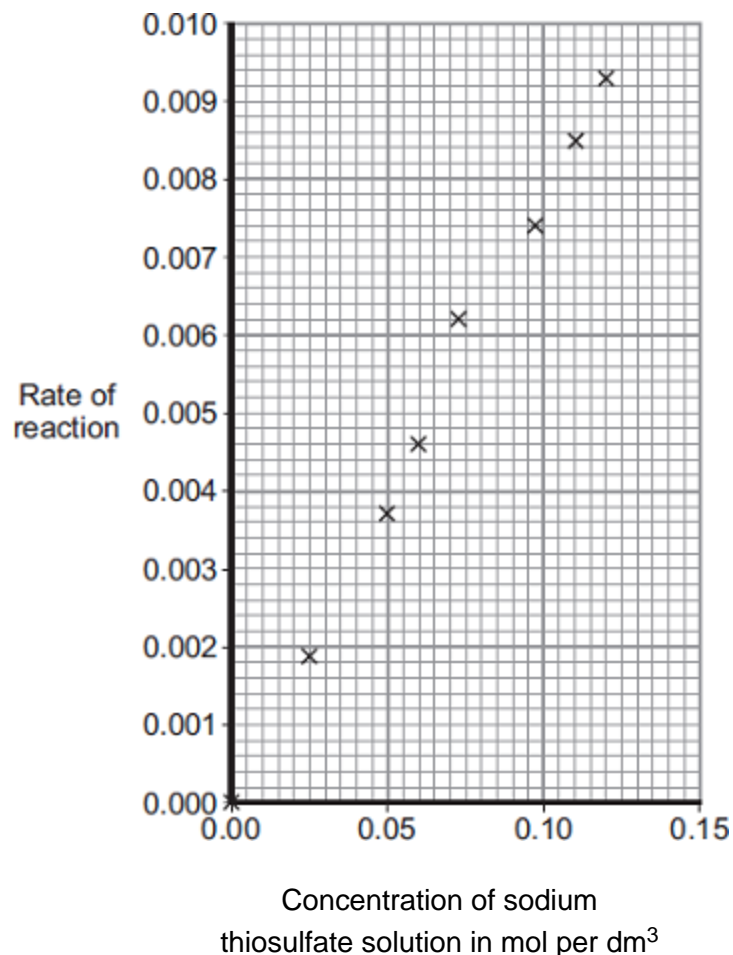
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(2)



(b) (i) In a conclusion to the experiment the student stated that:

'The rate of this reaction is directly proportional to the concentration of the sodium thiosulfate.'

How does the graph support this conclusion?

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(1)

(ii) Explain, in terms of particles, why the rate of reaction increases when the concentration of sodium thiosulfate is increased.

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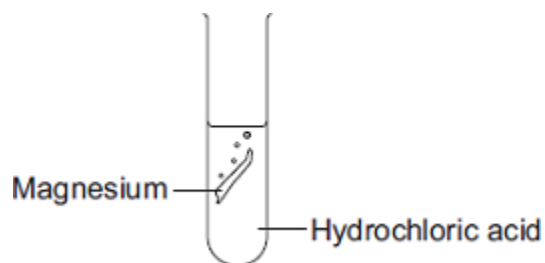
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(2)

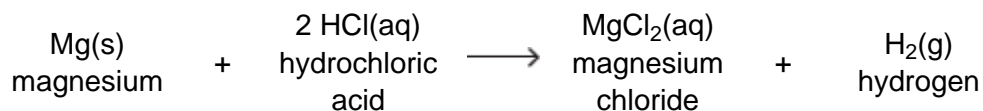
(Total 6 marks)

4.

A student investigated the reaction between magnesium and hydrochloric acid.



The equation for the reaction is:



(a) Give **two** observations the student could make during the reaction.

1. \_\_\_\_\_

\_\_\_\_\_

2. \_\_\_\_\_

\_\_\_\_\_

(2)



5.

The picture shows a lump of phosphate rock.



Rob Lavinsky, iRocks.com – CC-BY-SA-3.0 [CC-BY-SA-3.0], via Wikimedia Commons

Phosphoric acid is made by adding sulfuric acid to phosphate rock.

- (a) The rate of reaction between sulfuric acid and phosphate rock can be increased if the mixture is heated to a higher temperature.

Explain, in terms of particles, why an increase in temperature increases the rate of reaction.

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(2)

- (b) State **one** other way in which the rate of reaction between sulfuric acid and phosphate rock can be increased.

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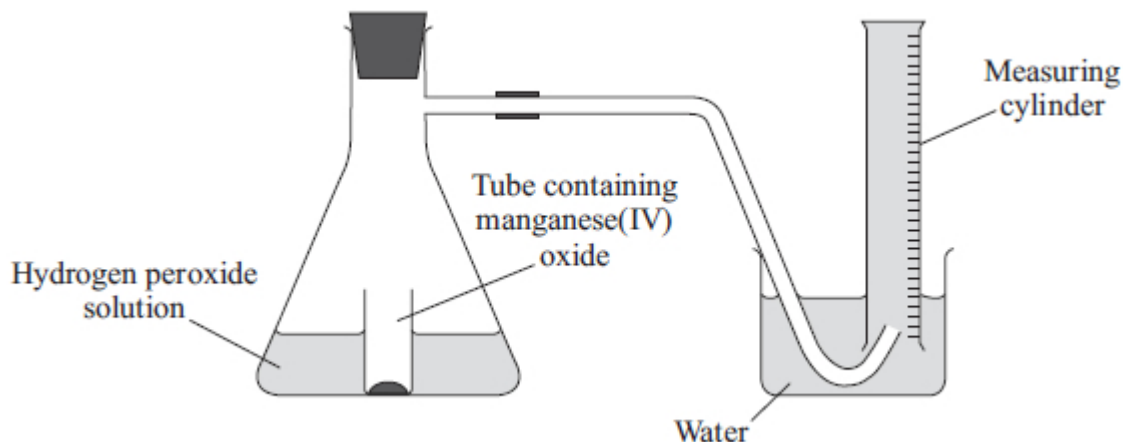
(1)

(Total 3 marks)

6. A student investigated the effect of temperature on the decomposition of hydrogen peroxide. Hydrogen peroxide decomposes to oxygen and water when a manganese(IV) oxide catalyst is added.

The student measured the time taken to collect 5 cm<sup>3</sup> of oxygen gas.

The apparatus shown below was used for the investigation. The reaction was started by shaking the flask so that the manganese(IV) oxide and hydrogen peroxide were mixed.



The student did the investigation at two different temperatures. All the other variables were kept constant.

The student's results are shown in the table.

Temperature of the hydrogen peroxide solution in °C	Volume of oxygen collected in cm <sup>3</sup>	Time taken to collect the oxygen in seconds	Rate of reaction in cm <sup>3</sup> per second
20	5	40	0.125
25	5	25	

- (a) (i) Calculate the rate of reaction at 25 °C.

\_\_\_\_\_

Rate of reaction = \_\_\_\_\_ cm<sup>3</sup> per second

(2)

- (ii) The teacher said that the student should repeat the investigation to get more results. Suggest why.

\_\_\_\_\_  
\_\_\_\_\_

(1)

(b) The student concluded that:

**'the rate of reaction increases when the temperature is increased'.**

Explain, in terms of particles, why the rate of reaction increases.

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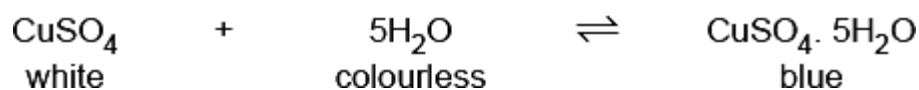
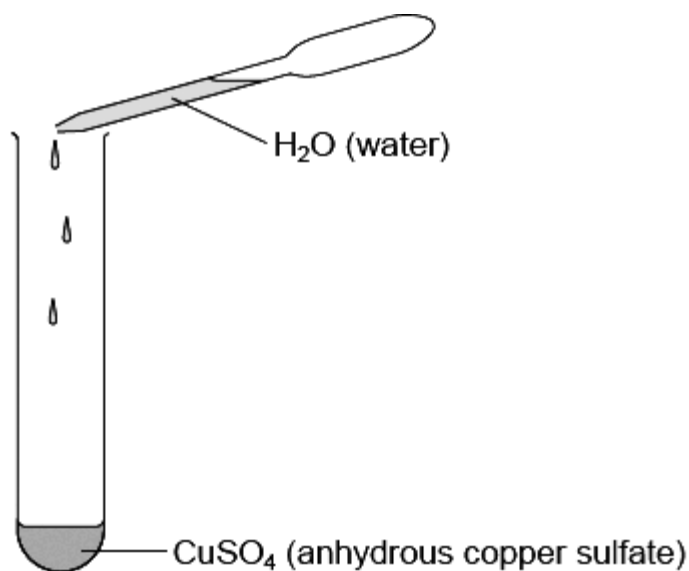
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(2)  
(Total 5 marks)

7.

The diagram shows how anhydrous copper sulfate can be used to test for water.



(a) What colour change will you see when water is added to the  $\text{CuSO}_4$ ?

Colour changes from \_\_\_\_\_ to \_\_\_\_\_

(1)

(b) Draw a ring around the meaning of the symbol  $\rightleftharpoons$

endothermic

exothermic

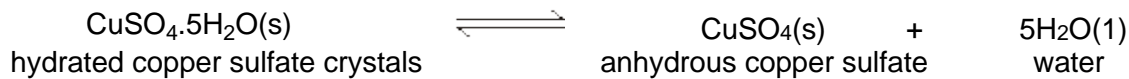
reversible

(1)

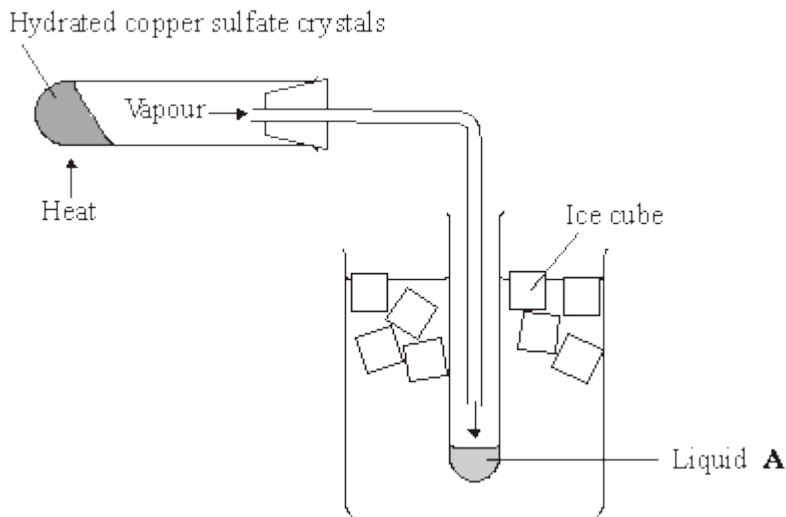
(Total 2 marks)

8.

A student heated some hydrated copper sulfate crystals.  
The equation for this reaction is shown below.



The diagram shows the apparatus used.



(a) Name liquid **A** \_\_\_\_\_

(1)

(b) What helped the vapour to condense into liquid **A**?

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(1)

(c) Put a tick (✓) next to the correct meaning of the symbol  $\rightleftharpoons$

Meaning	(✓)
equal amounts of reactants and products	
exothermic reaction	
reversible reaction	

(1)

- (d) The student weighed the copper sulfate before and after it was heated. The experiment was repeated and the two sets of results are shown in the table.

Mass of copper sulfate before heating in grams	Mass of copper sulfate after heating in grams	Mass lost in grams
2.50	1.65	0.85
2.50	1.61	0.89

- (i) Draw a ring around the **average** mass lost for these two sets of results.

**0.85 g          0.87 g          0.89 g**

(1)

- (ii) The student used the same mass of copper sulfate each time but the mass lost was different.

Put a tick (✓) next to the **two** reasons which could explain why the mass lost is different.

Reason	(✓)
The student used different test tubes for the two experiments.	
The student made errors in weighing during the experiments.	
The student used more ice in one of the experiments.	
The student did not heat the copper sulfate for long enough in one of the experiments.	

(2)

- (e) Anhydrous copper sulfate is used to test for water.

Use words from the box to complete the sentence.

<b>blue          green          red          white</b>
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Water changes the colour of anhydrous copper sulfate from

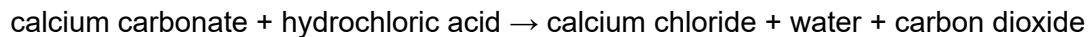
\_\_\_\_\_ to \_\_\_\_\_ .

(2)

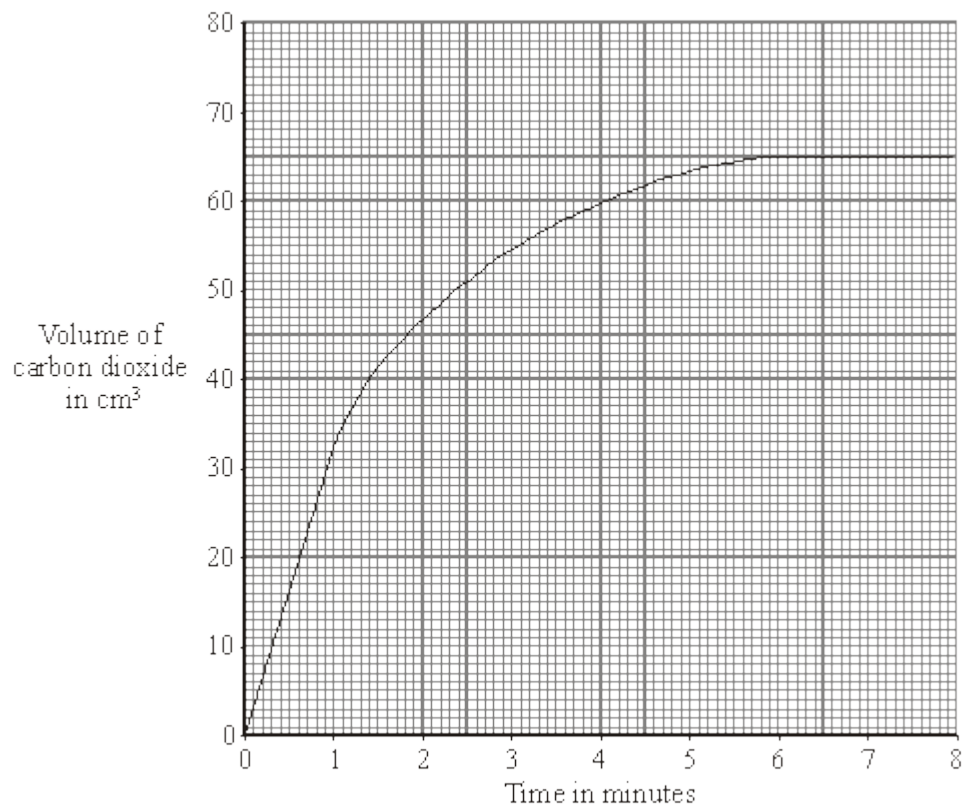
(Total 8 marks)

9.

A student studied the reaction between dilute hydrochloric acid and an **excess** of calcium carbonate.



The student measured the volume of carbon dioxide produced in the experiment. The results are shown on the graph.



(a) After how many minutes had all the acid been used up?

\_\_\_\_\_ minutes

(1)

(b) The student wrote this conclusion for the experiment:

**'The reaction gets slower and slower as the time increases.'**

Explain why the reaction gets slower. Your answer should be in terms of particles.

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(2)

- (c) A second experiment was carried out at a higher temperature. All other factors were the same.

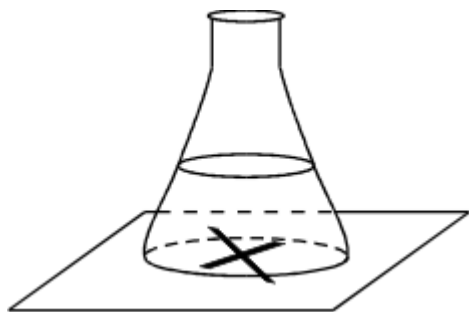
**Draw** a line on the graph above to show the results that you would expect.

(2)

(Total 5 marks)

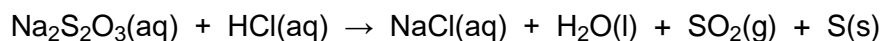
10.

A student studied the effect of temperature on the rate of reaction between hydrochloric acid and sodium thiosulphate.



- The student mixed 50 cm<sup>3</sup> of a sodium thiosulphate solution and 5 cm<sup>3</sup> of hydrochloric acid in a flask.
- The flask was placed over a cross.
- The student timed how long after mixing the cross could no longer be seen.

- (a) (i) Balance the chemical equation for this reaction.



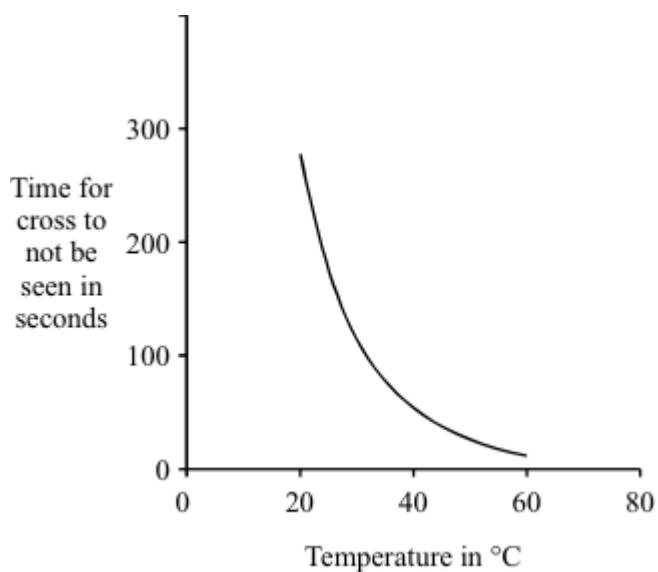
(1)

- (ii) What causes the cross to be seen no longer?

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(1)

(b) A graph of the results is shown.



(i) What effect does temperature have on the rate of this reaction?

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(1)

(ii) Explain why temperature has this effect on the rate of reaction.

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(2)

(Total 5 marks)

## Mark schemes

1.

- (a) the forward and backward reactions occur

*allow reversible*

1

at (exactly) the same rate

1

in a closed system

*allow therefore the concentrations / amounts of the reactants and products remain the same*

1

- (b) (i) increasing the temperature would lower the yield of ethanol **or** the (position of) equilibrium moves to the left

*if student has stated that increasing the temperature increases the yield then award 0 marks*

1

since the backwards reaction is endothermic **or** the forward reaction is exothermic

1

- (ii) increasing the pressure would increase the yield of ethanol **or** the (position of) equilibrium moves to the right

*if student has stated that increasing the pressure decreases the yield then award 0 marks*

1

because the position (of equilibrium) moves in the direction of the lower number of moles (of gas)

*2 (moles / molecules / volumes / particles) on lhs / 1 (mole / molecule / volume / particle) on rhs*

1

- (c) (a catalyst) provides an alternative pathway

1

with lower activation energy

**or**

(a catalyst) lowers the activation energy (1)

so less energy is needed to react **or** more particles react (1)

1

[9]

- 2.** (a) (i) oxygen, sulfur trioxide  
*both needed for mark* 1
- (ii) compound 1
- (b) increases  
*accept (goes) higher / (goes) up / (is) faster / (are) more frequent* 1
- (c) activation 1
- (d) catalyst **or** increase temperature 1
- [5]**
- 3.** (a) (i) a continuous straight line missing anomalous point  
*allow a line which does not start at zero / origin* 1
- (ii) any **two** sensible errors eg  
*ignore systematic / zero error / weighing error **or** error unqualified*
- timing errors and / or example
  - measurement errors and / or example
  - apparatus errors and / or example
  - human / experimental / reading / random error and / or example or 'did not do it right'  
*could be two from **same** category  
eg two timing errors – watch not started at the same time plus difficulty in deciding when the cross has disappeared.*
  - temperature fluctuation
  - anomalous point  
*accept outlier / wrong result*
  - results not recorded correctly
  - plotting error
  - rate calculated incorrectly  
*ignore 'not repeated'*
- 2

- (b) (i) straight line  
*allow as concentration increases the rate goes up **or** converse*  
*allow numerical example*  
*allow positive correlation*  
*allow same gradient*  
*ignore 'most points near / on line of best fit'*

1

- (ii) because of an increase in frequency of collisions  
*max 1 if incorrect reference to energy **or** if subatomic particle specified*  
*accept because particles are more likely to collide or higher chance of collision*  
*ignore more (successful) collisions*

1

because there are more particles (per unit volume)  
*allow because particles are closer together*

1

[6]

4.

- (a) any **two** from:

- effervescence / bubbles / fizzing  
*allow gas / hydrogen is given off*  
*allow volume of gas*  
*allow magnesium floats*
- magnesium disappears / dissolves  
*allow change in mass of magnesium*
- heat given off / exothermic  
*allow temperature change*  
*do **not** accept temperature decreases*
- change in pH  
*do **not** accept pH decreases*

2

- (b) Marks awarded for this answer will be determined by the Quality of Written Communication (QWC) as well as the standard of the scientific response. Examiners should also refer to the information in the [Marking guidance](#).

**0 marks**

No relevant content.

**Level 1 (1-2 marks)**

A simple plan without reference to changing any variable but should include an attempt at measuring rate **or** an attempt at fair testing

**Level 2 (3-4 marks)**

A plan including change of concentration / 'volume' of acid **and** should include an attempt at measuring rate **and / or** an attempt at fair testing

**Level 3 (5-6 marks)**

A workable plan including change of concentration **and** measurement of rate **and** fair testing

**Examples of chemistry points made in the response could include:**

**Plan:**

- add magnesium to acid
- time reaction / 'count bubbles' / measure volume of gas
- change concentration / 'volume' of acid

**Control Variables:**

- amount / mass / length / same 'size' of magnesium
- volume / amount of acid

6

[8]

5.

(a) particles move faster

*accept molecules / atoms / ions instead of particles*

**or**

particles have more energy

*ignore move / vibrate more*

1

so they collide more often / frequently

*allow particles collide harder / with more force*

*ignore collide quicker*

**or**

more of the collisions are successful / have the activation energy

*ignore collide more / more collisions*

1

(b) any **one** from:

- increase surface area (of the rock)  
*accept crush / powder the rock*
- increase the concentration (of the acid)  
*ignore increase the pressure / temperature*
- add a catalyst
- stir / mix the mixture

1

[3]

6.

(a) (i) 0.2

*correct answer gains 2 marks with or without working*  
*accept answer in table*  
*if answer incorrect 5/25 gains 1 mark*

2

(ii) any **one** from:

- wider range of temperatures (owtte)
- (repeat at the same temperature) to improve accuracy / reliability  
*allow to make it reliable / accurate*
- reveal anomalous results (owtte)  
*allow to eliminate random / human errors / to check results owtte*
- so you can get an average / better average  
*ignore to make it a fair test / to get better results*  
*ignore precision and validity*

1

(b) any **two** from:

*allow atoms / molecules / they instead of particles throughout*

- particles gain energy / have more energy  
*ignore increases particles activation energy*
- particles move faster  
*ignore move more / vibrate more*
- particles collide more
- more of the particles have the activation energy **or** more of the collisions are successful (owtte)  
*ignore increases / decreases activation energy*

**or**

particles collide with more force / harder / more energy  
*allow more successful collisions*  
*alone for 1 mark*

2

[5]

7.

(a) white to blue

*accept colourless to blue*

1

(b) reversible

1

[2]

8.

(a) water

*accept H<sub>2</sub>O or 5H<sub>2</sub>O*

2 must be below halfway

1

(b) the cold water / ice / cubes (owtte)

*accept 'cooled down' or references to cold*

1

(c) reversible reaction

1

(d) (i) 0.87g

1

(ii) the student made errors in weighing during the experiments

1

the student did not heat the copper sulfate for long enough in one of the experiments

1

(e) white 1  
blue  
*allow 1 mark for blue to white* 1

[8]

9.

(a) 6  
*accept 5.8 – 6* 1

(b) hydrochloric acid used up / reacted / combined / **or** fewer particles  
(of hydrochloric acid) **or** fewer hydrogen ions owtte  
*accept reactants used up*  
*accept less calcium carbonate **or***  
*smaller surface area of calcium*  
*carbonate*  
*accept lower concentration / less*  
*crowded*  
*do **not** accept atoms / molecules*  
*ignore references to energy*  
*do **not** accept references to atoms or molecules* 1

fewer collisions owtte  
*independent mark* 1

(c) steeper curve initially  
*independent marks* 1

levels out at same volume  

- must indicate levelling out*
- if line goes higher than 66 do **not** award this mark*
- diagonal line only = 0 marks*
- if steeper initially and then crosses the line and finishes correctly, then loses one*

 1

[5]

10.

(a) (i)  $\text{Na}_2\text{S}_2\text{O}_3(\text{aq}) + 2 \text{HCl}(\text{aq}) \rightarrow 2\text{NaCl}(\text{aq}) + \text{H}_2\text{O}(\text{l}) + \text{S}(\text{s}) + \text{SO}_2(\text{g})$  1

(ii) (formation of) sulphur  
*accept precipitate **or** solid produced*  
*do **not** accept goes cloudy **or** milky* 1

- (b) (i) heat  $\equiv$  temperature increased temperature increases (the rate of reaction)  
or decreased temperature decreases rate of reaction

*may be gained in part (ii) if stated and not implied*

1

- (ii) (these ideas may be given in (i))

particles have more kinetic energy

*accept particles move faster*

1

more collisions (so more reactions)

*more energetic collisions **two** marks*

1

**[5]**