Rates of Reaction 1

Name: _____

Class: _____

Date: _____

Time: **56 minutes**

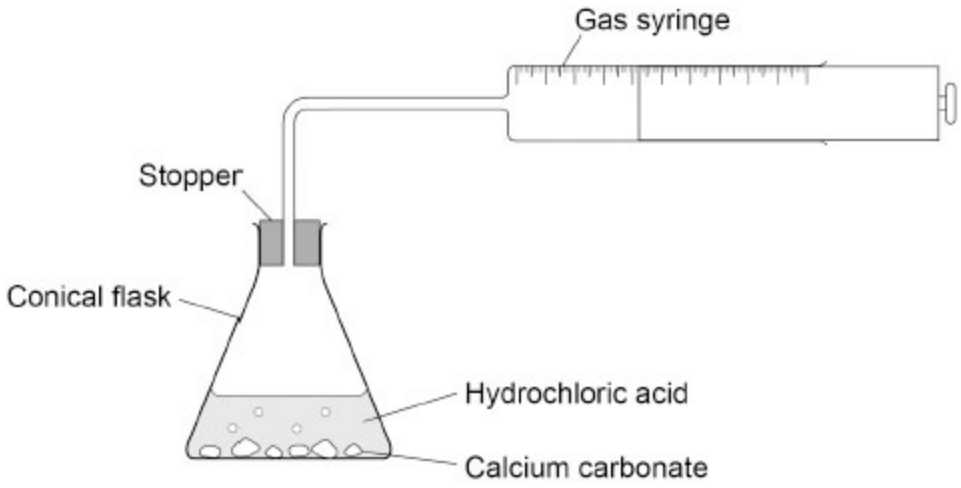
Marks: **52 marks**

Comments:

1. A student investigated the reaction of calcium carbonate with hydrochloric acid.

Figure 1 shows the apparatus.

Figure 1



This is the method used.

1. Measure 50 cm^3 of hydrochloric acid into a conical flask.
2. Add 4.0 g of calcium carbonate to the conical flask.
3. Insert the stopper into the conical flask as quickly as possible.
4. Start a timer.
5. Measure the volume of gas collected every 30 seconds for 3 minutes.
6. Repeat steps 1 to 5 using different concentrations of hydrochloric acid.

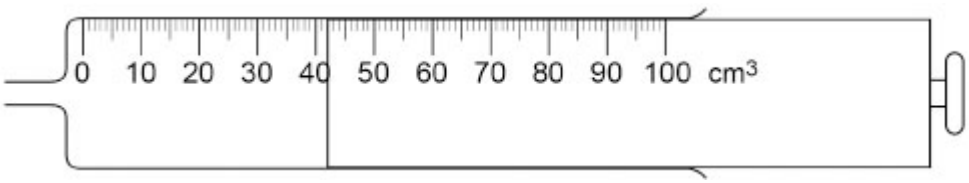
(a) Name a suitable piece of equipment to measure 4.0 g of calcium carbonate.

_____

(1)

(b) **Figure 2** shows the gas syringe during the investigation.

Figure 2



What is the reading on the gas syringe?

_____ cm^3

(1)

(c) What is the independent variable in the investigation?

Tick (✓) **one** box.

Concentration of hydrochloric acid ☐

Mass of calcium carbonate ☐

Temperature of the room ☐

(1)

(d) Why did the student insert the stopper into the conical flask as quickly as possible in step 3?

_____

_____

(1)

(e) The gas produced during the investigation is carbon dioxide.

The test for carbon dioxide uses limewater.

What is the chemical name for limewater?

Tick (✓) **one** box.

Calcium hydroxide solution ☐

Potassium carbonate solution ☐

Sodium chloride solution ☐

(1)

(f) The student measured the volume of gas collected every 30 seconds for 3 minutes.

The volume of gas was zero at the start.

For one concentration of hydrochloric acid, the volumes of gas collected were:

43 cm^3 66 cm^3 78 cm^3 83 cm^3 84 cm^3 85 cm^3

Complete the table below.

You should:

- add headings to each column
- add units
- add all of the results to the table.

0	0

(4)

(g) The student used a different concentration of hydrochloric acid.

18 cm^3 of gas was collected in the first 30 seconds.

Calculate the mean rate of reaction for the first 30 seconds.

Use the equation:

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

Choose the unit from the box.

cm^3	**cm^3/s**	**s**	**s/cm^3**

Mean rate of reaction = _____ Unit _____

(3)

(h) Increasing the concentration of hydrochloric acid increases the rate of the reaction.

What are **two** reasons why?

Tick (✓) **two** boxes.

- The particles are closer together. ☐
- The particles collide more frequently. ☐
- The particles have a lower surface area. ☐
- The particles have less energy. ☐
- The particles move faster. ☐

(2)

(Total 14 marks)

2. Screenwash is a mixture designed to keep car windscreens clean.

The components in screenwash include glycerol, methanol and water.

(a) Screenwash is made by mixing the components in carefully measured quantities so that the product has the required properties.

What name is given to this type of mixture?

Tick (✓) **one** box.

Catalyst ☐

Formulation ☐

Polymer ☐

(1)

(b) Glycerol has the formula $C_3H_8O_3$

How many atoms are there in one molecule of glycerol?

Tick (✓) **one** box.

3 ☐ 8 ☐ 11 ☐ 14 ☐

(1)

(c) Incomplete combustion happens when glycerol burns in limited oxygen.

Incomplete combustion produces carbon monoxide gas.

Why can the production of carbon monoxide gas be a problem?

Tick (✓) **one** box.

Carbon monoxide is a greenhouse gas. ☐

Carbon monoxide is a toxic gas. ☐

Carbon monoxide is an acidic gas. ☐

(1)

(d) Complete combustion happens when methanol (CH_4O) burns in excess oxygen.

Balance the equation for the reaction.

$$2\ CH_4O + 3\ O_2 \rightarrow \_\_\_\_\_\ CO_2 + 4\ H_2O$$

(1)

Methanol can be produced by the reaction of carbon dioxide with hydrogen.

(e) Describe the test for hydrogen gas.

Give the result of the test.

Test _____

_____

Result _____

_____

(2)

(f) Carbon dioxide is a greenhouse gas.

An increase in greenhouse gases in the atmosphere has led to an increase in average global temperature.

The increase in average global temperature has caused global climate change.

Give **two** effects of global climate change.

1 _____

_____

2 _____

_____

(2)

Anhydrous cobalt chloride can be used to test for water.

The word equation for the reaction is:

anhydrous cobalt chloride (blue) + water ⇌ hydrated cobalt chloride (pink)

(g) Suggest **one** observation that could be made when water is added to anhydrous cobalt chloride.

_____

_____

(1)

(h) The reaction between anhydrous cobalt chloride and water is exothermic.

What type of reaction is the reverse reaction?

_____

(1)

(Total 10 marks)

3. This question is about methanol.

(a) Methanol is used in screenwash.

Screenwash is used to keep car windscreens clean.

Screenwash is a formulation.

Define the term 'formulation'.

_____

_____

(1)

Carbon monoxide and hydrogen are used to produce methanol.

The conditions used in the production of methanol are:

- high temperature
- high pressure
- a catalyst.

The equation for the reaction is:

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

91 kJ/mol of energy is transferred during the exothermic forward reaction.

(b) How much energy is transferred when methanol is decomposed into carbon monoxide and hydrogen?

Tick (✓) **one** box.

< 91 kJ/mol ☐

91 kJ/mol ☐

> 91 kJ/mol ☐

(1)

(c) A scientist developed a principle to predict the effect of changing conditions on a system at equilibrium.

What was the name of the scientist?

_____

(1)

(d) What is the effect of increasing the temperature on the proportion of methanol in the equilibrium mixture?

Tick (✓) **one** box.

The proportion of methanol decreases. ☐

The proportion of methanol stays the same. ☐

The proportion of methanol increases. ☐

(1)

(e) What is the effect of using a catalyst on the proportion of methanol in the equilibrium mixture?

Tick (✓) **one** box.

The proportion of methanol decreases. ☐

The proportion of methanol stays the same. ☐

The proportion of methanol increases. ☐

(1)

(f) Explain the effect of increasing the pressure on the proportion of methanol in the equilibrium mixture.

(3)

(g) Explain the effect of using a catalyst on the **rate** of production of methanol.

(3)

(h) The catalyst allows the reaction to take place at a lower temperature.

Explain **one** advantage of using a lower temperature in the production of methanol.

Do **not** refer to the position of equilibrium in your answer.

(2)

(i) Methanol (CH_3OH) can also be produced by reacting carbon dioxide with hydrogen.

Water is the other product of the reaction.

Write a balanced equation for the reaction.

_____ + _____ → _____ + _____

(2)

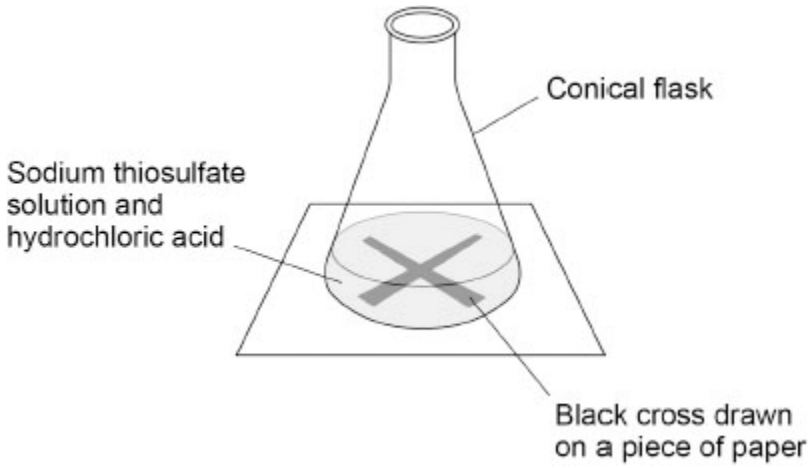
(Total 15 marks)

4. Students investigated the effect of changing the concentration on the rate of chemical reactions.

A student reacted sodium thiosulfate solution with hydrochloric acid.

Figure 1 shows the apparatus.

Figure 1



This is the method used.

1. Measure 50 cm^3 of sodium thiosulfate solution into a conical flask.
2. Put the conical flask on a black cross drawn on a piece of paper.
3. Add 10 cm^3 of hydrochloric acid to the conical flask.
4. Start a timer.
5. Stop the timer when the cross is no longer visible.
6. Record the time taken.
7. Repeat steps 1 to 6 using different concentrations of sodium thiosulfate solution.

(a) What is the dependent variable in this investigation?

_____

_____

(1)

(b) The equation for the reaction is:

$$Na_2S_2O_3(aq) + 2\,HCl(aq) \rightarrow 2\,NaCl(aq) + S(s) + SO_2(g) + H_2O(l)$$

The mixture becomes cloudy as the reaction takes place.

Explain why the mixture becomes cloudy.

_____

_____

_____

_____

(2)

(c) Explain the effect of changing the concentration of the sodium thiosulfate solution on the rate of reaction.

_____

_____

_____

_____

_____

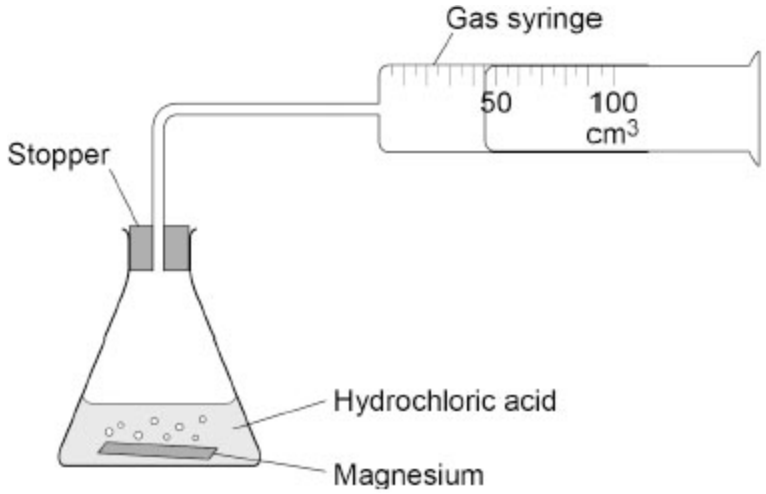
_____

(3)

A different student reacted magnesium with hydrochloric acid.

Figure 2 shows the apparatus.

Figure 2



This is the method used.

1. Measure 50 cm^3 of hydrochloric acid into a conical flask.
2. Add 0.1 g of magnesium ribbon to the conical flask.
3. Insert the stopper into the conical flask as quickly as possible.
4. Start a timer.
5. Record the volume of gas collected every 20 seconds for 5 minutes.
6. Repeat steps 1 to 5 using different concentrations of hydrochloric acid.

(d) Why is the stopper inserted into the conical flask as quickly as possible in step 3?

_____

_____

(1)

(e) The equation for the reaction of magnesium with hydrochloric acid is:

$$Mg + 2\,HCl \rightarrow MgCl_2 + H_2$$

Describe a test for the gas produced in the reaction.

Give the result of the test.

Test _____

_____

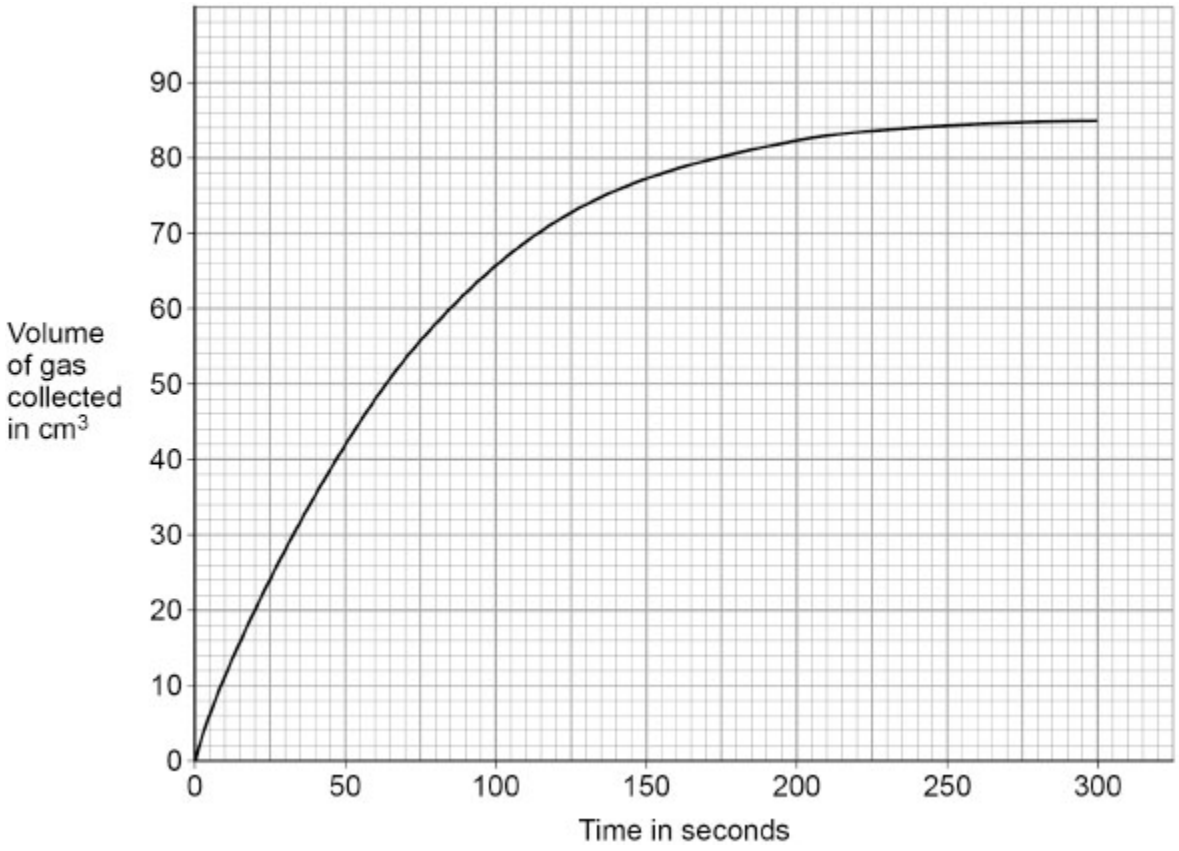
Result _____

_____

(2)

(f) **Figure 3** shows the results for one concentration of hydrochloric acid.

Figure 3



Determine the rate of reaction at 75 seconds.

Rate = _____ cm^3/s

(4)

(Total 13 marks)

1.

(a) balance

allow (weighing) scales

1

(b) 42 (cm^3)

1

(c) concentration of hydrochloric acid

1

(d) to reduce loss of gas

allow carbon dioxide for gas

*do **not** accept to stop loss of gas*

1

(e) calcium hydroxide solution

1

(f) time in s(econds)

1

volume (of gas collected) in cm^3

*if neither mark awarded allow **1** mark for headings of time **and** volume*

1

time values in correct order

1

volume values in correct order

1

(g) (mean rate of reaction =) $\frac{18}{30}$

1

= 0.6

1

cm^3/s

1

(h) the particles are closer together

1

the particles collide more frequently

1

[14]

2.

(a) formulation

1

(b) 14

1

(c) carbon monoxide is a toxic gas

1

(d) $2\ CH_4O + 3\ O_2 \rightarrow 2CO_2 + 4\ H_2O$

allow multiples

1

(e) (test)
add a burning splint

*do **not** accept glowing splint*

1

(result)
(hydrogen burns with) a pop sound

MP2 is dependent on MP1 being awarded

1

(f) any **two** from:

- melting ice caps
- rising sea levels
- more flooding
- extremes of weather

  allow increase in frequency of storms
- increase in droughts

  allow desertification
- increase in wildfires
- loss of habitats
- reduction in biodiversity
- change in migration patterns

*ignore global warming do **not** accept acid rain*

*do **not** accept global dimming*

*do **not** accept deforestation*

*do **not** accept natural disasters*

*do **not** accept references to ozone*

2

(g) colour change (from blue to pink)

1

(h) endothermic

allow (thermal) decomposition

1

[10]

3. (a) a mixture that has been designed as a useful product

1

(b) 91 kJ/mol

1

(c) Le Chatelier

1

(d) the proportion of methanol decreases

1

(e) the proportion of methanol stays the same

1

(f) (increasing the pressure) increases the proportion of methanol

1

(because) there are more molecules / moles of reactant (than product)

1

(so) the equilibrium (position) shifts to the side with fewer molecules / moles

1

(g) (the catalyst) increases the rate of the reaction

1

(by) providing an alternative pathway (for the reaction)

1

(with) a lower activation energy

1

(h) reduces the costs

1

(because) less energy is used

OR

less fuels burned (1)

(so) less contribution to global warming (1)

allow (so) less carbon dioxide produced

1

(i) $CO_2 + 3\ H_2 \rightarrow CH_3OH + H_2O$

allow multiples

*allow **1** mark for*

$CO_2 + H_2 \rightarrow CH_3OH + H_2O$ with no / incorrect balancing numbers

2

[15]

4. (a) time taken (for the cross to be no longer visible)

1

(b) sulfur (is produced)

1

(which is a) solid

allow (which is) insoluble

allow (which is) a precipitate

1

(c) increasing the concentration increases the rate of reaction

allow converse throughout

1

(because) there are more particles in the same volume (of solution)

allow (because) the particles are closer together

*do **not** accept the particles have more energy*

1

(so) there are more frequent collisions

1

(d) to reduce loss of gas

allow to reduce loss of hydrogen

*do **not** accept to stop loss of gas / hydrogen*

1

(e) (test)
add a burning splint

*do **not** accept glowing splint*

1

(result)
(hydrogen burns with) a pop sound

MP2 is dependent upon MP1 being awarded

1

(f) tangent drawn at 75 s

1

value of *x*-step **and** *y*-step from tangent

allow evidence of use of two points on tangent either on the graph or in the text

allow a tolerance of ± ½ a small square

1

$$(\text{rate}=)\ \frac{\text{value for y-step}}{\text{value for x-step}}$$

allow correct use of incorrectly determined value(s) for x-step and/or y-step from a drawn tangent

1

correct calculation of rate

1

[13]