Rates of Reaction 2

Name: _____

Class: _____

Date: _____

Time: **77 minutes**

Marks: **71 marks**

Comments:

1. Different tests can be used to identify chemicals.

(a) A student measured the melting points of four substances.

The table below shows the results.

Substance	Melting point in °C
A	52 to 54
B	61
C	–2 to 0
D	80 to 82

Which substance was pure?

Give **one** reason for your answer.

Substance _____

Reason _____

_____

(2)

Anhydrous copper sulfate can be used to test for water.

The word equation for the reaction is:

anhydrous copper sulfate + water ⇌ hydrated copper sulfate

(b) Complete the sentence.

Choose answers from the box.

blue	**green**	**red**	**white**	**yellow**

When water is added to anhydrous copper sulfate, the colour changes

from _____ to _____ .

(2)

(c) The reaction between anhydrous copper sulfate and water is reversible.

How does the word equation show that the reaction is reversible?

_____

(1)

(d) The formula of anhydrous copper sulfate is $CuSO_4$

What is the total number of atoms in the formula $CuSO_4$?

Tick (✓) **one** box.

3 ☐ 4 ☐ 6 ☐ 7 ☐

(1)

(e) Chlorine is a gas.

Describe the test for chlorine.

Give the result.

Test _____

_____

Result _____

_____

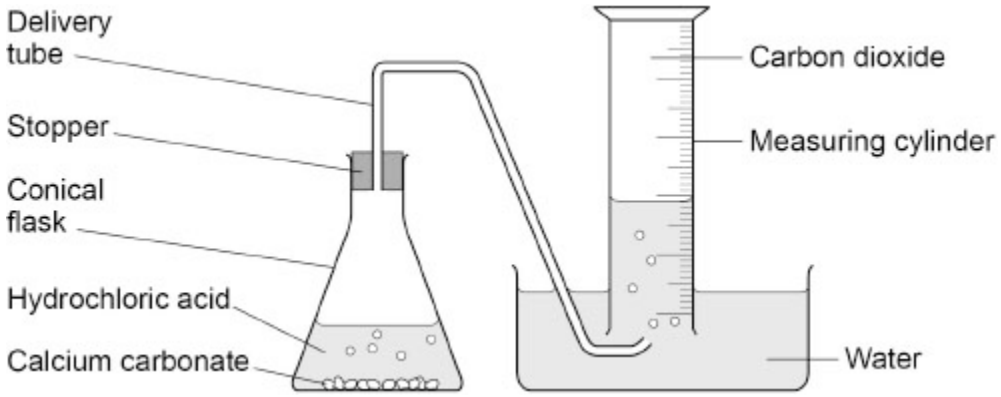
(2)

(Total 8 marks)

2. Some factors affect the rates of chemical reactions.

(a) A student investigated the effect of changing the particle size of calcium carbonate on the rate of reaction with hydrochloric acid.

The figure below shows the apparatus.



Describe a method the student could use to produce valid results.

(6)

(b) The student investigated the effect of increasing the temperature on the rate of a reaction.

Explain the effect of increasing the temperature on the rate of a reaction.

Refer to particles and collisions in your answer.

(3)

Catalysts affect the rate of reactions.

(c) What is meant by a 'catalyst'?

(2)

(d) What are catalysts in biological systems called?

(1)

(Total 12 marks)

3. Sulfuric acid is produced by an industrial process.

In the process, sulfur dioxide (SO_2) reacts with oxygen (O_2) to produce sulfur trioxide (SO_3).

The equation for the reversible reaction is:

$$2\ SO_2(g) + O_2(g) \rightleftharpoons 2\ SO_3(g)$$

The forward reaction releases 198 kJ/mol of energy.

(a) What is the amount of energy transferred during the reverse reaction?

Tick (✓) **one** box.

< 198 kJ/mol ☐

= 198 kJ/mol ☐

> 198 kJ/mol ☐

(1)

(b) The concentration of oxygen is increased.

What is the effect on the position of the equilibrium?

Tick (✓) **one** box.

Equilibrium position shifts to the left ☐

Equilibrium position does not change ☐

Equilibrium position shifts to the right ☐

(1)

(c) The pressure is decreased.

What is the effect on the position of the equilibrium?

Tick (✓) **one** box.

Equilibrium position shifts to the left ☐

Equilibrium position does not change ☐

Equilibrium position shifts to the right ☐

(1)

(d) The temperature is increased.

What is the effect on the position of the equilibrium?

Tick (✓) **one** box.

Equilibrium position shifts to the left	☐
Equilibrium position does not change	☐
Equilibrium position shifts to the right	☐

(1)

(e) A catalyst is used in the reaction.

Suggest what effect the catalyst has on the position of the equilibrium.

Give **one** reason for your answer.

Effect _____

_____

Reason _____

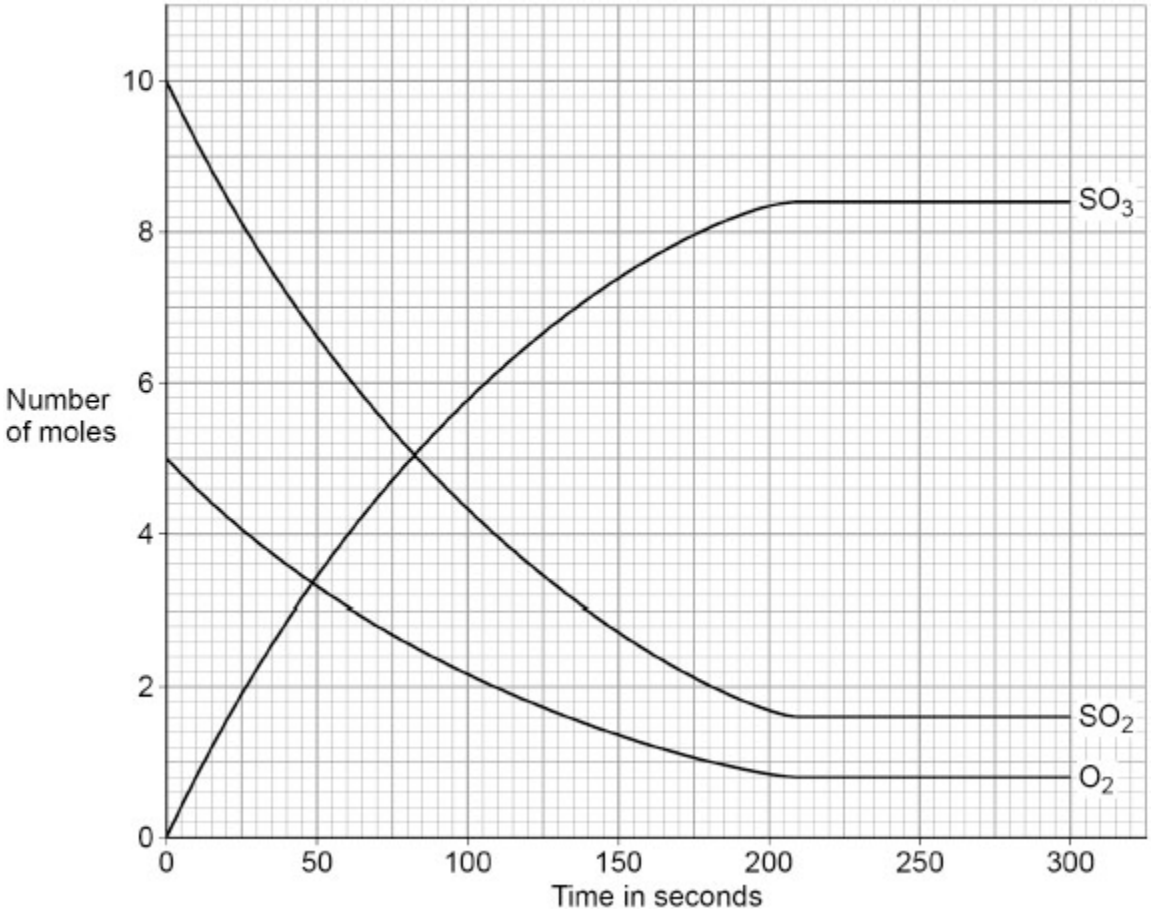
_____

(2)

A scientist measured how the number of moles of sulfur dioxide, oxygen and sulfur trioxide varied with time during the reaction.

Figure 1 shows the results.

Figure 1



(f) Determine the time taken for the reaction to reach equilibrium.

Explain your answer.

Use **Figure 1**.

Time _____ s

Explanation _____

_____

_____

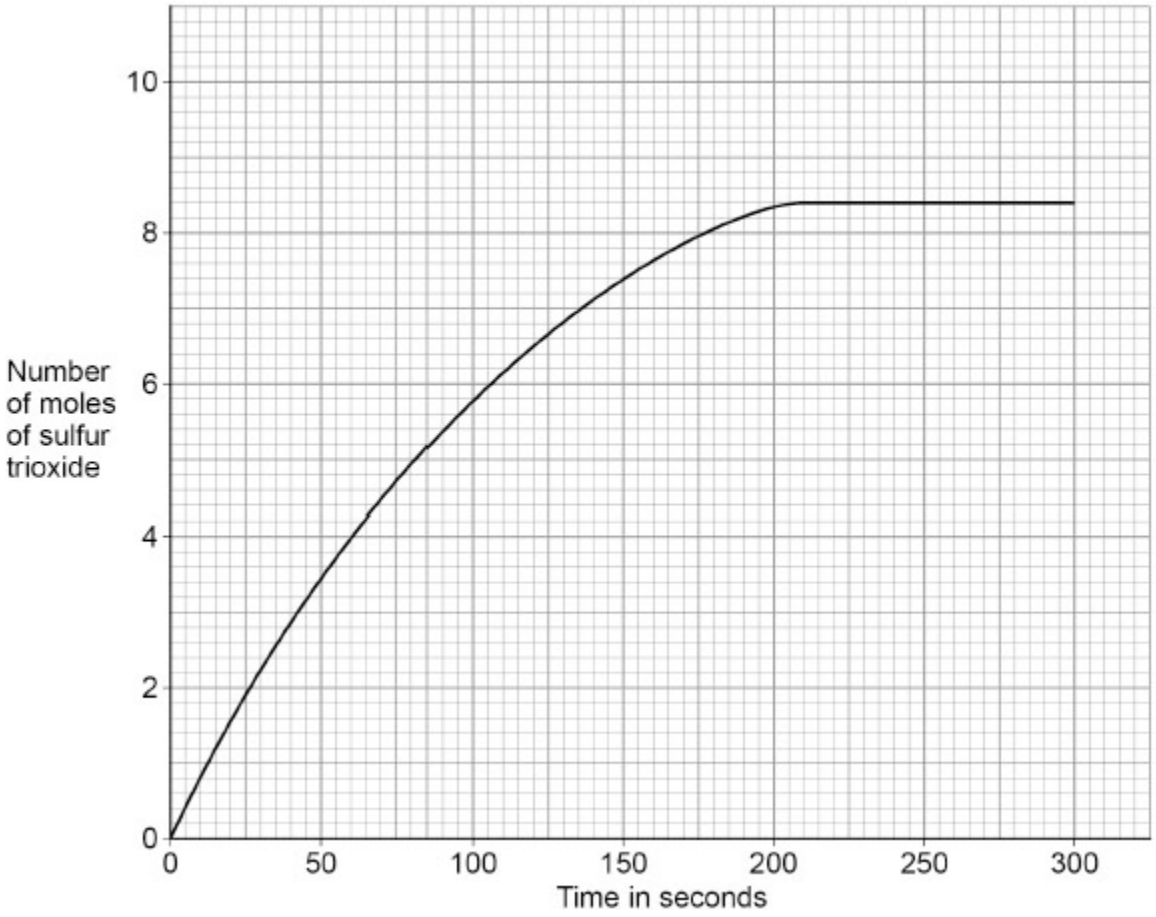
_____

_____

(3)

(g) **Figure 2** shows the results for sulfur trioxide.

Figure 2



Determine the rate of reaction at 60 seconds.

_____

_____

_____

_____

_____

_____

_____

Rate = _____ mol/s

(4)

(Total 13 marks)

4. A catalyst is used to increase the rate of decomposition of hydrogen peroxide.

(a) Hydrogen peroxide decomposes to produce water and oxygen.

Write a word equation for the reaction.

_____ → _____ + _____

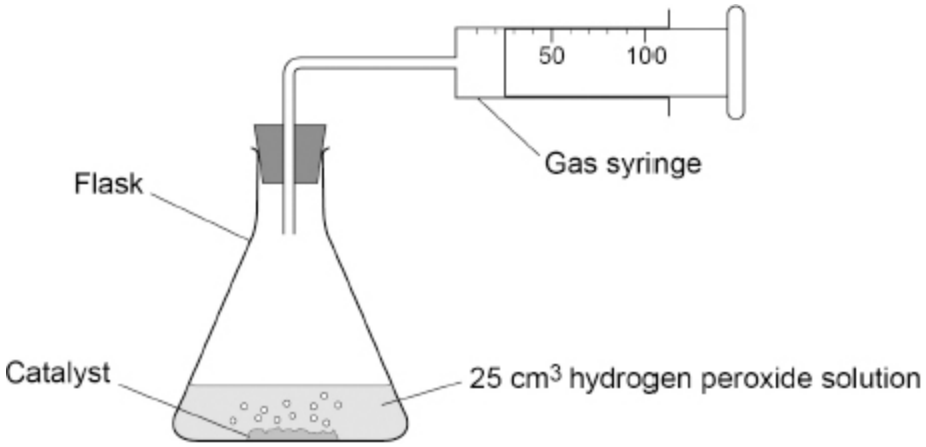
(1)

A student investigated the rate of decomposition of hydrogen peroxide using three different catalysts:

- manganese dioxide
- copper oxide
- zinc oxide.

Figure 1 shows the apparatus.

Figure 1



This is the method used.

1. Measure 25 cm^3 of hydrogen peroxide solution into a flask.

2. Add 0.5 g of manganese dioxide catalyst to the flask.

3. Attach a gas syringe to the flask.

4. Measure the volume of oxygen produced every 20 seconds for 120 seconds.

5. Repeat steps 1 to 4 two more times.

6. Repeat steps 1 to 5 using copper oxide catalyst.

7. Repeat steps 1 to 5 using zinc oxide catalyst.

(b) Which **two** control variables are used in the investigation?

Tick (✓) **two** boxes.

Mass of catalyst ☐

Shape of flask ☐

Time of taking readings ☐

Volume of hydrogen peroxide solution ☐

Volume of oxygen produced ☐

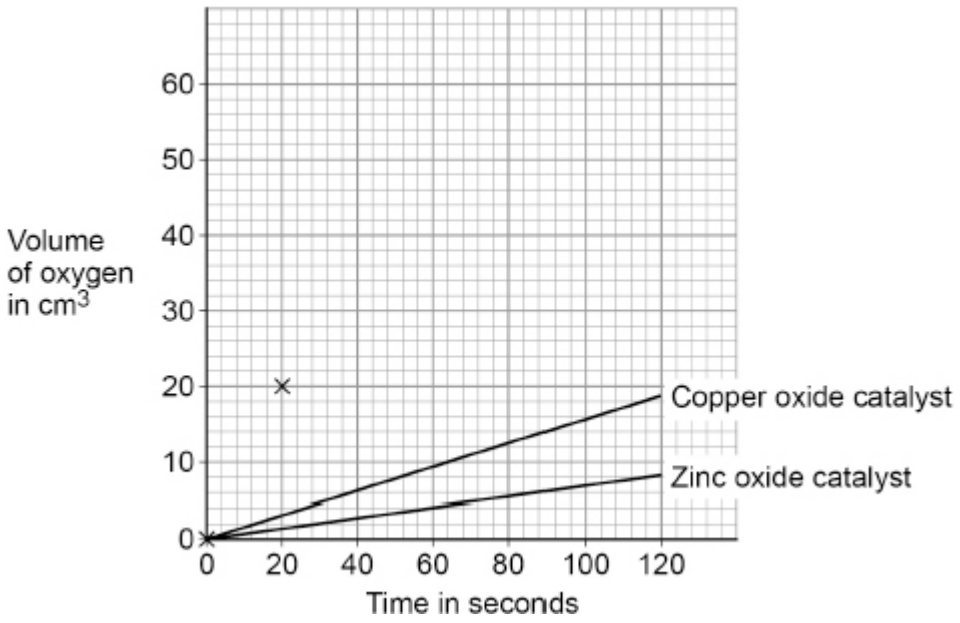
(2)

The table below shows the results with manganese dioxide catalyst.

Time in seconds	0	20	40	60	80	100	120
Volume of oxygen in cm^3	0	20	32	40	45	49	50

Figure 2 shows a graph of the results with copper oxide catalyst and with zinc oxide catalyst.

Figure 2



(c) Complete **Figure 2**.

You should:

- plot the data for the manganese dioxide catalyst from the table above
- draw a line of best fit.

The first two points have been plotted for you.

(3)

(d) Which is the best catalyst?

Give **one** reason for your answer.

Use the completed **Figure 2**.

Tick (✓) **one** box.

Copper oxide ☐

Manganese dioxide ☐

Zinc oxide ☐

Reason _____

_____

(2)

(e) The student repeated the investigation with manganese dioxide catalyst.

The results were all close to the true value.

Complete the sentence.

Choose the answer from the box.

accurate	**approximate**	**random**

Results that are close to the true value are _____.

(1)

(f) The student repeated the investigation using manganese dioxide catalyst at a higher temperature.

Complete the sentence.

Choose the answer from the box.

decrease	**stay the same**	**increase**

At a higher temperature, the rate of reaction will _____.

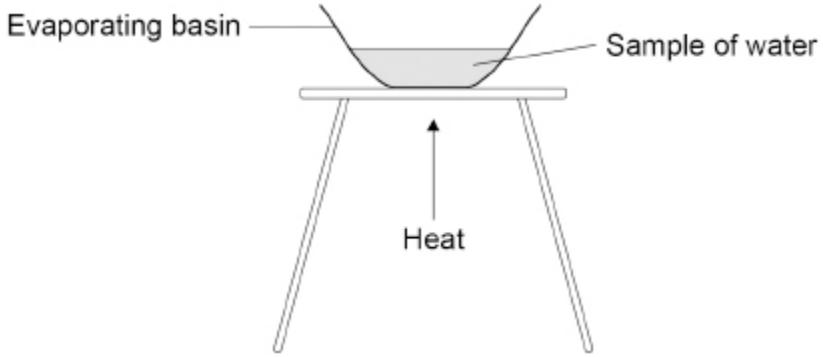
(1)

(Total 10 marks)

5. Some types of water contain dissolved substances.

A student investigated the mass of dissolved solids in distilled water and in sea water.

The figure below shows the apparatus.



This is the method used.

1. Weigh an evaporating basin.

2. Add 20 cm^3 of distilled water to the evaporating basin.

3. Weigh the evaporating basin and the water sample.

4. Heat the water sample for 2 minutes.

5. Weigh the evaporating basin and contents.

6. Repeat steps 1 to 5 two more times.

7. Repeat steps 1 to 6 with sea water.

(a) The method used by the student did **not** give valid results.

Describe **one** improvement the student could make to obtain valid results.

_____

_____

(1)

A different student used a method which gave valid results.

(b) The table below shows the results.

	Mass of dissolved solids in grams			
Type of water	**Test 1**	**Test 2**	**Test 3**	**Mean**
Distilled water	0.00	0.00	0.00	0.00
Sea water	0.30	**X**	0.26	0.29

Calculate the value **X** for the mass of dissolved solids in sea water in **Test 2**.

_____

_____

_____

Mass **X** = _____ g

(2)

(c) The student concludes that distilled water is pure.

Describe a test to confirm that distilled water is pure.

Test _____

_____

Result _____

_____

(2)

Tap water is potable.

A stage in the production of potable water is sterilising.

A gas is used to sterilise water.

The equation for the reaction is:

$$Cl_2(g) + H_2O(l) \rightleftharpoons HOCl(aq) + HCl(aq)$$

(d) What is meant by the symbol $\rightleftharpoons$?

_____

_____

(1)

(e) The reaction is at equilibrium.

The reaction is exothermic.

What happens to the equilibrium position when the temperature is increased?

Tick (✓) **one** box.

Shifts towards the left-hand side	☐
Stays in the same place	☐
Shifts towards the right-hand side	☐

(1)

(f) Describe a test to identify the gas used to sterilise water.

Test _____

_____

Result _____

_____

(2)

(g) Another stage in the production of potable water is filtering.

Explain why potable water contains dissolved solids after filtering.

_____

_____

_____

_____

(2)

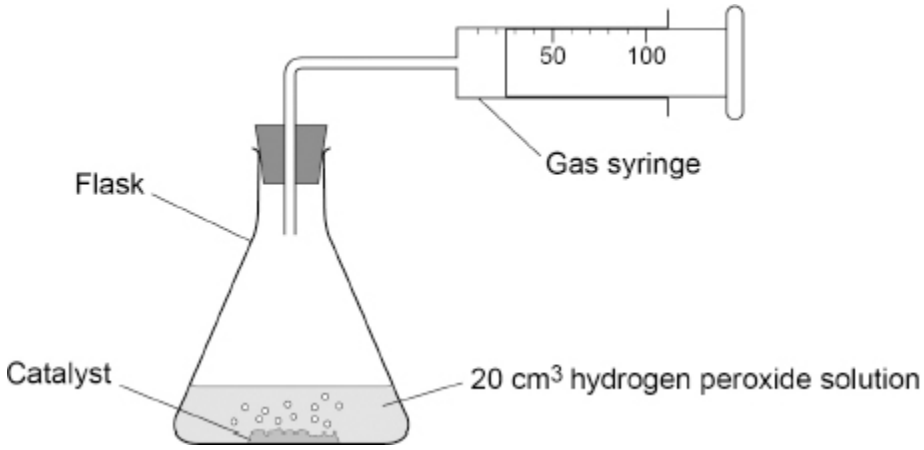
(Total 11 marks)

6. A student investigated the rate of decomposition of hydrogen peroxide using three different catalysts:

- manganese dioxide
- copper oxide
- zinc oxide.

Figure 1 shows the apparatus.

Figure 1



This is the method used.

1. Measure 20 cm^3 of hydrogen peroxide solution into a flask.

2. Add 0.5 g of manganese dioxide catalyst to the flask.

3. Attach a gas syringe to the flask.

4. Measure the volume of oxygen produced every 30 seconds for 180 seconds.

5. Repeat steps 1 to 4 two more times.

6. Repeat steps 1 to 5 using copper oxide catalyst.

7. Repeat steps 1 to 5 using zinc oxide catalyst.

(a) The equation for the decomposition of hydrogen peroxide is:

$$2\ H_2O_2 \rightarrow 2\ H_2O + O_2$$

Describe a test to identify the gas produced in the reaction.

Test _____

_____

Result _____

_____

(2)

(b) Using 10 cm^3 of hydrogen peroxide solution gives less accurate results than using 20 cm^3 of hydrogen peroxide solution of the same concentration.

Explain why.

_____

_____

_____

_____

(2)

(c) Suggest **one** possible source of systematic error in the investigation.

_____

_____

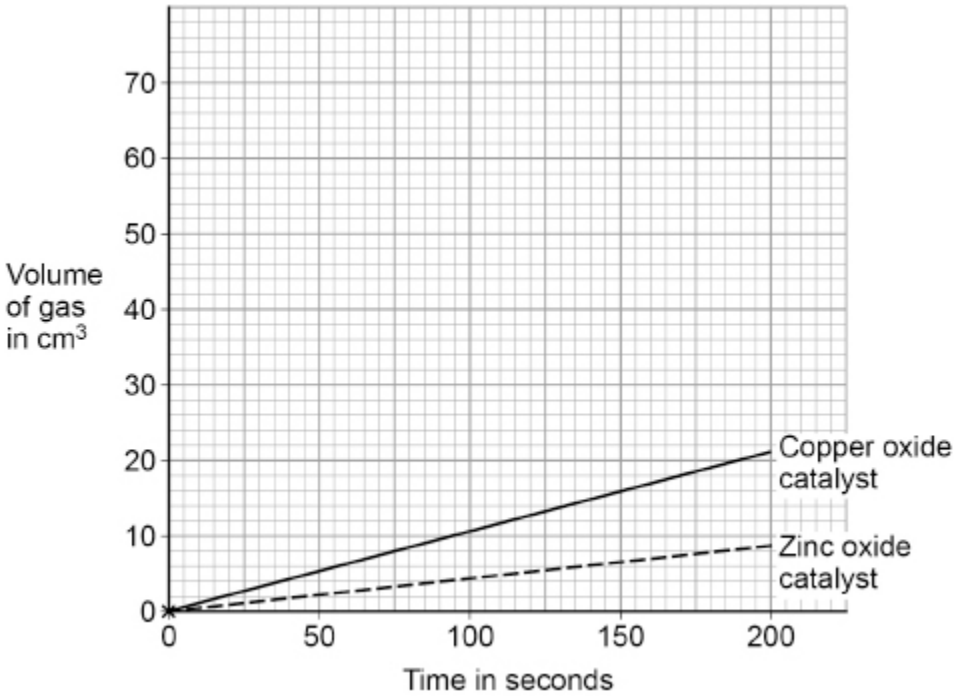
(1)

The table below shows the results for manganese dioxide catalyst.

Time in seconds	0	30	60	90	120	150	180
Volume of gas in cm^3	0	22	38	41	54	58	60

Figure 2 shows a graph of the results with copper oxide catalyst and with zinc oxide catalyst.

Figure 2



(d) Complete **Figure 2**.

You should:

- plot the data from the table above
- draw a line of best fit.

The first point has been plotted for you.

(3)

(e) Which catalyst gives the fastest **rate** of reaction?

Give **one** reason for your answer.

Use the completed **Figure 2**.

Catalyst _____

Reason _____

_____

(2)

(f) The rate of reaction is **not** dependent on the volume of hydrogen peroxide solution.

Explain why.

_____

_____

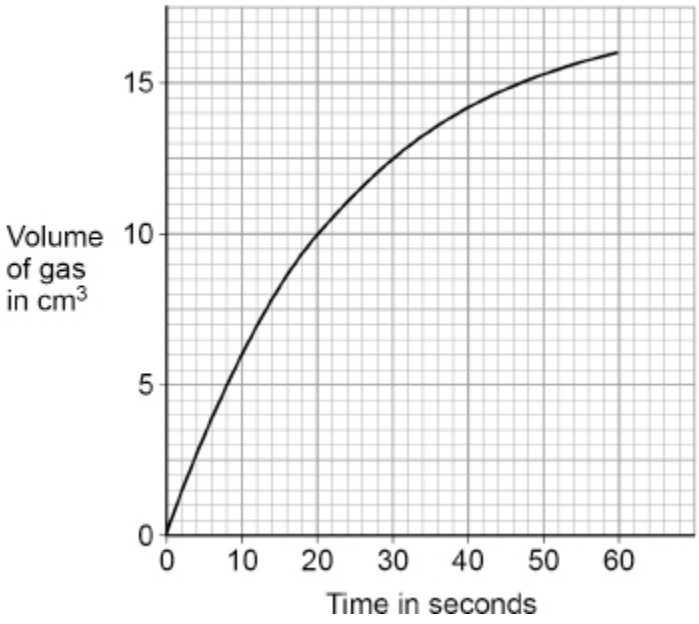
_____

_____

(2)

(g) **Figure 3** shows the results from a different investigation.

Figure 3



Determine the rate of reaction at 20 seconds.

Show your working on **Figure 3**.

Give your answer to 3 significant figures.

Rate (3 significant figures) = _____ cm^3/s

(5)

(Total 17 marks)

1.

(a) (substance) **B**

allow 61 (°C)

1

(**B**) has a specific melting point

allow all the other substances melted over a range of temperatures

MP2 is dependent on MP1 being awarded

1

(b) (from) white

1

(to) blue

1

(c) (the symbol / sign) ⇌

allow the symbol with arrows both ways

1

(d) 6

1

(e) (test) damp (blue / red) litmus paper

1

(result)
(litmus paper) is bleached
or
(litmus paper) turns white

ignore paper turns red

1

[8]

2.

(a) **Level 3:** The method would lead to the production of a valid outcome. The key steps are identified and logically sequenced.

5–6

Level 2: The method would not necessarily lead to a valid outcome. Most steps are identified, but the method is not fully logically sequenced.

3–4

Level 1: The method would not lead to a valid outcome. Some relevant steps are identified, but links are not made clear.

1–2

No relevant content

0

Indicative content

- measure volume of (hydrochloric) acid
- using a measuring cylinder

- measure mass of calcium carbonate
- using a balance

- **add (hydrochloric) acid to calcium carbonate in conical flask**

- **put stopper and delivery tube into conical flask**

- **start a timer**

- **record volume of gas collected at set time intervals**

or

time how long it takes for a fixed volume of gas to be collected

- **repeat using different sized pieces of calcium carbonate**

- use same mass of calcium carbonate
- use same volume of (hydrochloric) acid
- use same concentration of (hydrochloric) acid
- use same temperature of (hydrochloric) acid

- repeat each experiment

(b) (increasing the temperature) increases the rate of reaction

1

(because) particles have more energy

allow (because) particles move faster

1

(so) the frequency of collisions increases

allow (so) a greater proportion of collisions have enough energy to react

1

(c) (a substance that) increases the rate of reaction

allow (a catalyst) increases / changes the rate of reaction

1

and is not used up during the reaction

ignore does not take part in the reaction

1

(d) enzymes

1

[12]

3. (a) = 198 kJ/mol

1

(b) equilibrium position shifts to the right

1

(c) equilibrium position shifts to the left

1

(d) equilibrium position shifts to the left

1

(e) (effect)
(equilibrium position) does not change

1

(reason)
increases the rate of the forward reaction and reverse reaction equally

1

(f) 210 (s)

allow a value in the range 205 to 210 (s)

1

lines become level / horizontal

1

(because) the rates of the forward reaction and reverse reaction are equal
or
(because) the number of moles (of all three gases) remain constant

1

(g) tangent drawn at 60 s

1

correct values for *y* step **and** *x* step from tangent

allow correct use of an incorrectly drawn tangent

allow a tolerance of ± ½ a small square for each coordinate

1

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

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

1

correct calculation of rate (mol/s)

1

[13]

4. (a) hydrogen peroxide → water + oxygen

allow H_2O_2 for hydrogen peroxide

allow H_2O for water

allow O_2 for oxygen

1

(b) mass of catalyst

1

volume of hydrogen peroxide solution

1

(c) all points plotted correctly

allow a tolerance of ± ½ a small square

*allow at least 3 points plotted correctly for **1** mark*

2

line of best fit

1

(d) manganese dioxide

allow ecf from part (c)

1

any **one** from:

- steepest curve
- reaction finishes first
- greatest volume of oxygen (in given time)

1

(e) accurate

1

(f) increase

1

[10]

5. (a) heat the evaporating basin and contents to constant mass

allow heat until all of the water has evaporated

1

(b) (mass **X** =)
[0.29 × 3] - [0.30 + 0.26]

allow 0.87 - 0.56

allow $\frac{0.3 + \mathbf{X} + 0.26}{3} = 0.29$

1

= 0.31 (g)

1

(c) (test)
determine the boiling point

1

(result)
(pure water) boils at 100 °C

OR

(test)
determine the freezing point (1)

(result)
(pure water) freezes at 0 °C (1)

1

(d) reversible reaction

allow a reaction that can go both ways

1

(e) shifts towards the left hand side

1

(f) (test)
damp litmus paper

1

(result)
litmus paper bleached

allow litmus paper turns white ignore litmus paper turns red

1

(g) the dissolved solids pass through filter paper

1

(because) the dissolved solid (particles) are very small

1

[11]

6. (a) (test)
glowing splint

*do **not** accept burning / lit splint*

1

(result)
relights

allow glows more brightly

1

MP2 is dependent upon MP1 being awarded

(b) smaller volume of gas produced (per unit time)

1

(so) error in reading is a larger percentage of the total volume

1

(c) any **one** from:

- measuring vessel (for hydrogen peroxide or gas) wrongly calibrated
- balance wrongly calibrated
- timer slow / fast

1

(d) all points plotted correctly

allow a tolerance of ± ½ a small square

*allow at least 4 points plotted correctly for **1** mark*

2

line of best fit

1

(e) manganese dioxide

allow ecf from part (d)

1

(because manganese dioxide) has the steepest gradient

allow (because manganese dioxide) produces the most gas per unit time

1

(f) same number of particles per unit volume

allow same concentration (of hydrogen peroxide solution)

1

(so) same frequency of collisions (with catalyst)

1

(g) tangent drawn at 20 s

1

value for *x* step **and** *y* step from tangent

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

1

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

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

1

correctly calculated

1

to 3 significant figures

allow a correctly calculated answer to 3 significant figures from an incorrect calculation which uses values determined from the graph

1

[17]