



**IGCSE Chemistry**

# **RATE OF REACTION**

0620-THEORY

2026 EDITION

Q1

0620/43/O/N/21/Q6(a)

Definition - Easy

- 6 A student investigates the decomposition of hydrogen peroxide in the presence of a catalyst of manganese(IV) oxide.



- (a) State the meaning of the term *catalyst*.

.....

..... [2]



Q2

0620/42/O/N/23/Q5(b)(iv)-(v)

Definition - Hard

(iv) Define the term activation energy.

.....  
..... [2]

(v) State **one** way in which the activation energy of a reaction can be changed.

..... [1]



Q3

0620/41/M/J/23/Q4(b)(i)-(iii)

Factors affecting the rate of reaction - Easy

- 4 Oxygen is produced by the decomposition of aqueous hydrogen peroxide. Manganese(IV) oxide,  $\text{MnO}_2$ , is a catalyst for this reaction.

- (b) A student adds powdered manganese(IV) oxide to aqueous hydrogen peroxide in a conical flask as shown in Fig. 4.1. The mass of the conical flask and its contents is measured at regular time intervals. The mass decreases as time increases.

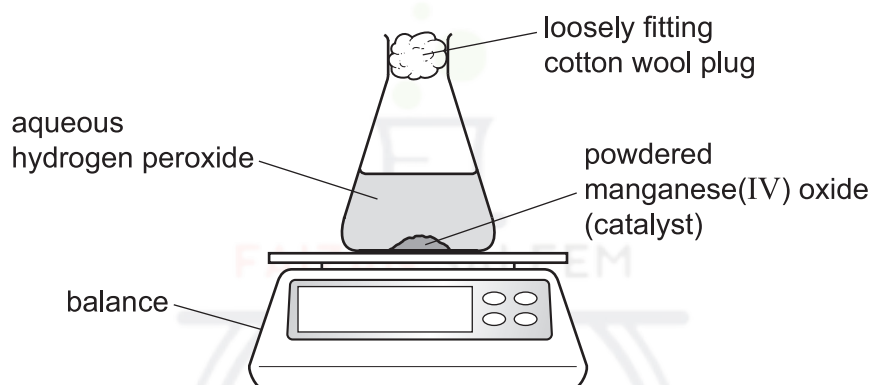


Fig. 4.1

- (i) State why the mass of the conical flask and its contents decreases as time increases.

..... [1]

- (ii) The rate of reaction is highest at the start of the reaction. The rate decreases and eventually becomes zero.

Explain why the rate of reaction is highest at the start of the reaction.

.....

..... [1]

- (iii) Explain why the rate of reaction eventually becomes zero.

.....

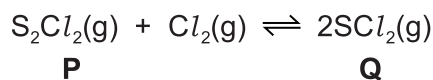
..... [1]

Q4

0620/42/O/N/24/Q3(e)

Factors affecting the rate of reaction - Hard

- (d) Chloride **P** is converted to chloride **Q** by reaction with chlorine in a closed system. The reversible reaction reaches an equilibrium.



The forward reaction is exothermic.

- (e) The rate of the forward reaction in (d) is determined by collision theory.

The rate of reaction depends upon two factors:

- the frequency of collisions between particles
- the proportion of collisions which have energy greater than or equal to the activation energy.

- (i) Define the term activation energy.

..... [1]

- (ii) Give the symbol for activation energy.

..... [1]

- (iii) Complete Table 3.1 to show the effect, if any, when the conditions are changed.

Use only the words **increases**, **decreases** or **no change**.

Table 3.1

| change to conditions                   | effect on the frequency of collisions between particles | effect on the proportion of collisions which have energy greater than or equal to the activation energy |
|----------------------------------------|---------------------------------------------------------|---------------------------------------------------------------------------------------------------------|
| concentration of chlorine is increased |                                                         |                                                                                                         |
| temperature is increased               |                                                         |                                                                                                         |
| a catalyst is added                    |                                                         |                                                                                                         |

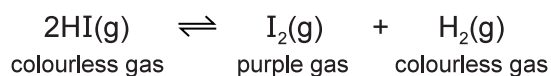
[5]

Q5

0620/43/M/J/21/Q4(c)(ii)

Rate and temperature - Easy

- 4 Hydrogen iodide, HI, decomposes into iodine and hydrogen. The reaction is reversible.



- (c) The forward reaction is endothermic.

- (ii) State what happens to the rate of the forward reaction and the rate of the backward reaction when the temperature of the mixture is decreased.

rate of the forward reaction .....

rate of the backward reaction .....

[2]

Q6

0620/42/F/M/21/Q3(a)(vi)

Rate and temperature - Hard

(vi) If the temperature is increased, the rate of reaction increases.

Explain why, in terms of particles.

.....

.....

.....

.....

..... [3]



Q7

0620/41/M/J/25/Q3(c)(vi)

Rate and concentration - Easy

- (c) Copper(II) sulfate crystals are made by the reaction between copper(II) carbonate and dilute sulfuric acid, using the following steps.

The sulfuric acid has a concentration of  $0.100 \text{ mol/dm}^3$ .

- step 1** Powdered copper(II) carbonate is added to dilute sulfuric acid. The mixture is stirred. A reaction occurs.
- step 2** More copper(II) carbonate is added, with stirring, until the reaction stops.
- step 3** Unreacted copper(II) carbonate is separated from aqueous copper(II) sulfate by filtration.
- step 4** Aqueous copper(II) sulfate is heated until some of the water evaporates.
- step 5** The remaining solution is allowed to cool and crystallise.
- step 6** The crystals are removed and dried.

- (vi) **Step 1** is repeated using sulfuric acid of concentration  $0.200 \text{ mol/dm}^3$  instead of  $0.100 \text{ mol/dm}^3$ .

All other conditions are the same.

The rate of reaction increases.

Explain why the rate of reaction increases. Give your answer in terms of particles.

.....

.....

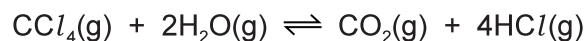
..... [2]

Q8

0620/42/O/N/23/Q5(b)(i)

Rate and concentration - Hard

(b) Tetrachloromethane gas,  $\text{CCl}_4(\text{g})$ , reacts with steam as shown.



The reaction is reversible. The forward reaction is exothermic.

(i) State what happens, if anything, to the rate of the forward reaction if the concentration of  $\text{CCl}_4$  is increased.

Explain your answer in terms of collision theory.

.....

.....

.....

..... [3]



Q9

0620/41/M/J/22/Q6(b)(iii)

Rate and surface area - Easy

(b) Zinc sulfate crystals,  $\text{ZnSO}_4 \cdot 7\text{H}_2\text{O}$ , are hydrated.

Zinc sulfate crystals are made by reacting zinc carbonate with dilute sulfuric acid.

The equation for the overall process is shown.



**step 1** Large pieces of solid zinc carbonate are added to dilute sulfuric acid until the zinc carbonate is in excess. This forms aqueous zinc sulfate.

(iii) **Step 1** is repeated using powdered zinc carbonate instead of large pieces.

All other conditions are kept the same.

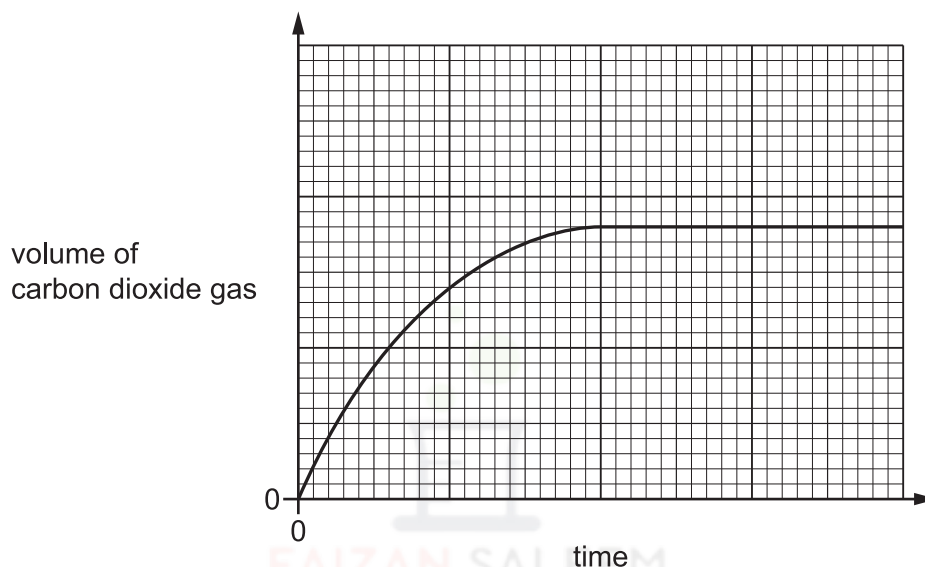
The rate of reaction increases.

Give a reason why the rate of reaction increases. Explain your answer in terms of particles.

.....  
.....  
..... [2]

- 2 A student adds excess large pieces of magnesium carbonate,  $\text{MgCO}_3$ , to dilute hydrochloric acid,  $\text{HCl}$ , and measures the volume of carbon dioxide gas,  $\text{CO}_2$ , given off.

(d) The graph shows how the volume of carbon dioxide gas changes with time.



- (i) Describe how the graph shows that the rate of this reaction decreases as time increases.

.....  
..... [1]

- (ii) Explain, in terms of particles, why the rate of this reaction decreases as time increases.

.....  
..... [2]

- (iii) The student repeats the experiment using powdered  $\text{MgCO}_3$  instead of large pieces.

All other conditions stay the same.

**On the grid**, draw the line expected when powdered  $\text{MgCO}_3$  is used instead of large pieces. [2]

Q11

0620/42/O/N/21/Q4(b)(ii)

Rate and catalyst - Easy

(ii) State why a catalyst is used.

..... [1]

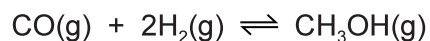


Q12

0620/41/M/J/24/Q4(e)(i), Q4(e)(iii)

Rate and catalyst - Hard

(e) Methanol is manufactured by reacting carbon monoxide with hydrogen.



The rate of formation of methanol increases when a catalyst is used.

(i) Choose from the list the element that is most likely to be used as the catalyst.

Draw a circle around your chosen answer.

calcium

carbon

copper

sodium

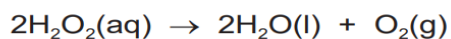
sulfur

[1]

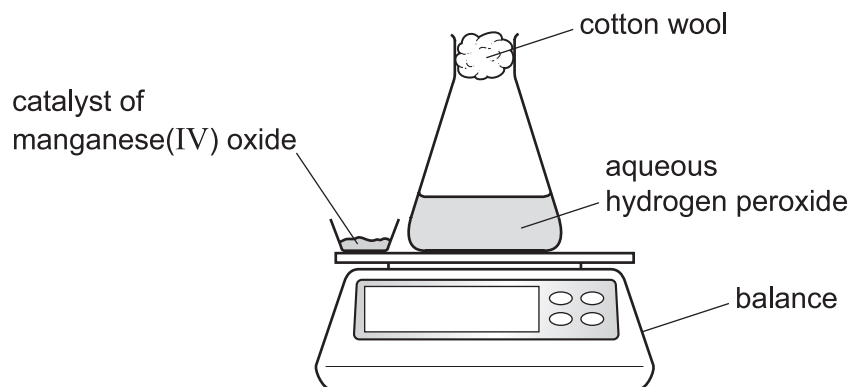
(iii) State the effect that a catalyst has on the activation energy,  $E_a$ , of a reaction.

..... [1]

- 6 A student investigates the decomposition of hydrogen peroxide in the presence of a catalyst of manganese(IV)oxide.



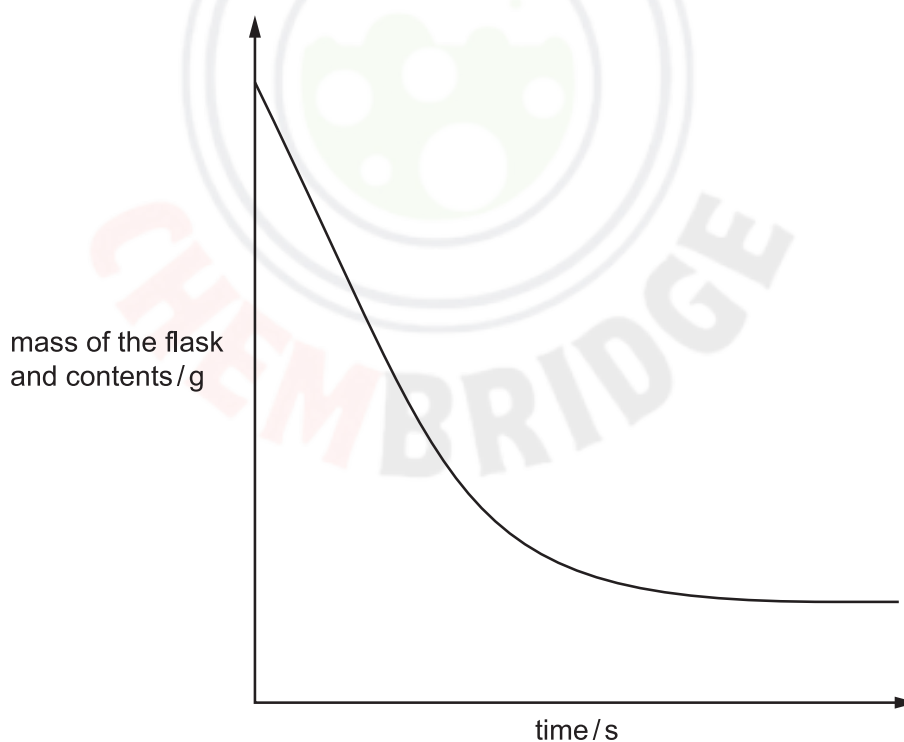
- (b) The diagram shows the equipment the student uses.



The student uses this method:

- the catalyst is added to the aqueous hydrogen peroxide
- the stop-clock is started
- the mass of the flask and contents is recorded at regular time intervals.

A graph of the mass of the flask and contents against time is shown.



- (i) Suggest why the mass of the flask and contents decreases as time increases.

..... [1]

- (ii) Describe what happens to the rate of the reaction as time increases.

.....  
..... [2]

- (c) The student repeats the experiment at a higher temperature. All other conditions stay the same. The rate of reaction increases.

- (i) Explain, in terms of collisions between particles, why the rate of reaction increases at a higher temperature.

.....  
.....  
.....  
..... [3]

- (ii) Draw a line on the graph in (b) for the experiment at a higher temperature. [2]

Q14

0620/43/O/N/24/Q5(a)-(b)

Graph questions - Hard

- 5 This question is about rate of reaction and equilibrium.

A student investigates the rate of decomposition of aqueous hydrogen peroxide,  $\text{H}_2\text{O}_2$ , using manganese(IV) oxide as a catalyst.

The equation for the reaction is shown.



The student uses the apparatus shown in Fig. 5.1.

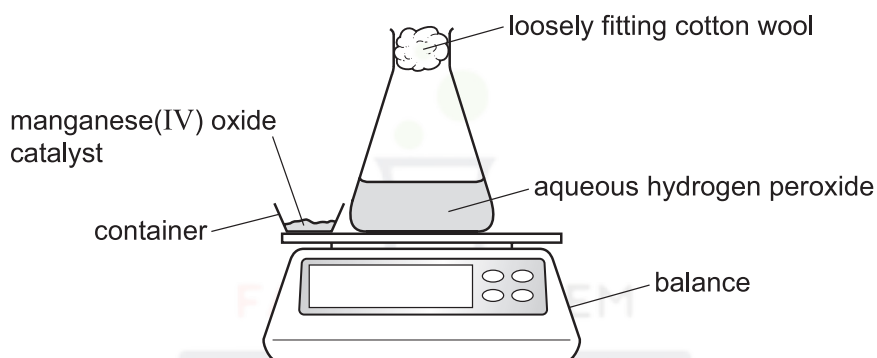


Fig. 5.1

The student:

- adds the catalyst to the aqueous hydrogen peroxide
- replaces the container on the balance
- starts a stop-watch
- records the mass at regular time intervals.

- (a) Table 5.1 shows the mass recorded at regular time intervals.

Table 5.1

| time/s | mass/g |
|--------|--------|
| 0      | 50.64  |
| 30     | 49.80  |
| 60     | 49.38  |
| 90     | 49.17  |
| 120    | 49.07  |
| 150    | 49.02  |
| 180    | 48.99  |
| 210    | 48.97  |
| 240    | 48.97  |
| 270    | 48.97  |

- (i) Suggest why the mass decreases as time increases.

..... [1]

- (ii) After a certain time the reaction stops.

Explain why the reaction stops.

..... [1]

- (iii) Suggest why it is **not** possible to use the results in Table 5.1 to determine the **exact** time when the reaction stops.

.....

..... [1]

- (b) Fig. 5.2 shows a graph of the mass against time.

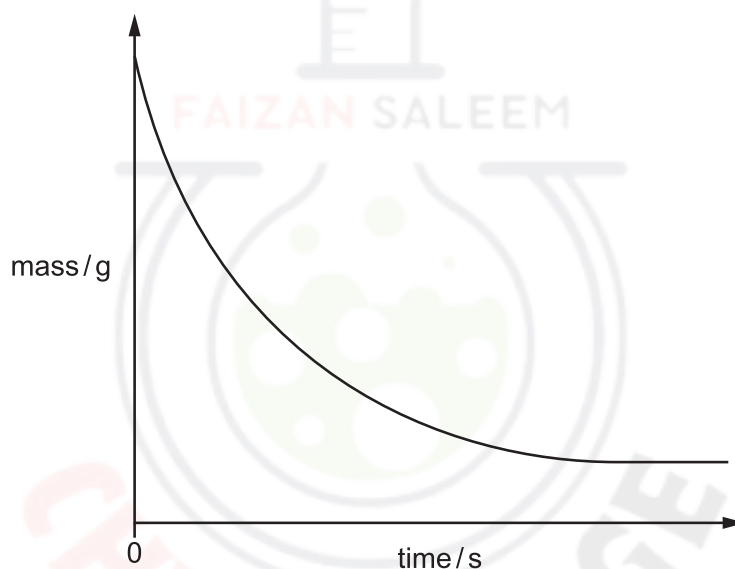


Fig. 5.2

The experiment is repeated at a higher temperature.  
All other conditions remain the same.

- (i) Explain, in terms of collision theory, why the rate of reaction is higher at a higher temperature.

.....

.....

.....

.....

..... [3]

- (ii) On Fig. 5.2, sketch the line expected when the experiment is repeated at a higher temperature. [2]

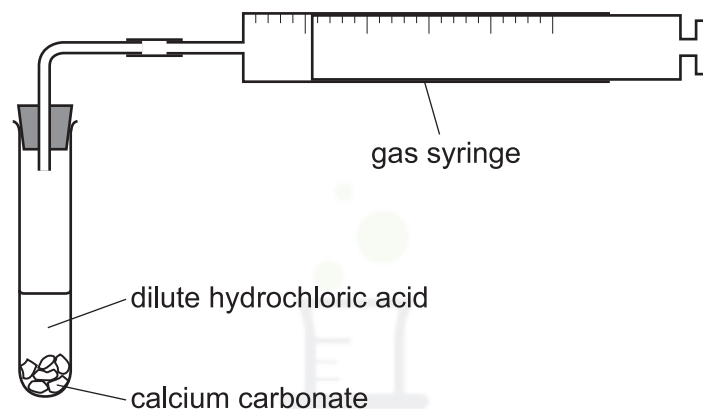
Q15

0620/61/O/N/21/Q2(g)-(i)

ATP questions - Practice

- 2 A student investigated the rate of reaction between small lumps of calcium carbonate and dilute hydrochloric acid.

The experiment was done at two different temperatures using the apparatus shown in the diagram. All other conditions were kept the same.



#### Experiment 1

- Using a 50 cm<sup>3</sup> measuring cylinder, 25 cm<sup>3</sup> of dilute hydrochloric acid was poured into a boiling tube.
- The temperature of the dilute hydrochloric acid was measured using a thermometer.
- 10 g of lumps of calcium carbonate were added to the boiling tube, the bung replaced and the stop-watch started.
- The volume of gas collected in the gas syringe was measured every 50 seconds for 250 seconds.

#### Experiment 2

- Using a 50 cm<sup>3</sup> measuring cylinder, 25 cm<sup>3</sup> of dilute hydrochloric acid was poured into a boiling tube.
- The dilute hydrochloric acid in the boiling tube was warmed using a Bunsen burner.
- The temperature of the dilute hydrochloric acid was measured using a thermometer.
- 10 g of lumps of calcium carbonate were added to the boiling tube, the bung replaced and the stop-watch started.
- The volume of gas collected in the gas syringe was measured every 50 seconds for 250 seconds.

Q15 continued 0620/61/O/N/21/Q2(g)-(i)

ATP questions - Practice

- (g) A student stated it would be an improvement to measure the volume of gas collected every 25 seconds.

Explain why this is an improvement.

.....  
.....  
..... [2]

- (h) State **two** changes to the apparatus to improve the accuracy of the results obtained if the experiment is repeated using the same thermometer.

change 1 .....  
.....  
change 2 .....  
..... [2]

- (i) Describe how the method used in Experiment 2 could be changed so that results can be obtained using dilute hydrochloric acid at 1 °C.

.....  
..... [1]

Q16

0620/63/O/N/22/Q2(a)-(h)

ATP questions - Practice

- 2 A student investigated the rate of the reaction between sodium metabisulfite and potassium iodate at different temperatures.

Five experiments were done at different temperatures.

(a) *Experiment 1*

- 70 cm<sup>3</sup> of aqueous potassium iodate was measured using a 100 cm<sup>3</sup> measuring cylinder and poured into a 250 cm<sup>3</sup> beaker.
- 5 cm<sup>3</sup> of aqueous starch was measured using a 10 cm<sup>3</sup> measuring cylinder and poured into the beaker containing the aqueous potassium iodate.
- 5 cm<sup>3</sup> of aqueous sodium metabisulfite was measured using a clean 10 cm<sup>3</sup> measuring cylinder and poured into the beaker. At the same time a stop-clock was started.
- The mixture was stirred until a sudden colour change was seen.
- The stop-clock was stopped and the temperature of the mixture in the beaker was measured using a thermometer.
- The beaker was rinsed with distilled water.

*Experiment 2*

- 70 cm<sup>3</sup> of aqueous potassium iodate was measured using a 100 cm<sup>3</sup> measuring cylinder and poured into a 250 cm<sup>3</sup> beaker.
- 5 cm<sup>3</sup> of aqueous starch was measured using a 10 cm<sup>3</sup> measuring cylinder and poured into the beaker containing the aqueous potassium iodate.
- The aqueous potassium iodate and starch mixture was warmed over a Bunsen burner until the temperature of the solution was about 35 °C. The beaker was then removed from above the Bunsen burner.
- 5 cm<sup>3</sup> of aqueous sodium metabisulfite was measured using a clean 10 cm<sup>3</sup> measuring cylinder and poured into the beaker. At the same time a stop-clock was started.
- The mixture was stirred until a sudden colour change was seen.
- The stop-clock was stopped and the temperature of the mixture in the beaker was measured using a thermometer.
- The beaker was rinsed with distilled water.

*Experiment 3*

- Experiment 2 was repeated but the aqueous potassium iodate and starch mixture was warmed until the temperature of the solution was about 40 °C.

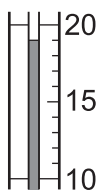
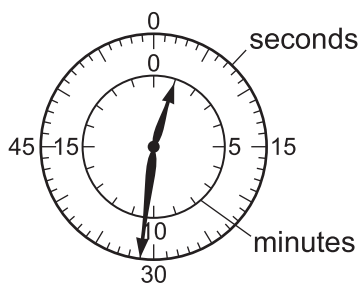
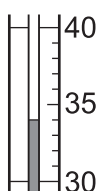
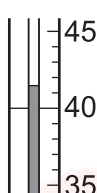
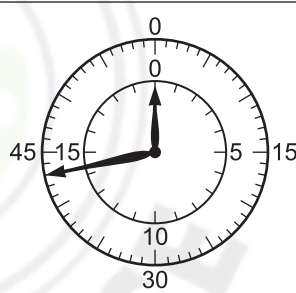
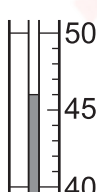
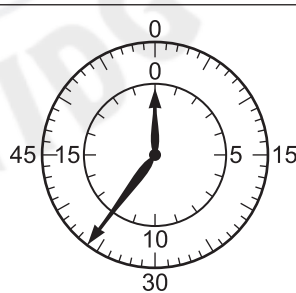
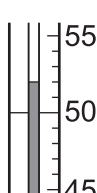
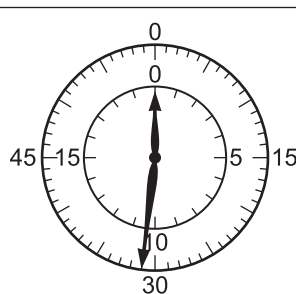
*Experiment 4*

- Experiment 2 was repeated but the aqueous potassium iodate and starch mixture was warmed until the temperature of the solution was about 45 °C.

*Experiment 5*

- Experiment 2 was repeated but the aqueous potassium iodate and starch mixture was warmed until the temperature of the solution was about 50 °C.

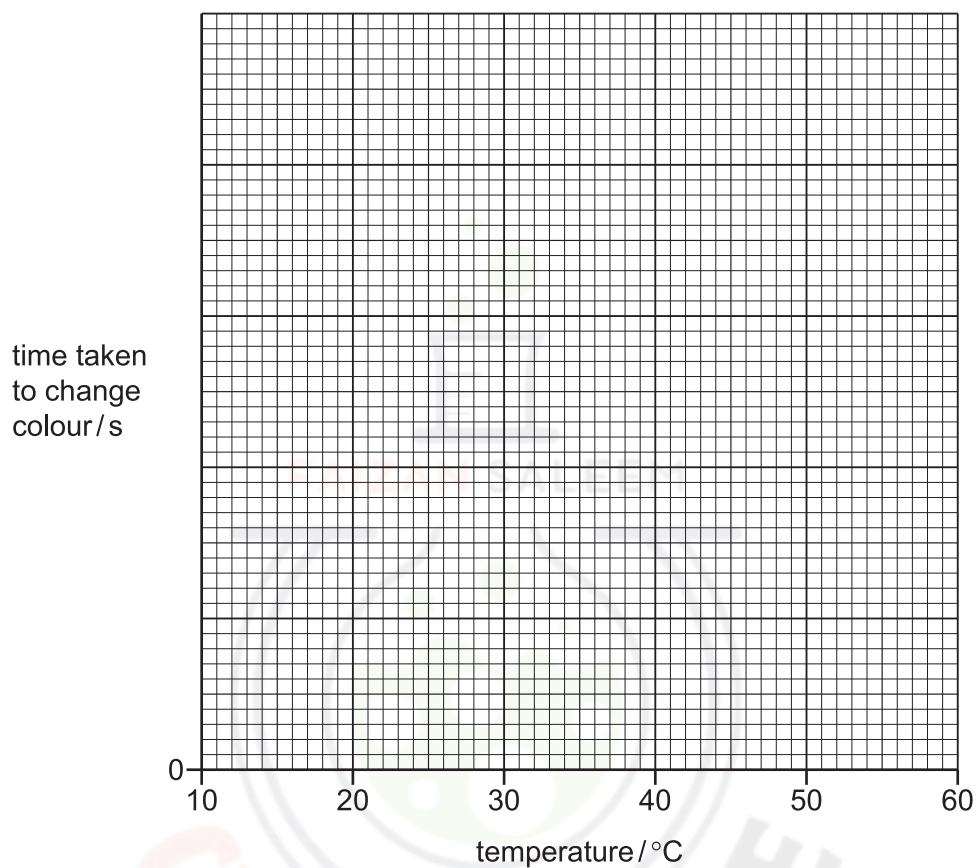
Use the thermometer diagrams and stop-clock diagrams to complete the table.

| experiment | thermometer diagram                                                                 | temperature /°C | stop-clock diagram                                                                   | time /s |
|------------|-------------------------------------------------------------------------------------|-----------------|--------------------------------------------------------------------------------------|---------|
| 1          |    |                 |    |         |
| 2          |    |                 |   |         |
| 3          |  |                 |  |         |
| 4          |  |                 |  |         |
| 5          |  |                 |  |         |

[4]

- (b) Complete a suitable scale on the y-axis and plot the results from Experiments 1 to 5 on the grid.

Draw a curve of best fit through your points.



[4]

(c) Deduce which experiment had the fastest rate of reaction.

..... [1]

(d) **From your graph**, deduce the time taken for the mixture to change colour at a temperature of 60.0 °C.

Show clearly **on the grid** how you worked out your answer.

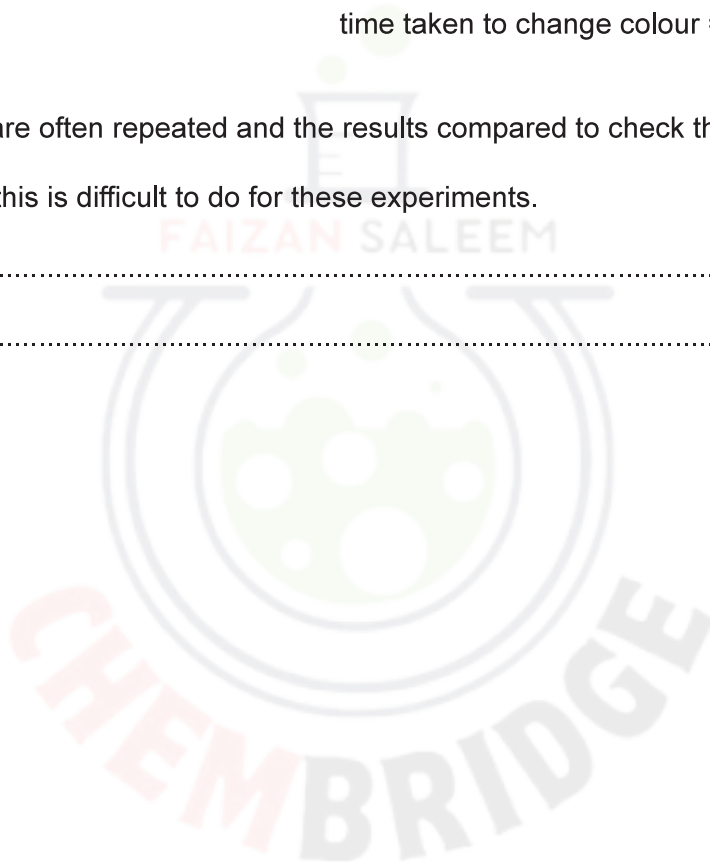
time taken to change colour = ..... [3]

(e) Experiments are often repeated and the results compared to check that they are reliable.

Suggest why this is difficult to do for these experiments.

.....

..... [1]



- (f) Suggest why the aqueous potassium iodate is warmed **before** the aqueous sodium metabisulfite is added rather than after it has been added.

.....  
..... [1]

- (g) A polystyrene cup can be used instead of the beaker in this experiment.

- (i) Explain the advantage of transferring the warmed potassium iodate to a polystyrene cup rather than leaving it in the beaker.

.....  
.....  
..... [2]

- (ii) Suggest why it is **not** a good idea to put the aqueous potassium iodate in a polystyrene cup before it is warmed.

.....  
..... [1]

- (h) Sketch **on the grid** the graph obtained when the experiments are repeated using aqueous potassium iodate of a higher concentration. [1]

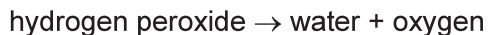
### Q17

**0620/63/O/N/23/Q4**

## ATP questions - Practice

- 4 You are asked to investigate the effect of temperature on the rate of decomposition of aqueous hydrogen peroxide.

Aqueous hydrogen peroxide decomposes to make oxygen gas.



The reaction is very slow unless a catalyst is added to the hydrogen peroxide. Manganese(IV) oxide is a catalyst for this reaction.

Plan an investigation to find how the **temperature** of the aqueous hydrogen peroxide affects the rate of the catalysed reaction. Your answer should include an explanation of how your results will tell you how the rate of reaction has changed.

You are provided with aqueous hydrogen peroxide, manganese(IV) oxide and common laboratory apparatus.

FAIZAN SALEEM



CHEM BRIDGE

16

Q18

0620/63/M/J/24/Q2(f)-(h)

ATP questions - Practice

- 2 A student investigates the rate at which hydrogen gas is made when magnesium ribbon reacts with dilute ethanoic acid at two different temperatures.

**Instructions**

The student does two experiments using the apparatus shown in Fig. 2.1.

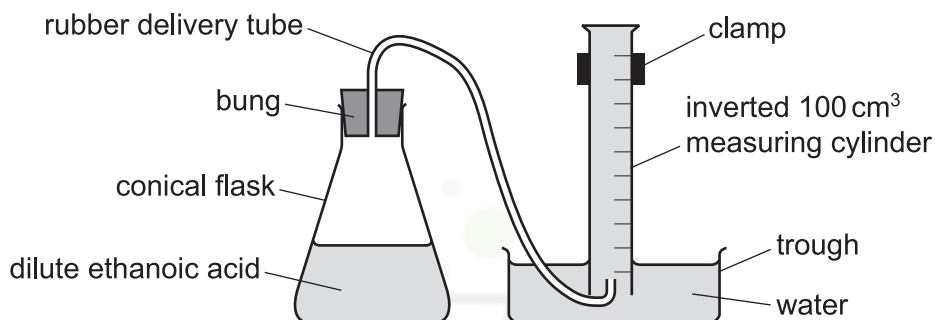


Fig. 2.1

**Experiment 1**

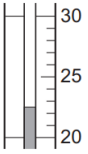
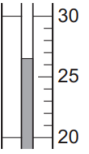
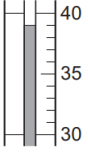
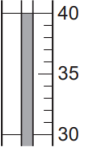
- Use a measuring cylinder to pour  $50\text{ cm}^3$  of dilute ethanoic acid into a conical flask.
- Use a thermometer to measure the initial temperature of the dilute ethanoic acid and record the initial temperature.
- Set the apparatus up as shown in Fig. 2.1, ensuring the inverted measuring cylinder is full of water.
- Remove the bung from the conical flask, ensuring the delivery tube remains in the measuring cylinder.
- Add a coil of magnesium ribbon to the conical flask, immediately put the bung back into the conical flask and start the timer. If the magnesium sticks to the side of the flask, gently shake the flask so that it is washed off the side.
- Measure the volume of gas collected in the inverted measuring cylinder every 15 seconds for 150 seconds. Record the volume of gas collected.
- Use the thermometer to measure the final temperature of the mixture in the conical flask and record the final temperature.
- Rinse out the conical flask with distilled water.

**Experiment 2**

- Repeat Experiment 1 but warm the acid by about  $15^\circ\text{C}$  after it has been poured into the conical flask and before the initial temperature is measured and recorded.

(a) Use the thermometer diagrams to complete Table 2.1.

Table 2.1

| experiment | initial                                                                           |                  | final                                                                             |                  | average temperature / °C |
|------------|-----------------------------------------------------------------------------------|------------------|-----------------------------------------------------------------------------------|------------------|--------------------------|
|            | thermometer diagram                                                               | temperature / °C | thermometer diagram                                                               | temperature / °C |                          |
| 1          |  |                  |  |                  |                          |
| 2          |  |                  |  |                  |                          |

(f) During Experiment 1, the temperature of the mixture in the conical flask changed. <sup>[3]</sup>

(i) State how this change in temperature affects the rate of the reaction.

..... [1]

(ii) Describe how the apparatus could be altered to minimise the change in temperature.

.....  
 ..... [1]

(g) Some gas escapes in the short time between adding the magnesium ribbon to the conical flask and putting the bung back into the conical flask.

Explain how the apparatus could be altered so that no gas escapes and the results of the experiment are more accurate. You may draw a diagram to help explain your answer.

.....  
 ..... [2]

(h) Describe one **other** way in which the results of Experiments 1 and 2 could be made more accurate.

.....  
 ..... [1]

Q19

0620/61/M/J/25/Q2(e), Q2(f)(ii)-(iv)

ATP questions - Practice

- 2 A student investigates how the rate of reaction of magnesium ribbon with dilute acid changes as the concentration of the acid is changed. The student uses five solutions of the same acid, **A**, **B**, **C**, **D**, and **E**. Each solution has a different concentration. The acid is in excess in all experiments.

The student does five experiments.

Experiment 1

- Use a 50 cm<sup>3</sup> measuring cylinder to pour 30 cm<sup>3</sup> of acid **A** into a 100 cm<sup>3</sup> conical flask.
- Add a coil of magnesium ribbon to the acid in the conical flask and immediately start a stop-watch.
- Continually swirl the mixture in the conical flask until the magnesium ribbon disappears completely. Immediately stop the stop-watch and record the time in seconds to the nearest second.
- Empty and rinse the conical flask with distilled water.

Experiment 2

- Repeat Experiment 1 using 30 cm<sup>3</sup> of acid **B** instead of acid **A**.

Experiment 3

- Repeat Experiment 1 using 30 cm<sup>3</sup> of acid **C** instead of acid **A**.

Experiment 4

- Repeat Experiment 1 using 30 cm<sup>3</sup> of acid **D** instead of acid **A**.

Experiment 5

- Repeat Experiment 1 using 30 cm<sup>3</sup> of acid **E** instead of acid **A**.

Q19 continued 0620/61/M/J/25/Q2(e), Q2(f)(ii)-(iv)

ATP questions - Practice

(e) Explain why repeating each experiment is an improvement.

.....  
..... [1]

Q19 continued 0620/61/M/J/25/Q2(e), Q2(f)(ii)-(iv)

ATP questions - Practice

(f) The student does another experiment to find the temperature change when magnesium reacts with acid **A**.

- Use the measuring cylinder to pour 30 cm<sup>3</sup> of acid **A** into the 100 cm<sup>3</sup> conical flask.
- Measure the initial temperature of the acid in the conical flask.
- Add a coil of magnesium ribbon to the acid in the conical flask.
- Continually swirl the conical flask until the magnesium ribbon disappears completely.
- Measure the final temperature of the acid in the conical flask.

Q19 continued 0620/61/M/J/25/Q2(e), Q2(f)(ii)-(iv)

ATP questions - Practice

(ii) Explain why controlling the temperature of the acid so that it remains constant is an improvement.

.....  
..... [1]

(iii) Explain why using a polystyrene cup instead of the 100 cm<sup>3</sup> conical flask does **not** control the temperature of the acid.

.....  
..... [1]

(iv) Describe how the temperature of the acid can be controlled and kept constant.

.....  
..... [1]

## MARKING SCHEME

### Q1 0620/43/O/N/21/Q6(a)

|      |                                                                                                                                           |          |
|------|-------------------------------------------------------------------------------------------------------------------------------------------|----------|
| 6(a) | <b>M1</b> (a substance that) speeds up a reaction / increases the rate of a reaction (1)<br><b>M2</b> unchanged chemically at the end (1) | <b>2</b> |
|------|-------------------------------------------------------------------------------------------------------------------------------------------|----------|

### Q2 0620/42/O/N/23/Q5(b)(iv)-(v)

|          |                                                                                           |          |
|----------|-------------------------------------------------------------------------------------------|----------|
| 5(b)(iv) | <b>M1</b> minimum energy (1)<br><b>M2</b> that colliding particles must have to react (1) | <b>2</b> |
| 5(b)(v)  | (decreased by adding) catalyst                                                            | <b>1</b> |

### Q3 0620/41/M/J/23/Q4(b)(i)-(iii)

|           |                                                                                                                                                                                                                |          |
|-----------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------|
| 4(b)(i)   | oxygen escapes from the flask or apparatus                                                                                                                                                                     | <b>1</b> |
| 4(b)(ii)  | <b>concentration</b> of hydrogen peroxide is highest at the start / <b>particles</b> of hydrogen peroxide are closest together at the start<br><b>OR</b><br><b>collision</b> frequency is highest at the start | <b>1</b> |
| 4(b)(iii) | the <b>hydrogen peroxide</b> is used up /<br><b>ALL</b> the <b>hydrogen peroxide</b> has reacted or decomposed                                                                                                 | <b>1</b> |

### Q4 0620/42/O/N/24/Q3(e)

|          |                                                                |          |
|----------|----------------------------------------------------------------|----------|
| 3(e)(i)  | the minimum energy that colliding particles must have to react | <b>1</b> |
| 3(e)(ii) | $E_a$                                                          | <b>1</b> |

### Q4 continued 0620/42/O/N/24/Q3(e)

|           |                                                                                                           |          |
|-----------|-----------------------------------------------------------------------------------------------------------|----------|
| 3(e)(iii) | <b>M1</b> increases <b>M2</b> no change<br><b>M3</b> increases <b>M4</b> increases<br><b>M5</b> increases | <b>5</b> |
|-----------|-----------------------------------------------------------------------------------------------------------|----------|

### Q5 0620/43/M/J/21/Q4(c)(ii)

|          |                                                |          |
|----------|------------------------------------------------|----------|
| 4(c)(ii) | decrease / slower (1)<br>decrease / slower (1) | <b>2</b> |
|----------|------------------------------------------------|----------|

## MARKING SCHEME

### Q6 0620/42/F/M/21/Q3(a)(vi)

|          |                                                                                                                                                                                                                                                                                                          |   |
|----------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---|
| 3(a)(vi) | <p>particles have more energy (1)</p> <p>more collisions (between particles) occur per second / per unit time (1)</p> <p>a greater percentage / proportion / fraction of collisions (of particles) are successful / have energy above activation energy / have energy equal to activation energy (1)</p> | 3 |
|----------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---|

### Q7 0620/41/M/J/25/Q3(c)(vi)

|          |                                                                                                                                |   |
|----------|--------------------------------------------------------------------------------------------------------------------------------|---|
| 3(c)(vi) | <p><b>M1</b> more particles per unit volume</p> <p><b>M2</b> more collisions per unit time / increased collision frequency</p> | 2 |
|----------|--------------------------------------------------------------------------------------------------------------------------------|---|

### Q8 0620/42/O/N/23/Q5(b)(i)

|         |                                                                                                                                                                                                                                     |   |
|---------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---|
| 5(b)(i) | <p><b>M1</b> rate of reaction increases (1)</p> <p><b>M2</b> more (CCl<sub>4</sub>) particles per unit volume (1)</p> <p><b>M3</b> frequency of collisions between (CCl<sub>4</sub> and H<sub>2</sub>O) particles increases (1)</p> | 3 |
|---------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---|

### Q9 0620/41/M/J/22/Q6(b)(iii)

|           |                                                                                                                                                                                                                                                                                          |   |
|-----------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---|
| 6(b)(iii) | <p>(powder has) <b>larger</b> surface area <b>OR</b> lumps have <b>smaller</b> surface area (1)</p> <p>(powder has) more collisions per unit time / more collision frequency</p> <p><b>OR</b></p> <p><b>lumps</b> have fewer collisions per unit time / less collision frequency (1)</p> | 2 |
|-----------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---|

### Q10 0620/42/F/M/22/Q2(d)

|          |                                                                                         |   |
|----------|-----------------------------------------------------------------------------------------|---|
| 2(d)(i)  | gradient (of line) decreases                                                            | 1 |
| 2(d)(ii) | concentration of particles (of acid) decreases<br>lower rate of collisions of particles | 2 |

### Q10 continued 0620/42/F/M/22/Q2(d)

|           |                                                                                                                                     |   |
|-----------|-------------------------------------------------------------------------------------------------------------------------------------|---|
| 2(d)(iii) | a new line steeper than printed line and starts at origin and levels off earlier than printed line<br>levels off at the same volume | 2 |
|-----------|-------------------------------------------------------------------------------------------------------------------------------------|---|

### Q11 0620/42/O/N/21/Q4(b)(ii)

|          |                            |   |
|----------|----------------------------|---|
| 4(b)(ii) | increases rate of reaction | 1 |
|----------|----------------------------|---|

**Q12** 0620/41/M/J/24/Q4(e)(i), Q4(e)(iii)

|         |        |   |
|---------|--------|---|
| 4(e)(i) | copper | 1 |
|---------|--------|---|

**Q12 continued** 0620/41/M/J/24/Q4(e)(i), Q4(e)(iii)

|           |                              |   |
|-----------|------------------------------|---|
| 4(e)(iii) | (activation energy is) lower | 1 |
|-----------|------------------------------|---|

**Q13** 0620/43/O/N/21/Q6(b)-(c)

|          |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |   |
|----------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---|
| 6(b)(i)  | oxygen gas escapes                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  | 1 |
| 6(b)(ii) | <b>M1</b> rate decreases<br><b>OR</b><br>rate / reaction is fastest at the start (1)<br><br><b>M2</b> reaction stops <b>or</b><br>rate = zero (1)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | 2 |
| 6(c)(i)  | <b>M1</b> (particles) have more kinetic energy / particles move faster(1)<br><br><b>M2</b> more collisions per unit time (1)<br><br><b>M3</b> more particles have energy greater than or equal to activation energy<br><b>OR</b><br>more particles have sufficient energy to react<br><b>OR</b><br>A greater percentage or greater proportion or greater fraction of collisions have sufficient energy to react<br><b>OR</b><br>A greater percentage or greater proportion or greater fraction of collisions have energy greater than or equal to activation energy<br><b>OR</b><br>A greater percentage or greater proportion or greater fraction of collisions are successful (1) | 3 |
| 6(c)(ii) | <b>M1</b> steeper gradient from start (1)<br><br><b>M2</b> levels off <b>at the same mass</b> (1)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | 2 |

**Q14**
**0620/43/O/N/24/Q5(a)-(b)**

|           |                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |          |
|-----------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------|
| 5(a)(i)   | oxygen gas escapes from the flask                                                                                                                                                                                                                                                                                                                                                                                                                                            | <b>1</b> |
| 5(a)(ii)  | the hydrogen peroxide is used up<br><b>OR</b><br><u>all</u> the hydrogen peroxide has reacted or decomposed                                                                                                                                                                                                                                                                                                                                                                  | <b>1</b> |
| 5(a)(iii) | time intervals are too large                                                                                                                                                                                                                                                                                                                                                                                                                                                 | <b>1</b> |
| 5(b)(i)   | <b>M1</b> kinetic energy of particles increases<br><b>M2</b> frequency of collisions between particles increases<br><b>M3</b> more / higher percentage <b>OR</b> higher proportion <b>OR</b> higher fraction of <u>particles</u> have energy greater than / equal to activation energy<br><b>OR</b><br>more of the collisions / higher percentage <b>OR</b> higher fraction or higher proportion of <u>collisions</u> have energy greater than or equal to activation energy | <b>3</b> |
| 5(b)(ii)  | <b>M1</b> graph starts at same mass and has steeper gradient<br><b>M2</b> levels off at the same mass but earlier                                                                                                                                                                                                                                                                                                                                                            | <b>2</b> |

**Q15**
**0620/61/O/N/21/Q2(g)-(i)**

|      |                                                                                                                                                                                                                                      |          |
|------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------|
| 2(g) | more data / more points                                                                                                                                                                                                              | <b>1</b> |
|      | can plot a better graph / see trend more clearly                                                                                                                                                                                     | <b>1</b> |
| 2(h) | any two from <ul style="list-style-type: none"> <li>insulate the tube / use a waterbath</li> <li>use a pipette/burette in place of the measuring cylinder</li> <li>use a divided flask / description of this</li> </ul> <b>max 2</b> | <b>2</b> |
| 2(i) | description of how the acid would be cooled, such as place acid in fridge or freezer / stand tube in ice bath                                                                                                                        | <b>1</b> |

**Q16**
**0620/63/O/N/22/Q2(a)-(h)**

| Question | Answer                                                                                                            | Marks    |
|----------|-------------------------------------------------------------------------------------------------------------------|----------|
| 2(a)     | <b>M1</b> all 5 temperatures correct (19.0, 34.0, 41.5, 46.0, 52.0)                                               | <b>1</b> |
|          | <b>M2</b> all temperatures recorded to 1 decimal place                                                            | <b>1</b> |
|          | <b>M3</b> all 5 times correct (91, 54, 43, 36, 31)                                                                | <b>1</b> |
|          | <b>M4</b> all times recorded in seconds only                                                                      | <b>1</b> |
| 2(b)     | <b>M1</b> y-axis scale in linear and points extend over halfway up the scale (each major grid line is 20 seconds) | <b>1</b> |
|          | <b>M2 and M3</b> all points plotted correctly                                                                     | <b>2</b> |
|          | <b>M4</b> best fit curve                                                                                          | <b>1</b> |
| 2(c)     | (Experiment) 5                                                                                                    | <b>1</b> |

**Q16 continued 0620/63/O/N/22/Q2(a)-(h)**

| Question | Answer                                                                          | Marks    |
|----------|---------------------------------------------------------------------------------|----------|
| 2(d)     | <b>M1</b> extrapolation of graph line shown                                     | <b>1</b> |
|          | <b>M2</b> value from graph given                                                | <b>1</b> |
|          | <b>M3</b> s                                                                     | <b>1</b> |
| 2(e)     | difficult to get the temperature (exactly) the same                             | <b>1</b> |
| 2(f)     | otherwise the temperature is still increasing / changing <b>while it reacts</b> | <b>1</b> |
| 2(g)(i)  | <b>M1</b> insulator / reduces <b>heat</b> loss                                  | <b>1</b> |
|          | <b>M2 temperature</b> (more) constant / accurate                                | <b>1</b> |
| 2(g)(ii) | the polystyrene would melt                                                      | <b>1</b> |
| 2(h)     | sketch line is below drawn line and does not meet plotted line at any point.    | <b>1</b> |

**Q17 0620/63/O/N/23/Q4**

| Question | Answer                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             | Marks    |
|----------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------|
| 4        | <p>any 6 from:</p> <p><b>volume of gas in set time</b><br/> <b>MP1</b> known / stated volume of hydrogen peroxide<br/> <b>MP2</b> add known / stated mass of catalyst<br/> <b>MP3</b> reaction done in a suitable container (test-tube / boiling tube / flask)<br/> <b>MP4</b> collect gas made in suitable graduated container<br/> <b>MP5</b> measure volume after set time<br/> <b>MP6</b> repeat at higher / different temperature(s)<br/> <b>MP7</b> higher volume (in set time) is faster rate</p> <p><b>OR</b></p> <p><b>time to get set volume of gas</b><br/> <b>MP1</b> known / stated volume of hydrogen peroxide<br/> <b>MP2</b> add known / stated mass of catalyst<br/> <b>MP3</b> reaction done in a suitable container (test-tube / boiling tube / flask)<br/> <b>MP4</b> collect gas made in suitable graduated container<br/> <b>MP5</b> measure time to get a set volume / measure time when no more gas collected / measure time for reaction to stop fizzing<br/> <b>MP6</b> repeat at higher / different temperature(s)<br/> <b>MP7</b> shorter time is faster rate</p> <p><b>OR</b></p> <p><b>mass loss in a set time</b><br/> <b>MP1</b> known / stated volume of hydrogen peroxide<br/> <b>MP2</b> add known / stated mass of catalyst<br/> <b>MP3</b> reaction done in a suitable container (test-tube / boiling tube / flask / beaker)<br/> <b>MP4</b> apparatus on balance<br/> <b>MP5</b> measure mass loss at set time<br/> <b>MP6</b> repeat at higher / different temperature(s)<br/> <b>MP7</b> higher mass loss (in set time) is faster rate</p> | <b>6</b> |

Q17 continued

0620/63/O/N/23/Q4

| Question | Answer                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            | Marks |
|----------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------|
| 4        | <p><b>OR</b></p> <p><b>time to get set mass loss</b></p> <p><b>MP1</b> known / stated volume of hydrogen peroxide</p> <p><b>MP2</b> add known / stated mass of catalyst</p> <p><b>MP3</b> reaction done in a suitable container (test-tube / boiling tube / flask / beaker)</p> <p><b>MP4</b> apparatus on balance</p> <p><b>MP5</b> measure time for set mass loss / measure time when no more change in mass</p> <p><b>MP6</b> repeat at higher / different temperature(s)</p> <p><b>MP7</b> shorter time is faster rate</p> <p><b>OR</b></p> <p><b>measure time to stop reacting</b></p> <p><b>MP1</b> known / stated volume of hydrogen peroxide</p> <p><b>MP2</b> add known / stated mass of catalyst</p> <p><b>MP3</b> reaction done in a suitable container (test-tube / boiling tube / flask / beaker)</p> <p><b>MP4</b> observe bubbles / collect gas until no more made / weigh until constant</p> <p><b>MP5</b> measure time for bubbles / fizzing</p> <p><b>MP6</b> repeat at higher / different temperature(s)</p> <p><b>MP7</b> shorter time is faster rate</p> <p><b>max 6</b></p> |       |

Q18

0620/63/M/J/24/Q2(f)-(h)

|          |                                                                                                                                                                                                                         |          |
|----------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------|
| 2(a)     | <b>M1</b> all four temperature readings correct (22.5, 26.5, 39.0, 40.0)                                                                                                                                                | <b>1</b> |
|          | <b>M2</b> both mean temperatures calculated correctly (24.5, 39.5)                                                                                                                                                      | <b>1</b> |
|          | <b>M3</b> all temperatures and mean temperatures recorded to nearest 0.5                                                                                                                                                | <b>1</b> |
| 2(f)(i)  | increases                                                                                                                                                                                                               | <b>1</b> |
| 2(f)(ii) | stand flask in a water bath (at initial temperature of the acid)                                                                                                                                                        | <b>1</b> |
| 2(g)     | <p><b>M1</b> place one reagent in tube inside boiling tube/flask</p> <p><b>M2</b> tip tube to start reaction</p>                                                                                                        | <b>1</b> |
|          | <p><b>OR</b></p> <p><b>M1</b> use a divided flask</p> <p><b>M2</b> tip flask to start reaction</p> <p><b>OR</b></p> <p><b>M1</b> suspend the magnesium (above the acid) in the flask</p> <p><b>M2</b> tip the flask</p> | <b>1</b> |
| 2(h)     | <p>repeat <b>and</b> find mean</p> <p><b>OR</b></p> <p>use a burette in place of measuring cylinder</p>                                                                                                                 | <b>1</b> |

## MARKING SCHEME

**Q19**

**0620/61/M/J/25/Q2(e), Q2(f)(ii)-(iv)**

|      |                                                                   |   |
|------|-------------------------------------------------------------------|---|
| 2(e) | to check / verify / compare results / to get concordant results / | 1 |
|------|-------------------------------------------------------------------|---|

**Q19 continued**

**0620/61/M/J/25/Q2(e), Q2(f)(ii)-(iv)**

|           |                                                                  |   |
|-----------|------------------------------------------------------------------|---|
| 2(f)(ii)  | a change of temperature will change the rate of reaction         | 1 |
| 2(f)(iii) | the polystyrene would prevent heat escaping                      | 1 |
| 2(f)(iv)  | use a water bath (at room temperature / at starting temperature) | 1 |

