Pearson Edexcel

Additional Assessment Materials
Summer 2021

Pearson Edexcel GCSE in Chemistry (1CH0)
Higher

Resource Set Topic K: Rates of reaction and energy changes

Questions

(Public release version)

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General guidance to Additional Assessment Materials for use in 2021

Context

- Additional Assessment Materials are being produced for GCSE, AS and A levels (with the exception of Art and Design).
- The Additional Assessment Materials presented in this booklet are an **optional** part of the range of evidence teachers may use when deciding on a candidate's grade.
- 2021 Additional Assessment Materials have been drawn from previous examination materials, namely past papers.
- Additional Assessment Materials have come from past papers both published (those materials available publicly) and unpublished (those currently under padlock to our centres) presented in a different format to allow teachers to adapt them for use with candidate.

Purpose

- The purpose of this resource to provide qualification-specific sets/groups of questions covering the knowledge, skills and understanding relevant to this Pearson qualification.
- This document should be used in conjunction with the mapping guidance which will map content and/or skills covered within each set of questions.
- These materials are only intended to support the summer 2021 series.

9 (a) The rate of reaction between magnesium ribbon and dilute hydrochloric acid at room temperature is investigated.

The apparatus used is shown in Figure 11.

The volume of hydrogen gas given off was measured at regular intervals during the reaction.

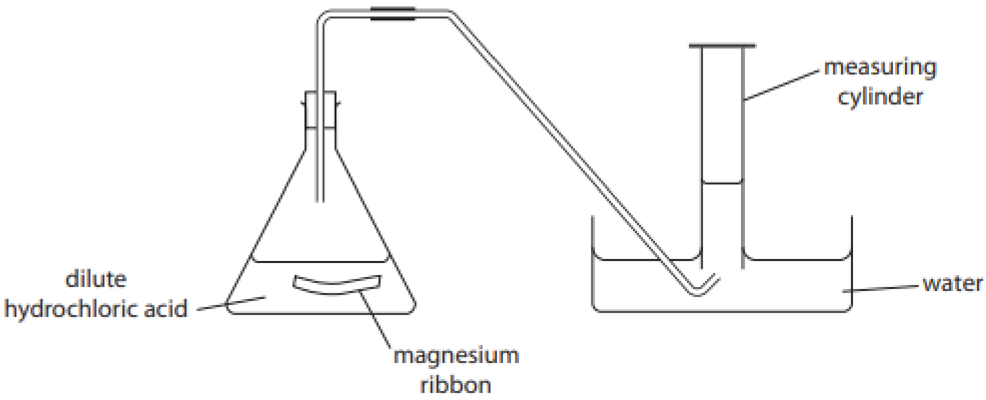


Figure 11

The graph in Figure 12 shows the results of this experiment.

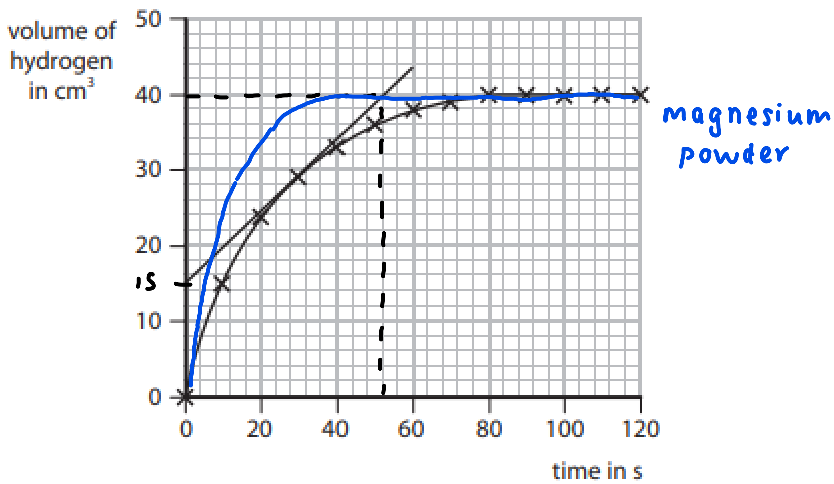


Figure 12

(i) State a change that can be made to the apparatus in Figure 11 to measure the volumes of gas more accurately.

(1)

use a gas syringe instead of measuring cylinder

(ii) A tangent has been drawn to the line on the graph in Figure 12.

Calculate the rate of reaction at this point.

(2)

$\frac{40-15}{52} = 0.48076$

$\simeq 0.481$

rate of reaction = 0.481 $cm^3 s^{-1}$

(iii) On the graph in Figure 12, draw the line you would expect to obtain if the magnesium ribbon in this experiment was replaced with an equal mass of powdered magnesium. All other conditions are kept the same.

(1)

*(c) Two substances, **A** and **B**, each form a colourless solution. If the solutions are mixed in a beaker, **A** and **B** react to form a coloured product. The rate of the reaction between **A** and **B** can be investigated by placing the beaker containing the mixture on a cross on a piece of paper and timing how long it takes for enough coloured product to be produced to make the cross invisible when viewed from above, through the solution.

	experiment 1	**experiment 2**	**experiment 3**
concentration of **A in solution** in g dm^{-3}	10	10	40
temperature in °C	20	40	40
time for cross to become invisible in s	320	80	20

Figure 13

Use the results of these experiments to explain, in terms of the behaviour of particles, the effect of changing temperature and the effect of changing the concentration of **A** in solution on the rate of this reaction.

(6)

From experiments 1 and 2, when concentration of A is constant and temperature increases, time taken for cross to become invisible becomes shorter. This is because particles gain more kinetic energy at higher temperature and move faster, they collide more frequently so there are more successful collisions and rate of reaction is faster. From experiments 2 and 3, when temperature is constant and concentration of A increases, time taken for cross to become invisible becomes shorter. At higher concentration, there are more particles so there are more successful collisions, therefore rate of reaction is higher.

10 (a) Hydrogen reacts with oxygen to form steam.

$$2H_2(g) + O_2(g) \rightarrow 2H_2O(g)$$

Bond energies are shown in Figure 14.

bond	bond energy in kJ mol^{-1}
H—H	435
O═O	500
O—H	460

Figure 14

Calculate the energy change for the reaction of 2 mol of hydrogen gas, H_2, with 1 mol of oxygen gas, O_2, to give 2 mol of steam, H_2O.

(4)

2(435) + 500 - 460(2)(2) = -470 kJ mol^{-1}

energy change = - 470 kJ mol^{-1}

8 Calcium carbonate reacts with dilute hydrochloric acid to produce calcium chloride, water and carbon dioxide.

$$CaCO_3 + 2HCl \rightarrow CaCl_2 + H_2O + CO_2$$

(a) A student wanted to measure the amount of gas produced in two minutes.

The student suggested that this could be done by counting the number of bubbles formed.
However, the bubbles are produced too quickly to count them.

Figure 4 shows a conical flask in which the calcium carbonate and dilute hydrochloric acid are reacting.

Complete Figure 4 to show the apparatus that could be used to measure accurately the volume of gas given off in two minutes.

(2)

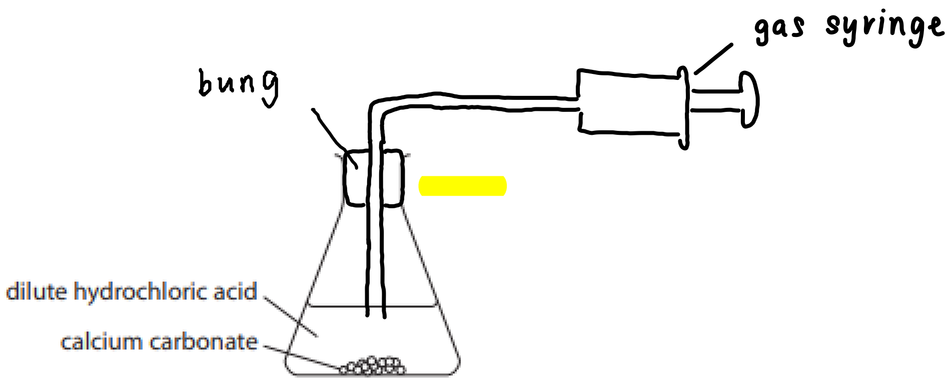


Figure 4

(b) The reaction between calcium carbonate and dilute hydrochloric acid is exothermic.

Explain, in terms of bond breaking and bond making, why some reactions are exothermic.

(3)

Energy is taken in to break bonds and released when bonds form. If the energy released when bonds form is greater than energy taken in to break bonds, the reaction is exothermic.

*(c) An investigation was carried out into the rate of reaction of calcium carbonate with dilute hydrochloric acid.

5.0g of small lumps of calcium carbonate were reacted with 50 cm^3 of 0.50 mol dm^{-3} hydrochloric acid.
Another 5.0g of the same sized lumps of calcium carbonate were reacted with 50 cm^3 of 1.0 mol dm^{-3} hydrochloric acid.
The volume of gas collected in two minutes was recorded for each experiment.

The two experiments were then repeated, each using 5.0g of large lumps of calcium carbonate.

Figure 5 shows the results.

concentration of hydrochloric acid in mol dm^{-3}	volume of gas collected in cm^3	
	small lumps of calcium carbonate	large lumps of calcium carbonate
0.50	17.2	3.1
1.0	35.1	5.6

Figure 5

Explain, in terms of collision of particles, how these results show the effect of the size of the lumps of calcium carbonate and the effect of the concentration of the acid on the rate of this reaction.

(6)

Small lumps of calcium carbonate have a greater surface area to volume ratio so the total surface available to react is greater, so reaction is faster and more gas is collected during the time interval. At higher concentration of HCl, there are more particles so they collide more frequently. There are more successful collisions so rate of reaction is faster. There are also more reactants available so the total volume of gas collected will be greater.

3 Calcium carbonate reacts with dilute hydrochloric acid to produce carbon dioxide gas.

The rate of reaction between calcium carbonate and dilute hydrochloric acid at room temperature was investigated.

(a) The investigation was carried out with different sized calcium carbonate pieces.

The mass of calcium carbonate and all other conditions were kept the same.

The results are shown in Figure 1.

size of calcium carbonate pieces used	volume of carbon dioxide gas produced in five minutes in cm^3
large	16
small	48
powder	90

Figure 1

State, using the information in Figure 1, the effect of the surface area of the calcium carbonate on the rate of this reaction.

(1)

Rate of reaction is higher if surface area is larger.

(b) The calcium carbonate powder produced 90 cm^3 of carbon dioxide in five minutes.

Calculate the average rate of reaction in $cm^3\,s^{-1}$.

(3)

$\frac{90}{5(60)} = 0.3\,cm^3 s^{-1}$

average rate of reaction = 0.3 $cm^3\,s^{-1}$

(c) The experiments were repeated at a higher temperature.
The rate of reaction for each experiment increased.

Explain, in terms of particles, why the rate of reaction increased when the temperature was increased.

(3)

particles gain more kinetic energy and move faster, so they collide more frequently. There are more successful collisions so rate of reaction is increased.

6 (a) Sodium thiosulfate solution, $Na_2S_2O_3$, reacts with dilute hydrochloric acid.

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

(i) When dilute hydrochloric acid is mixed with sodium thiosulfate solution, the mixture turns cloudy.

Explain why the mixture turns cloudy.

(2)

sulfur is formed from the reaction and it forms a suspension in water.

(ii) In an investigation, different concentrations of hydrochloric acid are reacted with sodium thiosulfate solution.
The mixture goes cloudy at different rates.

Describe how the rate at which the mixture goes cloudy can be measured.

(3)

A cross can be drawn at the base of the beaker containing $Na_2S_2O_3$. Pour HCl in and start the timer. measure the time taken for the cross to become invisible.

(iii) You are provided with some dilute hydrochloric acid which has a concentration of 50 g dm^{-3}.

For this experiment, dilute hydrochloric acid with a concentration of 20 g dm^{-3} is required.

How much water must be added to 100 cm^3 of 50 g dm^{-3} hydrochloric acid to make dilute hydrochloric acid with a concentration of 20 g dm^{-3}?

(1)

☐ **A** 200 cm^3

☒ **B** 150 cm^3

☐ **C** 100 cm^3

☐ **D** 50 cm^3

$C_1V_1 = C_2V_2$

$100(50) = 20(V_2)$

$V_2 = 250$

$250 - 100 = 150$

7.

(b) The density of a gas can be found using the equation

$$\text{density} = \frac{\text{mass}}{\text{volume}}$$

A student carried out an experiment to find the density of argon.

The mass of a stopper and flask, containing no gas, was known.
The flask was completely filled with argon and its mass measured.

Figure 4 shows the results the student wrote down.

mass of stopper and flask in g	78.639
mass of stopper and flask full of argon in g	79.120
volume of flask in cm^3	250.0

Figure 4

(i) Use the results to calculate the density of argon in g cm^{-3}.

(2)

$\frac{79.120 - 78.639}{250} = 1.924 \times 10^{-3}$

$\approx 1.92 \times 10^{-3}$

density of argon = 1.92×10^{-3} g cm^{-3}

(ii) The flask used for the experiment is shown in Figure 5.
The flask holds 250.0 cm^3 when filled up to the line.

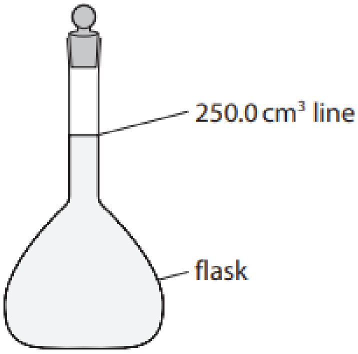


Figure 5

There is an error in the volume the student has used in the calculation.
This would give an incorrect value for the density of argon.

Identify this error and state what should be done to correct it.

(2)

error the flask has a volume greater than 250.0cm^3

what should be done to correct it use the actual volume of the flask

9.

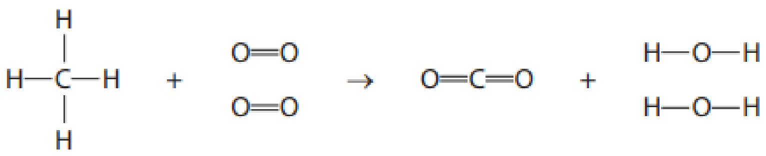
(b) The energies of some bonds are shown in Figure 8.

bond	bond energy in kJ mol^{-1}
C—H	435
O═O	496
C═O	805
H—O	463

Figure 8

Methane burns in oxygen to form carbon dioxide and water.

The equation shows the structures of the molecules.



Calculate the energy change, in kJ mol^{-1}, for this reaction.

(4)

$435(4) + 496(2) - 2(805) - 4(463) = -730$

energy change = -730 kJ mol^{-1}

TOTAL FOR PAPER IS 46 MARKS