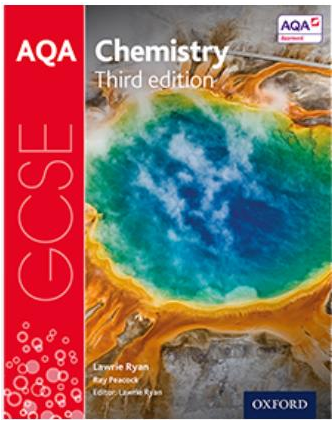
Extended Homework Task

Chemistry C8 – Rates and Equilibrium

Name ……

Please hand in a completed printed version at the end of the topic



The online text book access to support this homework can be accessed through your Kerboodle account at www.kerboodle.com.

The username is your first initial and sir name (no gap).

If you have not accessed the book before the password will be the same as your username. If you have logged on before you will have changed the password to your own choice.

Click onto the science 9-1 tile and then onto the digital book.

Resources to support this homework can be found in the online student book

- **Rates and equilibrium pages 128 to 147**

Aims

This worksheet gives you practice at calculating the rate of a reaction from data showing the quantity of product formed or the quantity of reactant used up against time.

Initially you are asked to calculate the mean rate of the reaction at a specific time. Later on in the questions you are asked to calculate the actual rate at a specific time, by drawing the tangent to the curve at the specified time and calculating the gradient of the tangent.

Learning outcomes

After completing this worksheet, you should be able to:

- recall a definition for rate of reaction
- state the units for, and explain how there can be different units for measuring rate of reaction
- calculate the mean rate of reaction from given information about the quantity of reactant used or the quantity of product formed in a given time
- draw and interpret graphs showing the quantity of product formed or quantity of reactant used up against time
- draw tangents to curves and use the slope of the tangent as a measure of the rate of the reaction
- calculate the gradient of a tangent to a curve as a measure of the rate of a reaction at a specific time. (H)

Setting the scene

The **rate of a chemical reaction** tells you how fast reactants are turned into products. You can work out the rate of a reaction by finding out how quickly:

- the reactants are used up as they make products, or
- the products of the reaction are made.

Reactions start off quickly and then slow down as the reaction progresses. The **mean rate** of a reaction tells you the mean rate for the reaction after a certain amount of time. You can calculate the mean rate of a reaction by using the equation:

$$\text{mean rate of reaction} = \frac{\text{quantity of reactant used}}{\text{time}} \text{ or } \frac{\text{quantity of product formed}}{\text{time}}$$

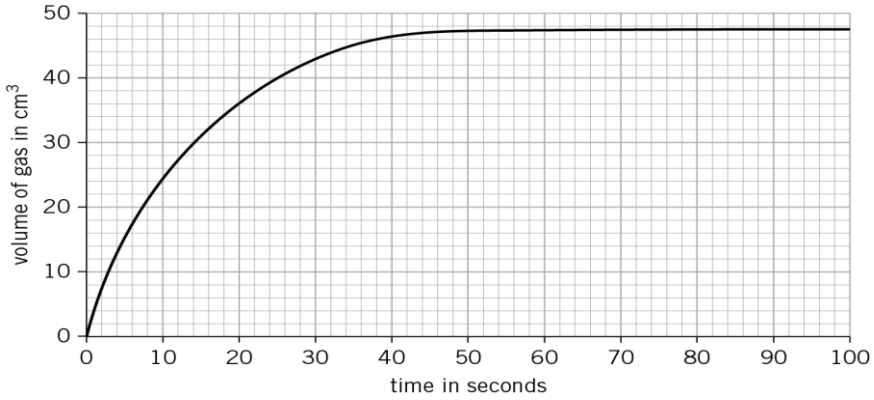
A graph can be plotted to show how the quantity of product formed or the quantity of reactant used up changes with time. The gradient of the curve at a specific time indicates the **actual rate** of the reaction at that time. The rate can be calculated by drawing a tangent to the curve at that point, followed by calculating the gradient of the tangent drawn.

Worked example

A student is investigating the rate of the reaction between magnesium and hydrochloric acid. The equation for the reaction is;

$$Mg(s) + 2HCl(aq) \rightarrow MgCl_2(aq) + H_2(g)$$

She measures the volume of gas produced every 10 seconds and plots the results on a graph.



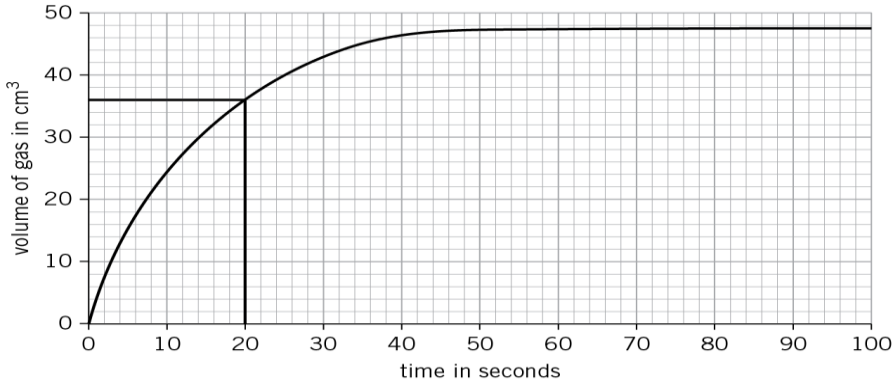
Example 1:

Calculate the **mean rate** of the reaction after 20 seconds.

Step 1

Using the graph, first of all find out the total volume of gas produced after 20 seconds.

HINT: always draw horizontal and vertical lines on the graph to help with reading the values of the axes.



After 20 seconds, 36 cm^3 of gas has been produced.

Step 2

Then substitute the values into the equation;

$$\text{mean rate of reaction} = \frac{\text{quantity of product formed}}{\text{time}}$$

$$= \frac{36\ cm^3}{20\ s}$$

$$= 1.8\ cm^3/s$$

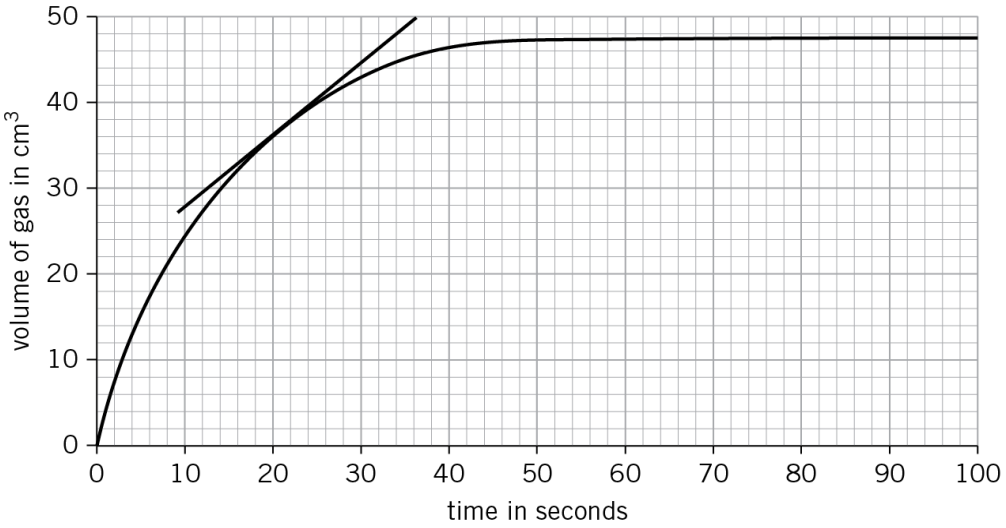
The units of rate are taken from the equation. In this case a volume in cm^3 is divided by a time in seconds, and so the units of rate are cm^3 per second or cm^3/s.

Example 2:

Calculate the rate of the reaction at 20 seconds.

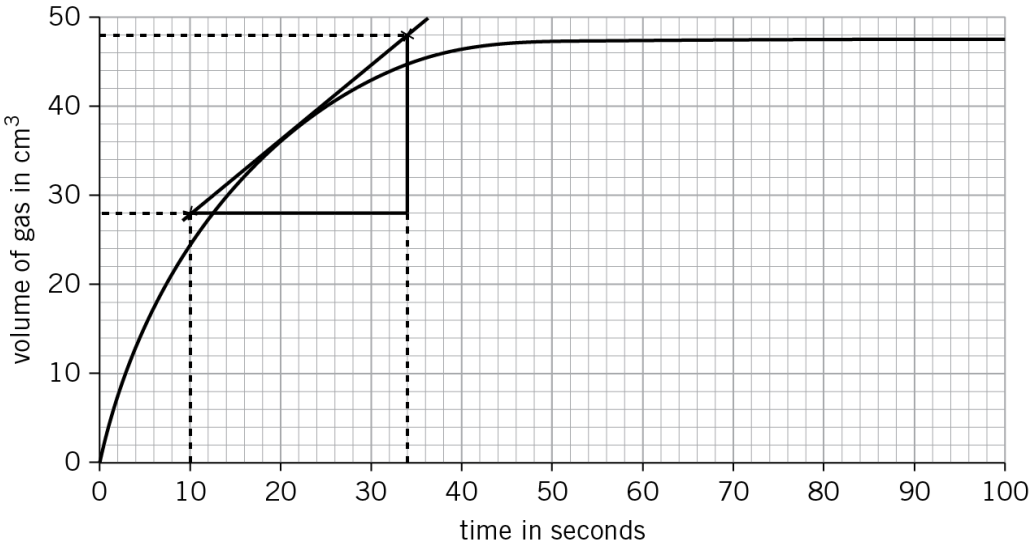
Step 1

You need to draw a tangent to the curve at the specified time (a straight line that just touches the curve at that point).



Step 2

Then construct a right angled triangle, using the tangent as its longest side. Choose two points which you can easily read the values for from the axes as the corners for the triangle and make the triangle as large as possible to reduce measurement errors.



Step 3

Calculate the gradient of the tangent using the equation:

$$\text{gradient} = \frac{\text{change in } y}{\text{change in } x}$$

change in $y = 48\,\text{cm}^3 - 28\,\text{cm}^3 = 20\,\text{cm}^3$

change in $x = 34\,\text{s} - 10\,\text{s} = 24\,\text{s}$

$$\text{gradient} = \frac{20\,\text{cm}^3}{24\,\text{s}} = \mathbf{0.83\,cm^3/s}$$

Questions

Use the data provided to calculate the mean rate at the time indicated for each of the following reactions. **Remember to include units.**

a The decomposition of hydrogen peroxide in which 15 cm^3 of oxygen was produced after 6 minutes.

.....

..... (*2 marks*)

b The reaction between sodium thiosulfate and acid in which 6 g of sulfur was produced in 24 seconds.

.....

..... (*2 marks*)

c The reaction between calcium carbonate and hydrochloric acid in which 0.6 g of calcium carbonate was used up after 2.5 minutes.

.....

..... (*2 marks*)

d The reaction between lithium and water in which 2.5×10^{-3} moles of hydrogen is produced in 10 seconds.

.....

..... (*2 marks*)

2 Stephen is investigating the rate of the reaction between calcium carbonate and hydrochloric acid. The equation for the reaction is;

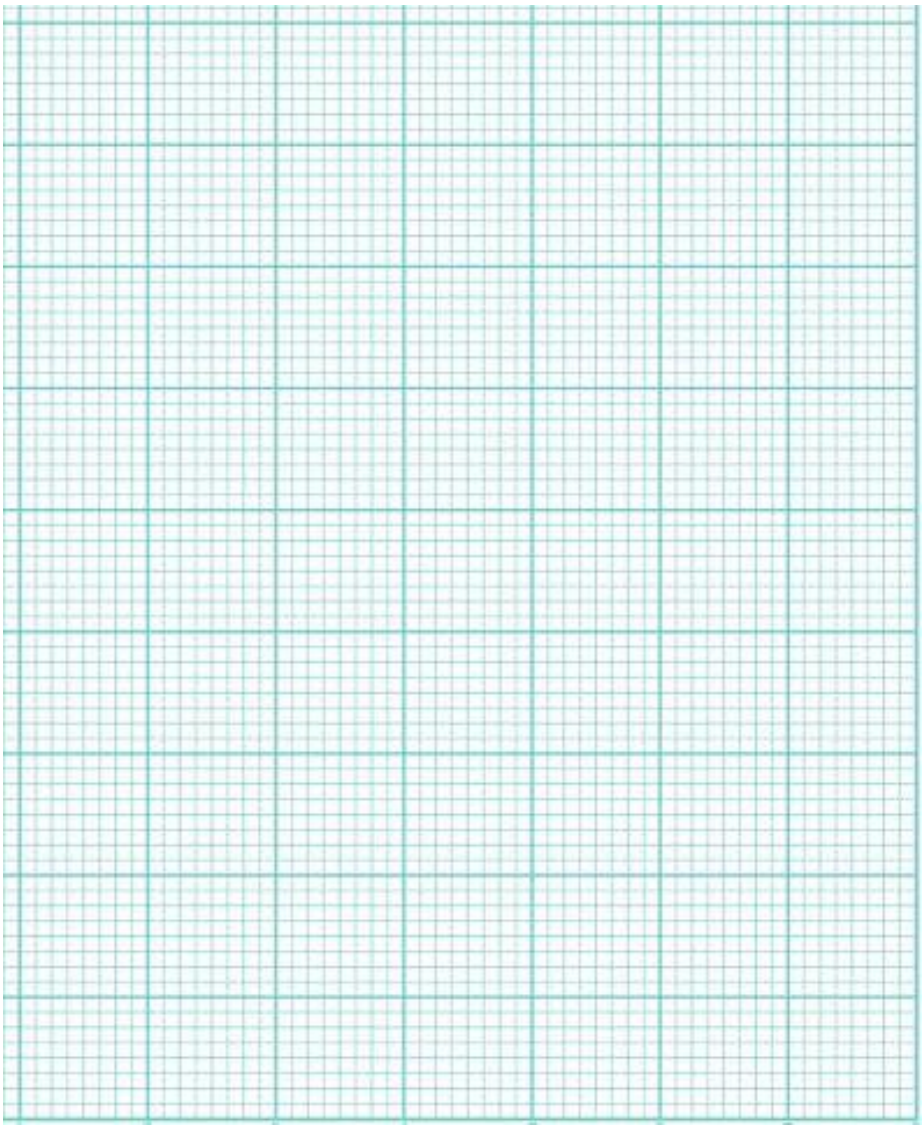
$$CaCO_3 + 2HCl \rightarrow CaCl_2 + H_2O + CO_2$$

He adds 5.0 g of calcium carbonate to an excess of hydrochloric acid and measures the mass of carbon dioxide given off every 10 seconds. The results of his reaction are shown in the table.

Time in seconds	Mass of CO_2 produced in grams
0	0
10	13
20	18
30	22
40	24
50	25
60	26
70	26
80	26

a Plot a graph of mass of carbon dioxide produced (*y*-axis) against time x axis).

(*4 marks*)



b Calculate the mean rate of the reaction after 15 seconds.

.....

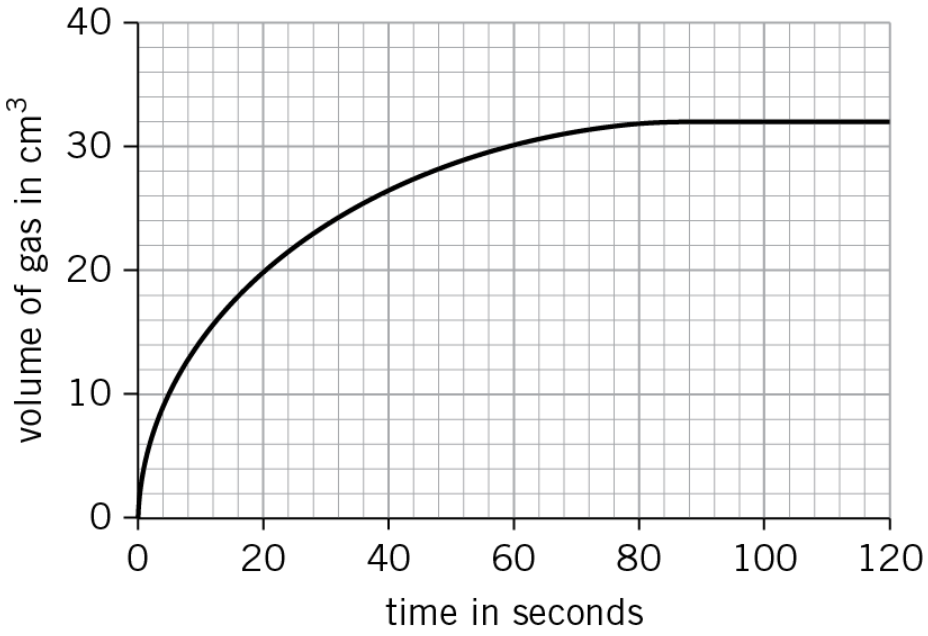
..... (*2 marks*)

c After how many seconds has the reaction finished?

..... (*1 mark*)

3 The graph below shows how much hydrogen was given off during the reaction between magnesium ribbon and hydrochloric acid.

a



Calculate the rate of the reaction at:

i 20 seconds

.....

..... (*2 marks*)

ii 40 seconds.

.....

..... (*2 marks*)

b Show by calculation that the mean rate between 40 and 60 seconds is slower than the mean rate between 0 and 20 seconds.

.....

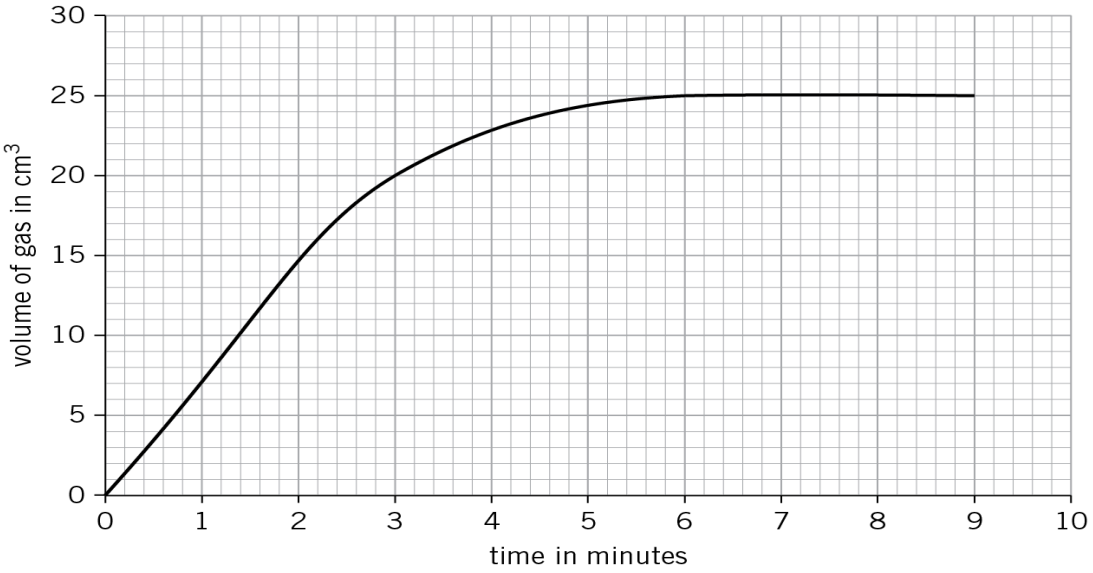
..... (*2 marks*)

Student follow up

4 Zinc reacts with sulfuric acid to produce a salt and hydrogen gas.

A student investigates how the size of the pieces of zinc used in reaction affects the rate of the reaction.

He reacts 2.0 g of zinc granules with an excess of sulfuric acid and measures the volume of hydrogen given off.



a Name the salt produced in this reaction.

.....

(*1 mark*)

b Calculate the mean rate of the reaction up to the time the reaction is complete.

.....

.....

(*3 marks*)

c Calculate the rate of the reaction at 3 minutes.

.....

.....

(*2 marks*)

The student repeats the experiment using 2.0 g of powdered zinc.

d **i** Sketch a line on the graph to show the results you would expect with the powdered zinc. (*2 marks*)

ii Explain your reasoning behind the line you have sketched.

.....

.....

(*3 marks*)