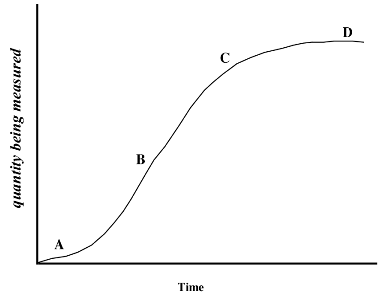
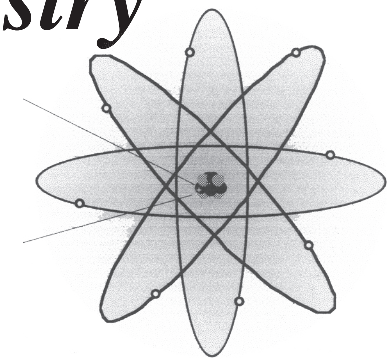
National 5 Chemistry



Unit 1:



Chemical Changes & Structure

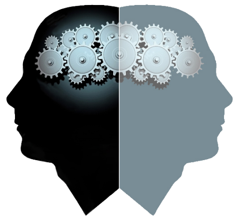
Student:

Topic 1

Reaction Rates

Topics	Sections			Done	Checked
1.1 ***Reaction Rates***	1.	Factors Affecting Rate of Reaction (Revision)			
	2.	Measuring Reaction Rates - Weight Loss			
	3.	Measuring Reaction Rates - Gas Volume			
	4.	Measuring Reaction Rates - Cloudiness			
	5.	Measuring Reaction Rates - Catalyst			
	6.	Homogeneous & Heterogeneous Catalysts			
		Self -Check Questions 1 - 9	Score: /		
1.2 ***Reaction Progress***	1.	Progress of a Reaction			
	2.	Calculating the Rate			
	3.	Comparing Reaction Progress			
		Self -Check Questions 1 - 3	Score: /		
Consolidation Work		Consolidation A	Score: /		
		Consolidation B	Score: /		
		Consolidation C	Score: /		
		Consolidation D	Score: /		
End-of-Unit Assessment	Score: %		Grade:		

Learning Outcomes



Assumed Knowledge - Met in Earlier Courses

Chemical Reactions

- In ***all*** chemical reactions new substances are formed
- In ***many*** chemical reactions there is a change in appearance
- In ***many*** chemical reactions there is a detectable energy change
- Reactions that ***release energy*** are described as ***exothermic***
- Reactions that ***take in energy*** are described as ***endothermic***
- ***Precipitation*** is the reaction of two solutions to form an insoluble solid called a precipitate - use of ***Solubility Table*** in *Data Booklet*.

Chemical Tests

• Test for ***hydrogen***:	burns	with a squeaky pop
• Test for ***oxygen***:	glowing splint	relights
• Test for ***carbon dioxide***:	lime water	turns cloudy / milky
• Test for ***acid***:	indicator	turns red /orange
• Test for ***alkali***:	indicator	turns purple /blue

Elements

- Everything in the universe is made from about 100 elements
- Every element is made up of small particles called ***atoms***.
- Elements cannot be broken down into simpler substances
- Atoms of different elements are different.
- There is a different ***symbol*** for every element

Periodic Table

- The ***periodic table*** is how chemists classify elements.
- A column of elements in this table is called a ***group***.
- Elements in the same group have similar chemical properties.
- Important groups include: Group 1 - ***alkali metals*** (reactive)
Group 7 - ***halogens*** (reactive non-metals)
Group O - ***noble gases*** (very unreactive)
- The ***transition metals*** are an important block of elements between groups 2 & 3
- Most elements are solids, a few are gases and two, bromine and mercury, are liquids.

Compounds

- Compounds are formed when elements react with each other and join together
- To separate the elements in a compound requires a chemical reaction

Mixtures

- Mixtures are formed when two or more substances are mingled together without reacting. They are ***not joined***
- Separating the substances in a mixture does ***not*** involve a chemical reaction
- Air is a ***mixture*** of many gases (some elements, some compounds):

  nitrogen, oxygen, carbon dioxide, water vapour, noble gases

- Air is mainly *nitrogen* (~78%) and *oxygen (~21%)*.

Solvents, Solutes and Solutions

- A ***solvent*** is the *liquid* in which a substance dissolves
- A ***solute*** is the substance (solid, liquid or gas) that dissolves in a liquid
- A ***solution*** is a liquid with something dissolved in it
- A ***dilute solution*** has a small amount of solute compared to solvent
- A ***concentrated solution*** has a large amount of solute compared to the solvent
- A ***saturated solution*** can dissolve no more solute, it is 'full-up'
- Water is the most common solvent

Rates of Reactions

- Decreasing ***particle size*** (smaller lumps) speeds up chemical reactions
- Increasing ***temperature*** speeds up chemical reactions
- Increasing ***concentration*** speeds up chemical reactions
- Using a ***catalyst*** speeds up some chemical reactions

Catalysts

- Catalysts ***speed up*** some reactions
- Catalysts are ***not used up*** during reactions
- Catalysts can be recovered and used again at the end of reactions
- Catalysts in living things (biological catalysts) are called ***enzymes***
- Catalysts in the ***same state*** as the reactants are called ***homogeneous***
- Catalysts in a ***different state*** from the reactants are called ***heterogeneous***

1.1 Reaction Rates

This lesson revises the factors which can effect the speed of a reaction, methods used to measure the speed of a reaction and their graphical representation.

Factors

The ***rate*** of a chemical reaction is the ***speed*** of the reaction. It can be effected by:-

Temperature

As you ***incr*** ***the temp*** of the reacting chemicals the ***reaction gets fa***

Concentration

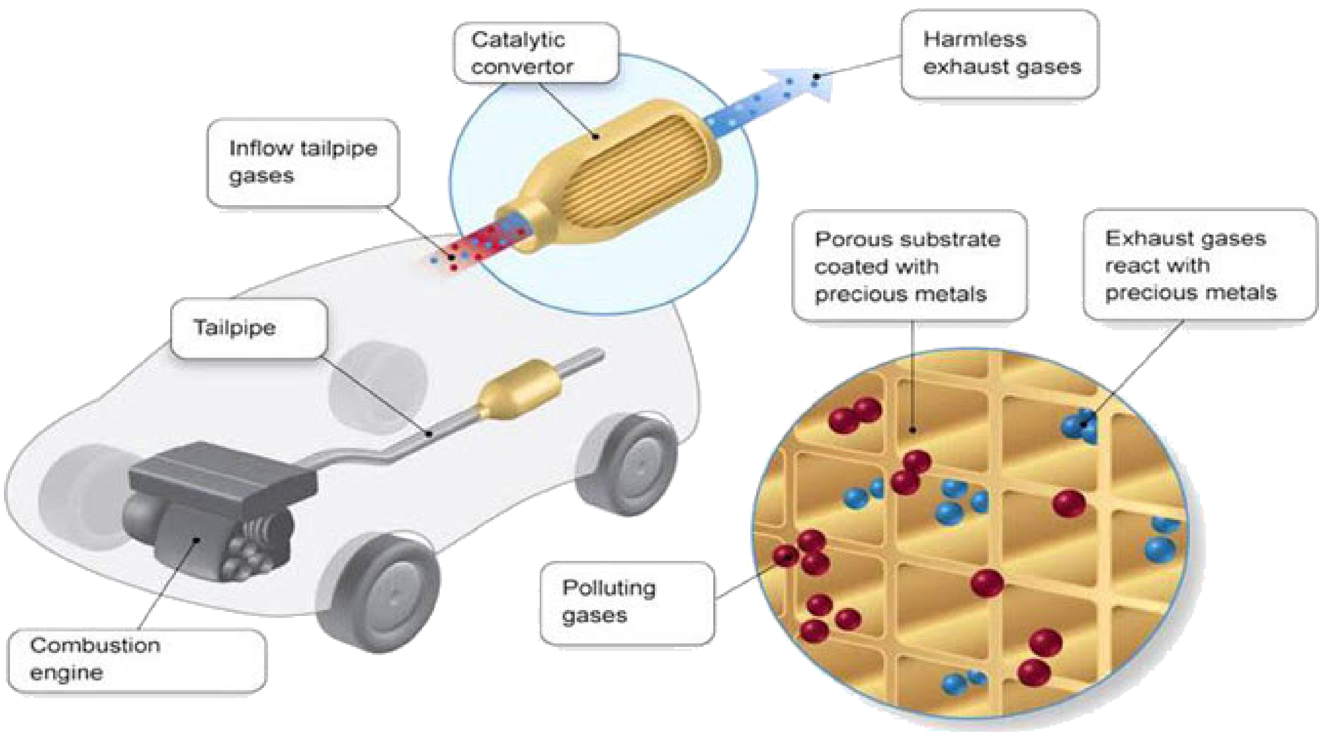
If any of your reacting chemicals are ***solu*** then ***increasing the conc*** of the solution will make the ***reaction fa***

Surface area
(Particle Size)

If any of your reacting chemicals are ***solids*** then breaking the solid into ***sma*** ***lumps*** will ***increase the sur*** ***area*** of the solid and make the ***reaction fa*** .

Catalysts

For ***some*** reactions it is possible to find an ***extra*** ingredient that allows the reacting chemicals to ***react fa*** than normal but will ***not be us*** ***up*** during the reaction.



One of the most important uses of ***cat*** is to help ***control poll***, in particular, ***exh fumes*** from cars which contain ***pois*** chemicals, ***can causing*** chemicals and gases that help form ***ac rain***.

Exh fumes normally ***poll*** the air with a mixture of ***unburnt oil*** and ***pet***, ***carbon monox*** and ***oxides of nitr***.

The ***cat*** chamber converts these into ***harmless gases*** by helping them to react with each other and ***oxy*** from the air.

Nitr, ***oxy***, ***wat vapour*** and ***car dioxide*** are produced and released into the air instead.

Cat make use of very expensive ***Tran Metals*** like ***platinum***.

Many ***cat*** simply provide a ***surf*** onto which ***mol*** can be *adsorbed*, *weakened*, *reacted* more easily and then *released*.

e.g

$$NH_3 \quad + \quad O_2 \quad \rightarrow \quad NO \quad + \quad H_2O$$

(Try balancing this equation)

The ***cat*** remains ***unch*** by the process and ***none of the catalyst is used up*** - ***sa am*** at the end as you started with.

Other ***catalysts*** quite definitely *take part* in a reaction and *appear* to ***cha***. Eg, *pink cobalt (II) chloride* turns *green* whilst ***spe*** up the reaction between *rochelle salt & hydrogen peroxide*.

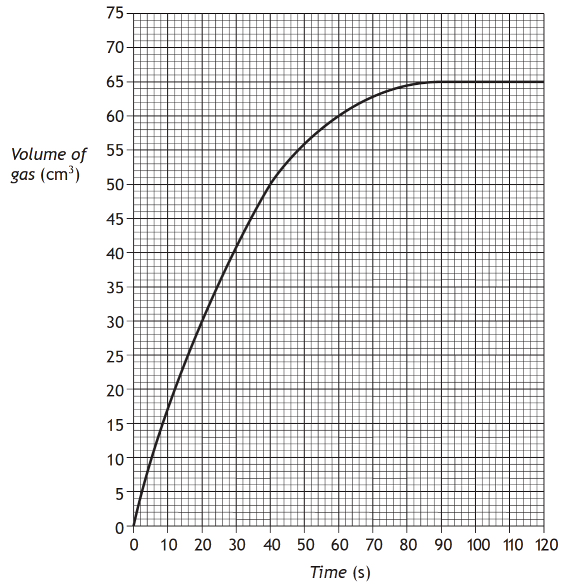
However, the *pink* colour ***ret*** when the reaction stops so ....

The ***catalyst*** remains ***unch*** by the process and ***none of the catalyst is used up*** - ***sa am*** at the end as you started with.

Following Progress of a Reaction

To monitor a reaction we either:-

① Measure the ***qua*** of a ***pro*** being *produced* at ***regular ti*** ***intervals***.

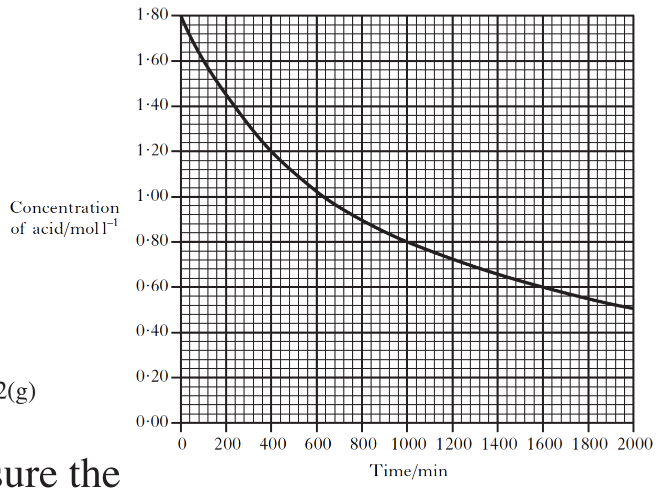


eg in the reaction between *magnesium* and *hydrochloric acid*:-

$$Mg_{(s)} + 2HCl_{(aq)} \rightarrow MgCl_{2(aq)} + \boldsymbol{H_{2(g)}}$$

an 'easy option' is to measure the ***vol*** ***of hydrogen*** gas.

② Measure the ***qua*** of a ***reac*** being *used up* at ***regular ti*** ***intervals***.



eg in the reaction between *magnesium* and *hydrochloric acid*:-

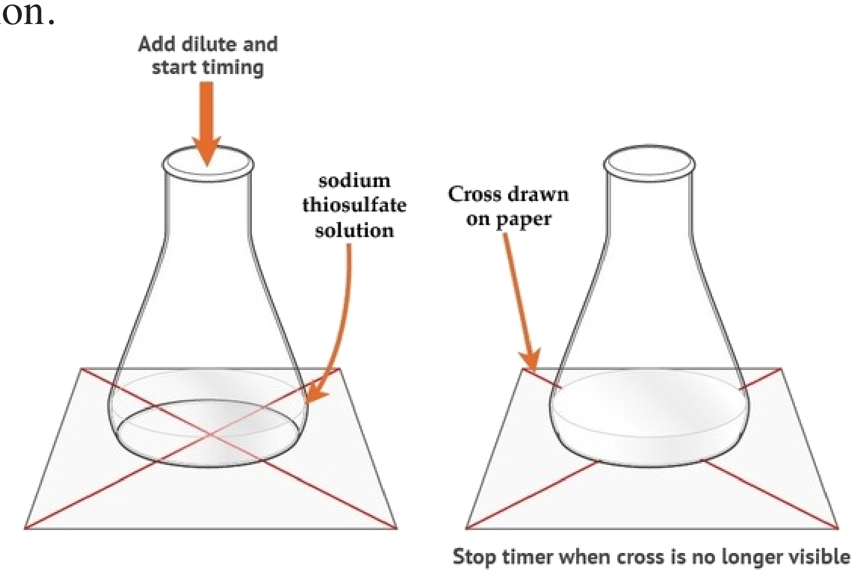
$$Mg_{(s)} + \boldsymbol{2HCl_{(aq)}} \rightarrow MgCl_{2(aq)} + H_{2(g)}$$

a 'difficult option' would be to measure the ***conc*** ***of hydrochloric*** acid.

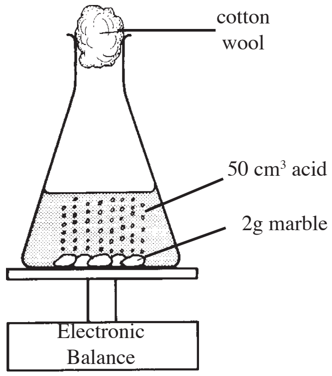
③ Time ***how long it takes*** for a certain ***qua*** of ***product*** to be *produced* or ***how long it takes*** for a certain ***qua*** of ***reactant*** to be *used up* - set an '*end-point*' for the reaction.

eg in the reaction between *sodium thiosulfate* and *hydrochloric acid* the solid ***prec*** of *sulfur powder* would be difficult to measure directly.

Instead we set an '*end-point*' for the reaction.



Weight Loss



Any reaction that produces a ***g*** which can ***esc*** into the room will lose ***wei*** .

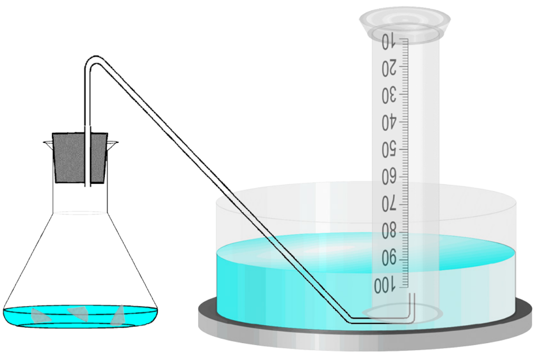
An ***electronic balance*** can be used to ***mea*** the ***wei*** of chemicals and ***appa*** and the ***weight of g*** produced can be ***calculated*** by subtracting from the ***star*** weight.

Diff ***sizes*** of marble lumps were compared using this apparatus and it was found that:-

small lumps react ***faster*** than ***medium*** lumps react ***faster*** than ***large*** lumps

Gas Volume

A number of different methods can be used to ***mea*** the ***vol*** ***of a g*** produced during a ***chem*** ***reaction***



The easiest and most common method is to collect the ***g*** in an upturned ***meas*** ***cylinder*** filled with ***wat*** .

As the ***g*** goes in it pushes the ***wat*** out allowing the ***vol*** ***of gas*** to be measured using the ***sca*** on the measuring cylinder.

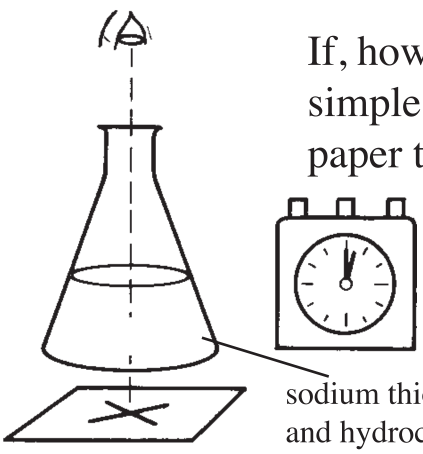
Diff ***conc*** of *hydrochloric acid* were compared using this apparatus and it was found that:-

more conc (1M) acid reacts ***fas*** than *less concentrated* (0.5M)

Cloudiness

Many reactions produce ***solid prec*** and go ***clo*** but most do so ***imm*** .

If, however, the reaction is ***sl*** enough, we can use a simple technique involving a ***cr*** drawn on a piece of paper to ***meas*** the ***ra*** ***of the reaction***.

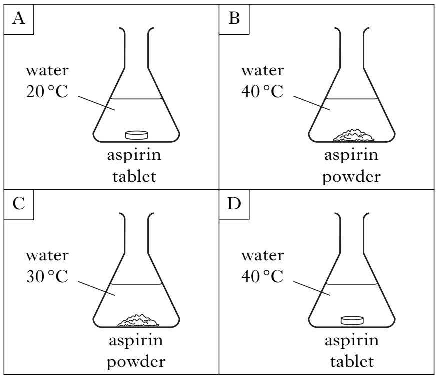


The ***ra*** of this reaction was measured at ***diff*** ***temp*** and it was found that:-

hi ***the temp*** the ***fas*** the reaction

Q1. SG

A student set up four experiments to investigate the solubility of aspirin.



(*a*) Identify the experiment in which the aspirin would take the longest time to dissolve.

A	B
C	D

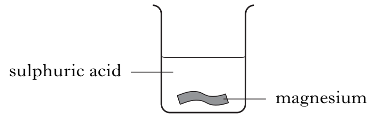
(*b*) Identify the **two** experiments which should be compared to show the effect of particle size on the speed of dissolving.

A	B
C	D

Q2. SG

A student investigated the effect of concentration on the rate of reaction between magnesium and sulphuric acid.

In each case she used the same mass of magnesium ribbon and timed how long it took for the magnesium to disappear.



The results are shown.

	Volume of 2 mol/l sulphuric acid/cm^3	Volume of water/cm^3	Total volume/cm^3	Time/s
Experiment 1	20	0	20	50
Experiment 2	15		20	65

(*a*) (i) Complete the table to show the volume of water the student should have used in experiment **2**.

(ii) How did the **speed** of the reaction in experiment **2** compare with the speed of the reaction in experiment **1**?

____

(*b*) Magnesium reacts with dilute sulphuric acid to produce magnesium sulphate and hydrogen gas.

State the test for hydrogen gas.

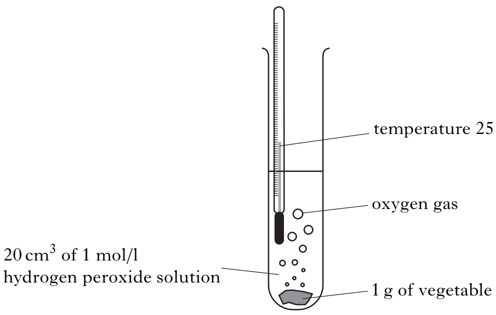
____

____

Q3. SG

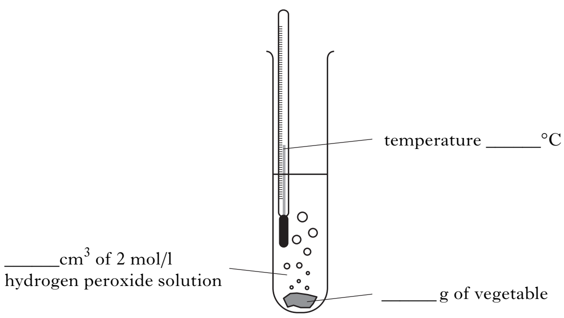
A student investigated the amount of the biological catalyst, catalase, in different vegetables.

Catalase breaks down hydrogen peroxide solution to produce water and oxygen.



The experiment was repeated to find out if increasing the concentration of hydrogen peroxide solution would speed up the reaction.

Complete the labelling of the diagram to show how she would make her second experiment a fair test.

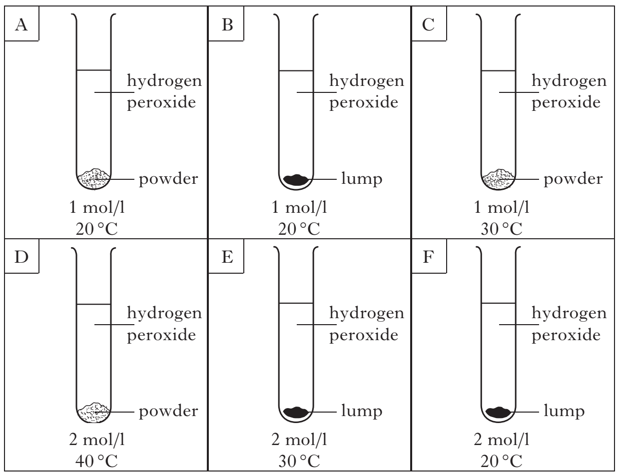


Q4. SG

A catalyst speeds up the following reaction:

hydrogen peroxide $\longrightarrow$ water + oxygen

The grid shows reactions carried out using the **same** mass of catalyst with two different concentrations of hydrogen peroxide.



(*a*) Identify the **two** experiments which could be used to show the effect of concentration on the speed of reaction.

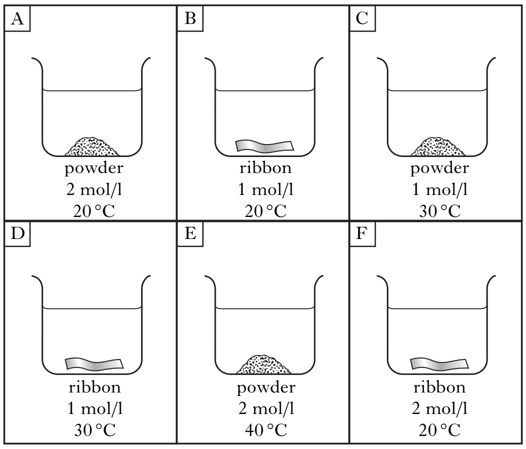
A	B	C
D	E	F

(*b*) Identify the experiment with the fastest speed of reaction.

A	B	C
D	E	F

Q5. SG

Two students investigated the reaction between magnesium and dilute hydrochloric acid.



(*a*) Identify the **two** experiments which could be used to show the effect of concentration on the speed of reaction.

A	B	C
D	E	F

(*b*) Identify the experiment with the fastest speed of reaction.

Q6. Int2

Which of the following pairs of reactants would produce hydrogen most slowly?

A Magnesium powder and 4 mol l^{-1} acid

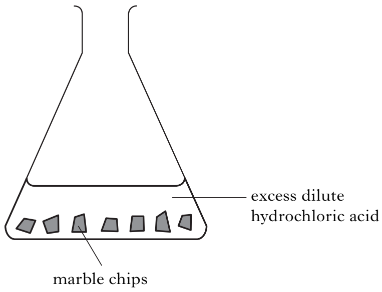
B Magnesium ribbon and 2 mol l^{-1} acid

C Magnesium powder and 2 mol l^{-1} acid

D Magnesium ribbon and 4 mol l^{-1} acid

Q7. Int2

A student investigated the reaction between marble chips and excess dilute hydrochloric acid.



Which of the following would **not** affect the rate of the reaction?

A Increasing the volume of the acid

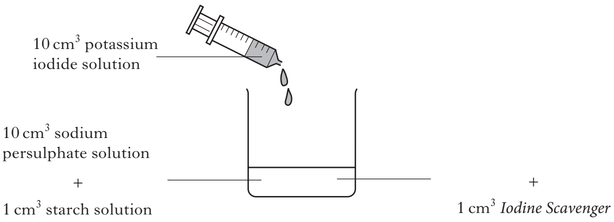
B Decreasing the size of the marble chips

C Decreasing the concentration of the acid

D Increasing the temperature of the acid

Q8. Int 2

The reaction between sodium persulphate and potassium iodide was investigated to show the **"Effect of Concentration on Reaction Rate"**



The **Iodine Scavenger** is there to react with the iodine produced meaning that the starch cannot turn blue-black until the Scavenger is used up. In effect, it acts like a a ***'finishing line'*** that the reaction must reach. Once the 'finishing line' is reached, their is a dramatic change in colour.

The results obtained during this PPA are shown in the table.

Experiment	Volume of sodium persulphate (cm^3)	Volume of water (cm^3)	Reaction time (s)
1	10	0	126
2	8		162
3	6		210
4	4		336

(*a*) Complete the results table to show the volumes of water used in experiments 2, 3 and 4.

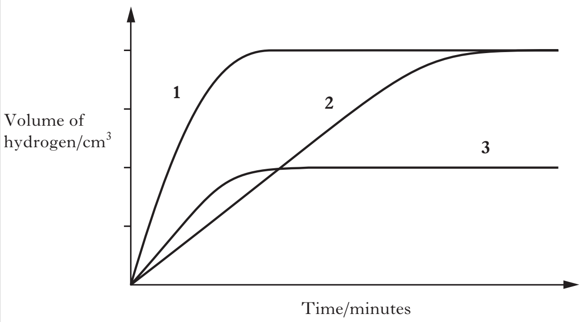
(*b*) How was the end-point of the reaction determined?

(*c*) Apart from using a timer, what allowed the accurate measurement of reaction times?

Q9. SC

A student carried out some experiments between zinc and excess 1 mol/l hydrochloric acid.

The graph shows the results of each experiment.



(*a*) In which experiment did the reaction take longest to finish, **1**, **2** or **3**?

(*b*) In **all** three experiments she kept the temperature the same and used the same volume of 1 mol/l hydrochloric acid.

(i) Suggest one factor that could have been changed from experiment **1** to produce the results in experiment **2**.

(ii) 1 g of zinc was used in experiment **1**.

What mass of zinc was used in experiment **3**?

______ g

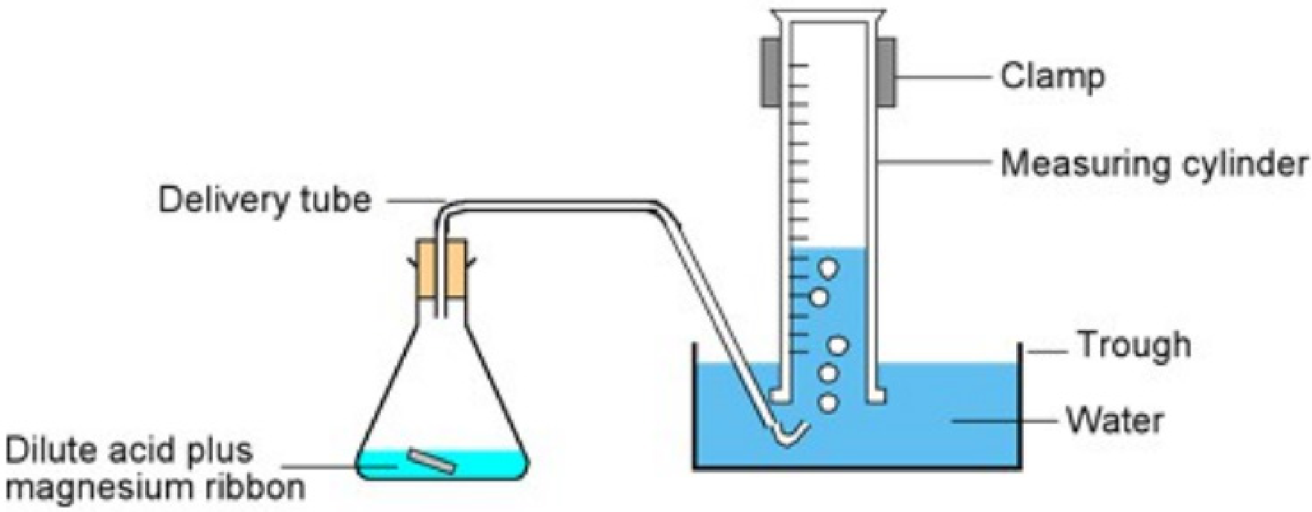
1.2 Reaction Progress

This lesson topic deals with some ways of following the progress of a chemical reaction.

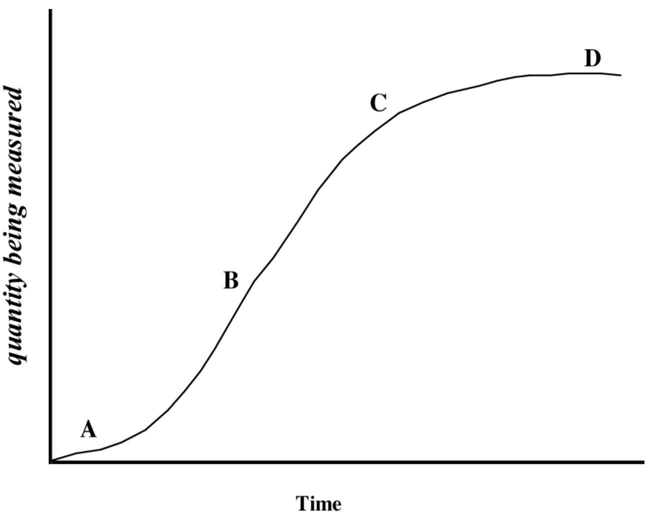
Progress of a Reaction

The aim of the following experiment is to follow the progress of a reaction by recording the volume of gas produced at regular intervals.

magnesium	+	*hydrochloric acid*	→		+	
	+		→	$MgCl_2$	+	H_2



Time (s)		*Time (s)*		*Time (s)*	
0					



A ***sha*** ***slope*** - many reactions are slow to get started

B ***st*** ***slope*** - fast reaction rate

C ***sha*** slope - reaction starts to slow down as chemicals are used up (their concentrations fall)

D ***le*** ***slope*** - reaction has stopped. One of the chemicals has been used up completely

Calculating the Rate

This activity examines how the rate of a reaction can be calculated from a progress graph.

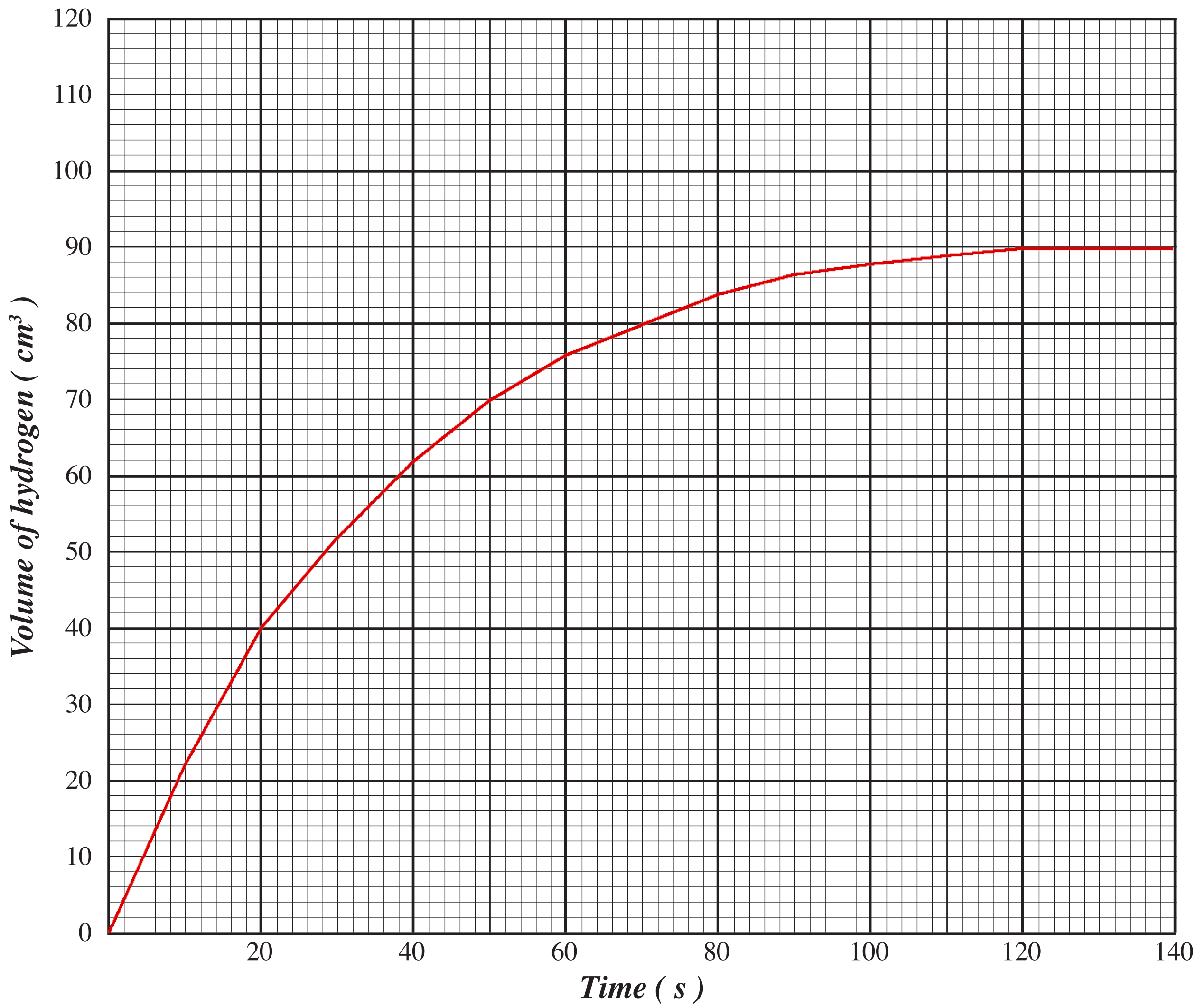
Rate of reaction *is the* ***cha*** *in* ***qua*** *of a* ***rea*** *or* ***pro*** *per unit of* ***ti*** .

$$\textit{average rate} = \frac{\textit{change in quantity}}{\textit{change in time}}$$

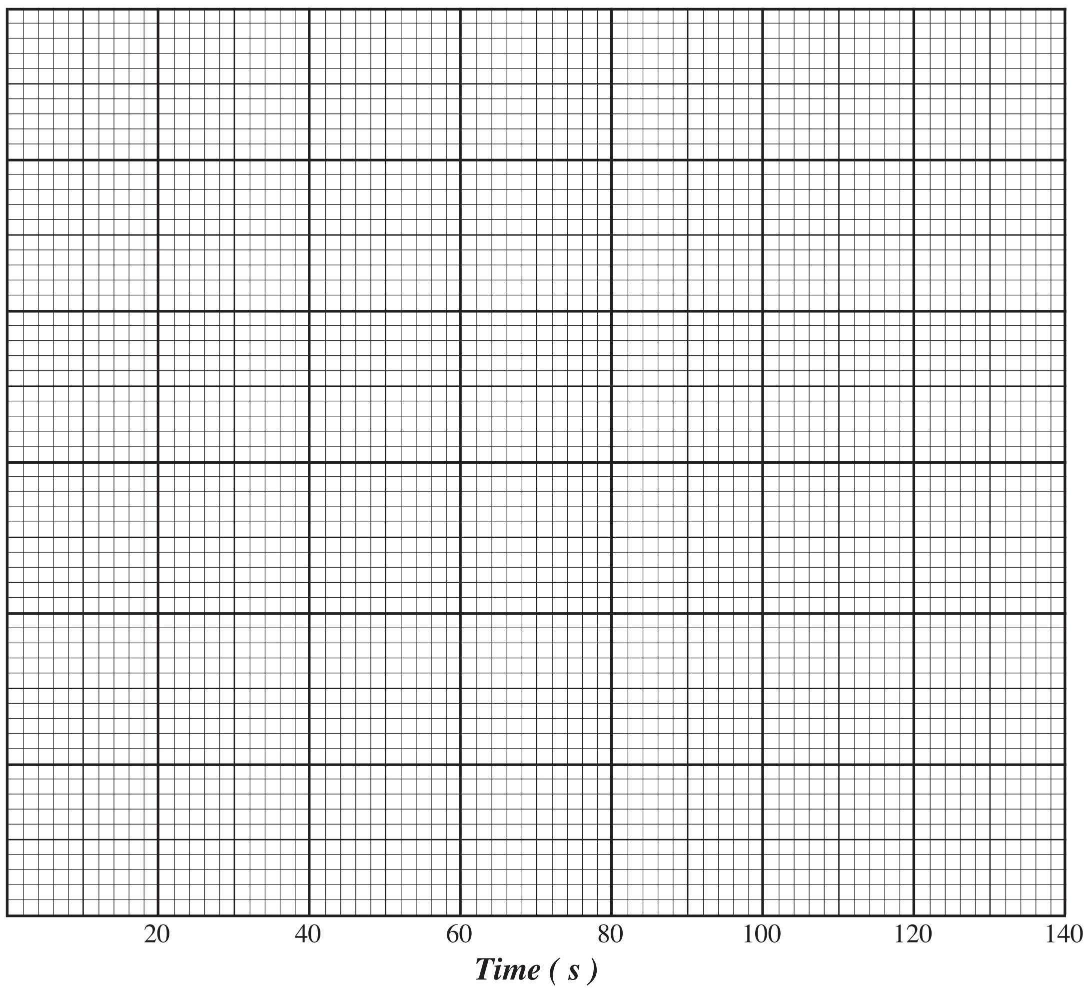
The ***un*** used for ***ra*** depends on the ***qua*** of the ***rea*** /***pro*** that is being measured, and the ***ti*** ***scale*** for the reaction.

e.g	***wei loss***	(electrical balance)	***gr***	g/s , g/min, g/hour
	gas vol	(syringe)	ml or cm^3	cm^3/s etc.
	conc	(colourimeter)	moles/litre	moles/l/s etc.

The reaction between ***sul*** ***acid*** and ***mag*** produces ***hyd*** gas. The progress of the reaction can be monitored by ***mea*** the ***vol*** of gas produced. The ***Progress Graph***, below, can be used to ***cal*** the rate of this reaction at different stages.



Time interval ***(s)***	***Change in volume*** ***(cm^3)***	***Average rate*** ***($cm^3\ s^{-1}$)***
0 – 20		
20 – 40		
40 – 60		
60 – 80		
80 – 100		
100 – 120		
120 – 140		

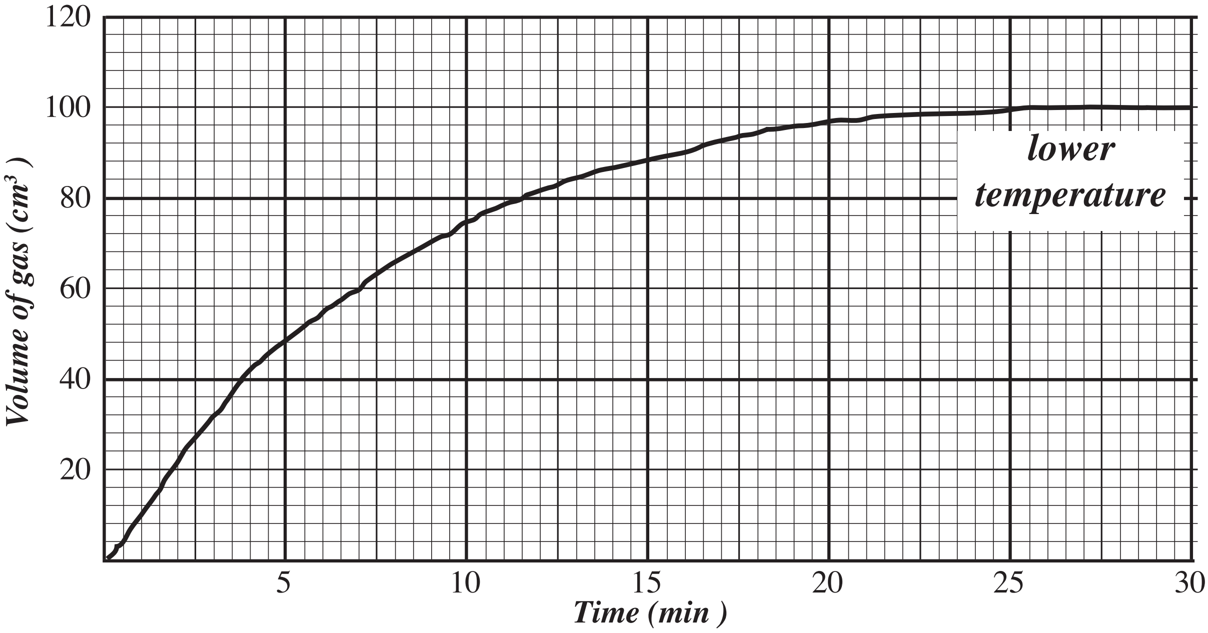


The rate will be at a ***max*** near the ***beg*** of the reaction, (when the ***conc*** of the ***rea*** are at their ***hi*** level), will usually ***dr*** quite steadily (as the ***rea*** concentrations ***dec***) and will eventually reach ***ze*** (once one of the reactants is used up completely.)

Comparing Reaction Progress

*The purpose of this activity is to **add another labelled line** to each of the progress graphs*

Ex 1- Higher Temperature



Both reactions have used the ***same ma*** of *zinc*, with the ***same par size***, with the ***same vol*** and ***con*** of *hydrochloric acid*.

lower temperature

The reaction has finished when the ***volume*** reached its ***maximum*** value:-

maximum volume = cm^3

The ***end-point*** of the reaction came after

minutes.

The ***starting slope*** of the reaction can be measured/estimated using

$$\textit{average rate} = \frac{\textit{change in quantity}}{\textit{change in time}}$$

For example:

after **2** minutes

volume = cm^3

Average Rate = / **2**

= cm^3 min^{-1}

higher temperature

The ***final volume*** of the reaction will be

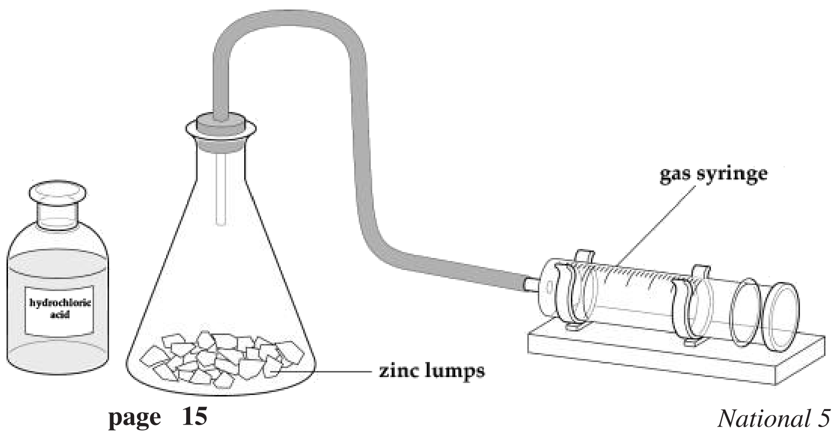
smaller / the same / larger

The ***end-point*** of the reaction will be

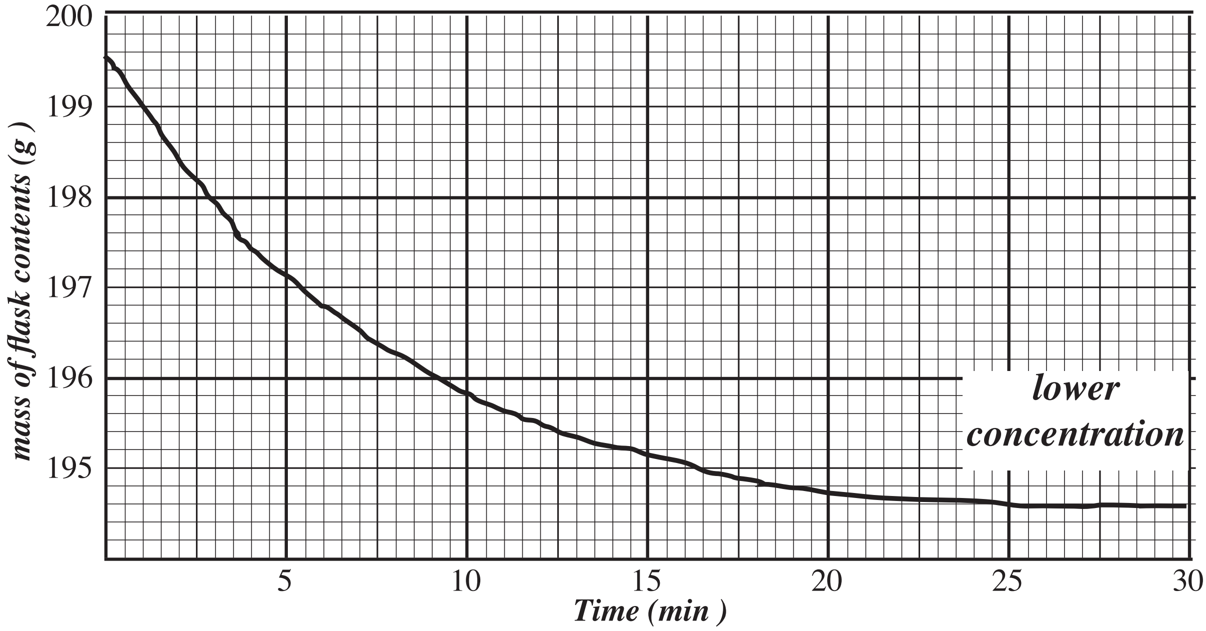
sooner / the same / later

The ***starting slope*** of the reaction will be

shallower / the same / steeper



Ex 2 - Higher Concentration



Both reactions have used the ***same ma*** of *marble*, with the ***same par*** ***size***, with the ***same vol*** of *hydrochloric acid* at the ***same temperature***.

lower concentration

The reaction has finished when the ***mass*** reached its ***minimum*** value:-

minimum mass = g

The ***end-point*** of the reaction came after

minutes.

The ***starting slope*** of the reaction can be measured/estimated using

$$\textit{average rate} = \frac{\textit{change in quantity}}{\textit{change in time}}$$

For example:

after **0** min mass = **199.6** g

after **2** min mass = g

Δmass = 199.6 - = g

Average Rate = / **2**

= g min^{-1}

higher concentration

The ***final mass*** of the reaction will be

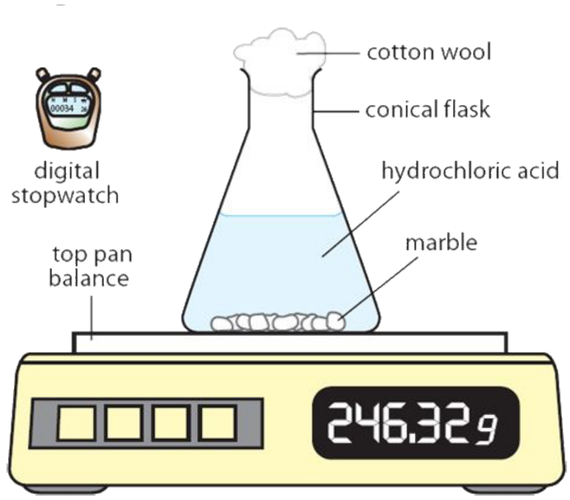
smaller / the same / larger

The ***end-point*** of the reaction will be

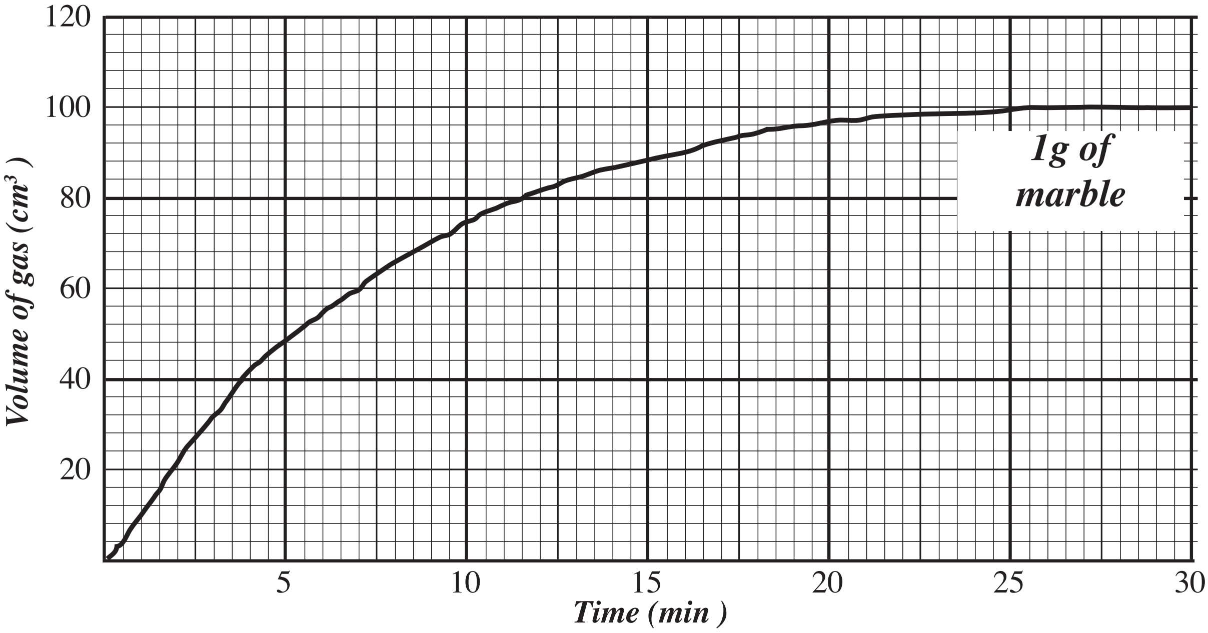
sooner / the same / later

The ***starting slope*** of the reaction will be

shallower / the same / steeper



Ex 3- Smaller Amount



Both reactions have used the ***same par*** ***size***, with the ***same vol*** and ***same conc*** of *hydrochloric acid* at the ***same temp*** .

1 g of marble

The reaction has finished when the ***volume*** reached its ***maximun*** value:-

maximum volume = **100** cm^{-3}

The ***end-point*** of the reaction came after

minutes.

0.5 g of marble

The ***final volume*** of the reaction will be

halved / *the same* / doubled

The ***end-point*** of the reaction will be

sooner / *the same* / *later*

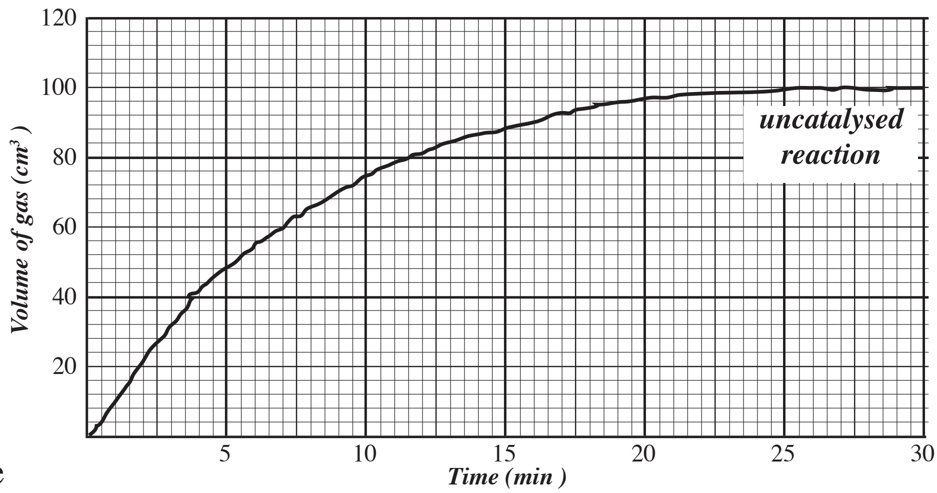
The ***starting slope*** of the reaction will be

shallower / *the same* / *steeper*

Ex 4 - Catalysed Reaction

The *catalysed reaction* will be the ***fas*** ***reaction*** and will produce ***mo*** ***gas*** over the ***sa*** ***time*** interval:- the slope will be ***st*** .

The *catalysed reaction* will ***fin*** ***first***.

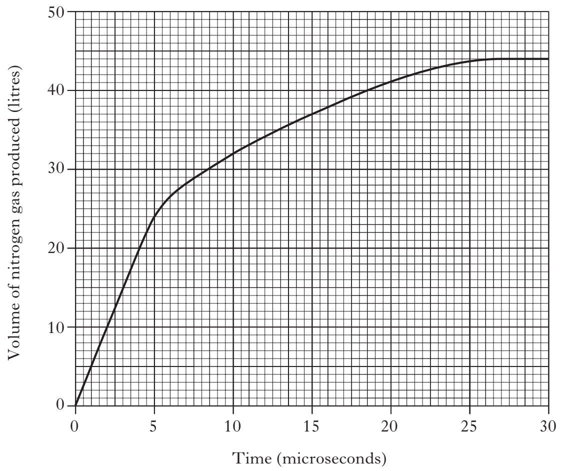


Both reactions have used the ***same ma*** of *zinc*, with the ***same par*** ***size***, with the ***same vol*** and ***con*** of *sulphuric acid* at the ***same temperature***, so the ***fin*** ***volume of gas*** will be the ***sa*** .

Q1. Int2

Rapid inflation of airbags in cars is caused by the production of nitrogen gas.

The graph gives information on the volume of gas produced over 30 microseconds.



(*a*) (i) Calculate the average rate of reaction between 2 and 10 microseconds.

______________________ litres per microsecond

(ii) At what time has half of the final volume of nitrogen gas been produced?

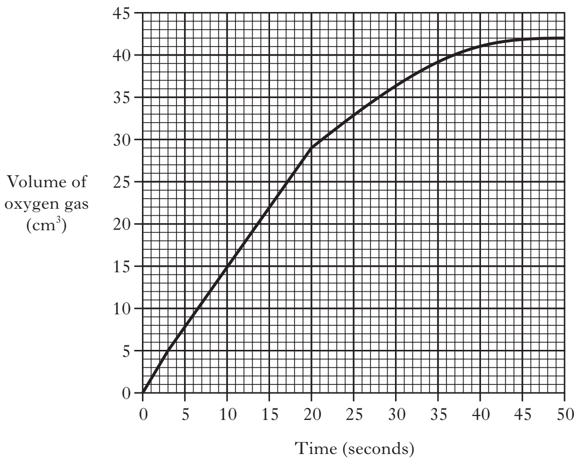
______________________ microseconds

Q2. Int2

Hydrogen peroxide solution decomposes to give water and oxygen.

$$2H_2O_2(aq) \rightarrow 2H_2O(\ell) + O_2(g)$$

The graph shows the results of an experiment carried out to measure the volume of oxygen gas released.



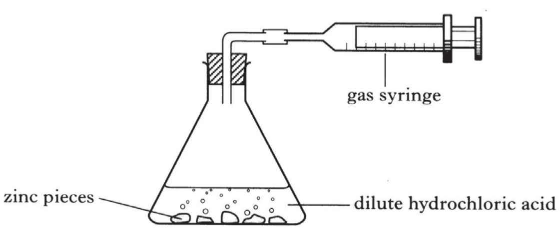
Calculate the average rate of reaction between 0 and 20 seconds.

$cm^3 s^{-1}$

Q3. Int2

Zinc reacts with dilute hydrochloric acid producing hydrogen gas.

The rate of reaction between zinc and dilute hydrochloric acid can be followed by measuring the volume of gas given off during the reaction.



Results	
Time (seconds)	**Volume of gas (cm^3)**
0	0
10	20
20	40
30	58
40	72
50	80
60	

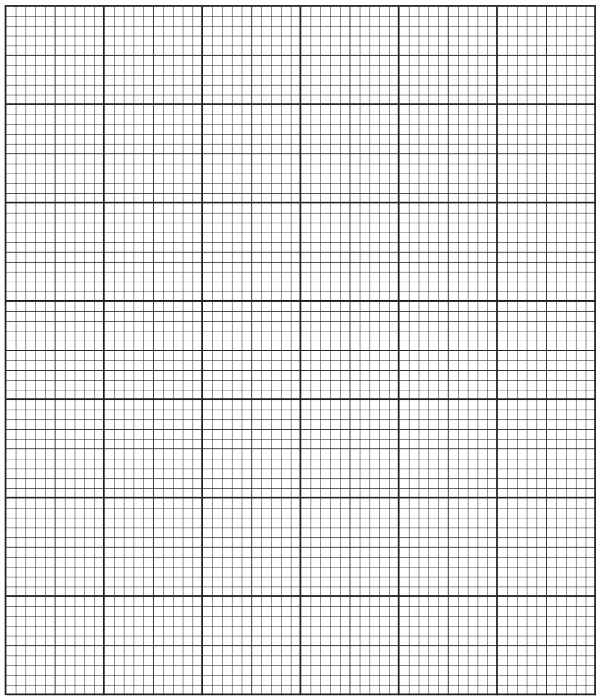
b) Calculate the average rate at which gas is given off during the first 40 seconds of the reaction.

______________ $cm^3 s^{-1}$

c) Why would increasing the concentration of the acid increase the rate of the reaction?

____

____

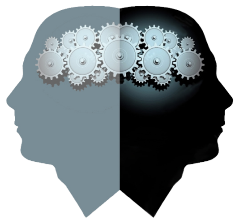


a) (i) Plot a line graph of the results of the reaction.

(ii) Predict the volume of gas which would have been given off after 60 seconds.

______________ cm^3

Learning Outcomes Topic 1



Knowledge Met in this Section

Measuring Reaction Rates

- Reactions can be followed by ***measuring*** changes in *concentration*, *mass* or *volume* of *reactants* or *products*.
- ***Rates*** of reaction can be ***increased*** by:-

  increasing the ***temperature*** of the *reactants*

  increasing the ***concentration*** of a *reacting* **solution**

  increasing the ***surface area*** *(decreasing particle size)* of a *reacting* ***solid***

  using a ***catalyst***

- The ***progress of a reaction*** can be shown graphically.
- Graphs can be used to show the ***end-point*** of a ***reaction***.
- Graphs can be used to show the effect of ***changes*** in ***reaction conditions***.
- Graphs can be used to show the effect of ***changes*** in ***reaction quantities***.
- The ***average rate*** of a reaction can be calculated from ***initial*** and ***final quantities*** and the ***time interval***.
- The ***average rate*** at any ***stage*** of a reaction can be calculated from ***change in quantities*** and the ***time interval***.

$$\textit{average rate} = \frac{\textit{change in quantity}}{\textit{change in time}}$$

$$\textit{average rate} = \frac{\Delta\ \textit{quantity}}{\Delta\ \textit{time}}$$

- The ***rate of a reaction*** can be shown to ***decrease*** over time by calculating the ***average rate*** at ***different stages*** of the reaction.

CONSOLIDATION QUESTIONS A

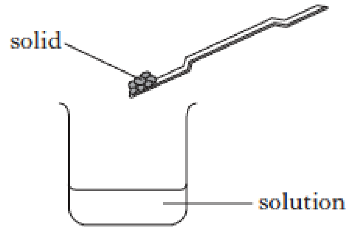
Q1. Int2

Which of the following elements has similar properties to argon?

A Fluorine
B Krypton
C Potassium
D Zinc

Q2. Int2

Which of the following would ***not*** be evidence of a chemical reaction when the solid is added to the solution?



A A colour change
B A gas being given off
C The temperature rising
D The solid disapppearing

Q3. Int2

Which line in the table shows the approximate composition of air?

	Nitrogen	Oxygen	Carbon dioxide	Noble gases
A	78	21	0·03	1
B	21	78	1	0·03
C	1	21	78	0·03
D	0·03	78	1	21

Q4. Int2

Vinegar is prepared by dissolving ethanoic acid in water.

Which term describes the water used when making the vinegar?

A Solute
B Saturated
C Solvent
D Solution

Q5. Int2

Vinegar is prepared by dissolving ethanoic acid in water.

Which line in the table identifies the solute, solvent and solution?

	Solute	Solvent	Solution
A	water	ethanoic acid	vinegar
B	water	vinegar	ethanoic acid
C	ethanoic acid	water	vinegar
D	vinegar	water	ethanoic acid

Q6. Int2

Which of the following elements is an alkali metal?

A Aluminium
B Calcium
C Copper
D Sodium

Q7. Int2

Lemonade can be made by dissolving sugar, lemon juice and carbon dioxide in water. In lemonade, the solvent is

A water
B sugar
C lemon juice
D carbon dioxide

Q8. Int2

Which line in the table correctly shows how the concentration of a solution changes by adding more solute or by adding more solvent?

	Adding solute	Adding solvent
A	concentration falls	concentration rises
B	concentration falls	concentration falls
C	concentration rises	concentration falls
D	concentration rises	concentration rises

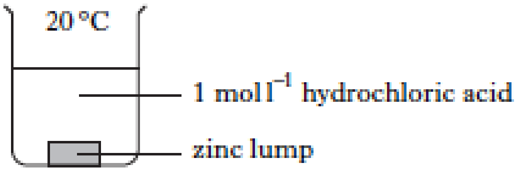
CONSOLIDATION QUESTIONS B

Q1. Int2

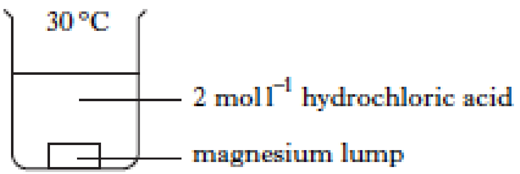
Magnesium and zinc both react with hydrochloric acid.

In which of the following experiments would the reaction rate be fastest?

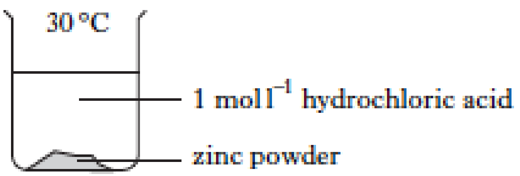
A



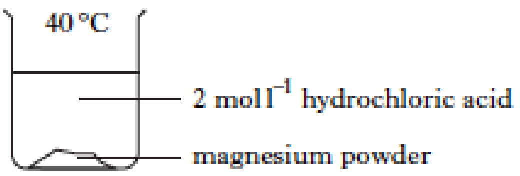
B



C



D



Q2. Higher

The following results were obtained in the reaction between marble chips and dilute hydrochloric acid.

Time/minutes	0	2	4	6	8	10
Total volume of carbon dioxide produced/cm^3	0	52	68	78	82	84

What is the average rate of production of carbon dioxide, in cm^3 min^{-1}, between 2 and 8 minutes?

A 5

B 26

C 30

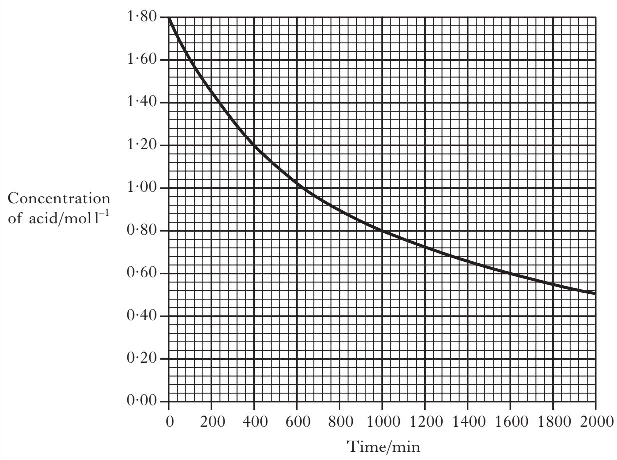
D 41

Q3. Higher

Chloromethane, CH_3Cl, can be produced by reacting methanol solution with dilute hydrochloric acid using a solution of zinc chloride as a catalyst.

$$CH_3OH(aq) + HCl(aq) \xrightarrow{ZnCl_2(aq)} CH_3Cl(aq) + H_2O(\ell)$$

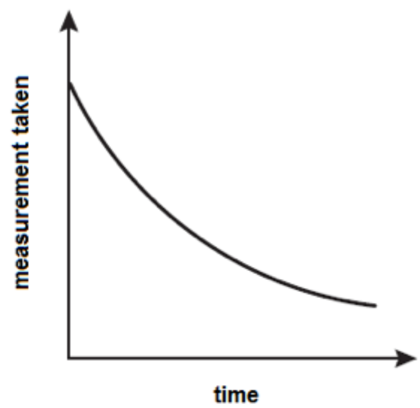
The graph shows how the concentration of the hydrochloric acid changed over a period of time when the reaction was carried out at 20 °C.



Calculate the average rate, in mol l^{-1} min^{-1}, in the first 400 minutes.

Q4. Higher

Excess marble chips (calcium carbonate) were added to 25 cm^3 of hydrochloric acid, concentration 2 mol l^{-1}.



Which of the following measurements, taken at regular intervals and plotted against time, would give the graph shown above?

A Temperature

B Volume of gas produced

C pH of solution

D Mass of the beaker and contents

CONSOLIDATION QUESTIONS C

Q1. Int2

Hydrogen peroxide solution decomposes to give water and oxygen.

$$2H_2O_{2(aq)} \rightarrow 2H_2O_{(l)} + O_{2(g)}$$

The graph shows the results of an experiment carried out to measure the volume of oxygen gas released.

a) State the test for oxygen gas

____

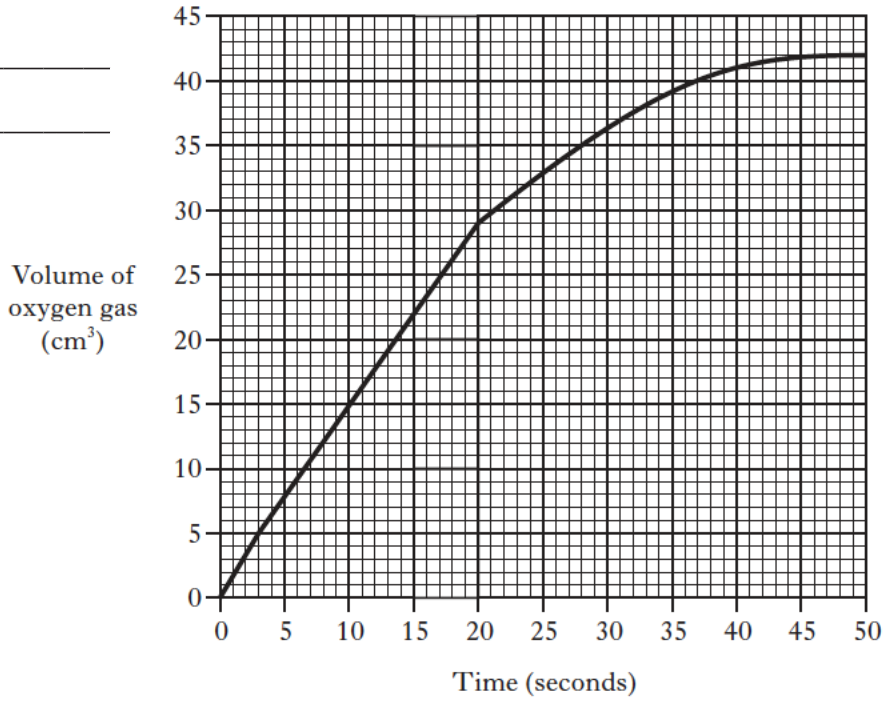
____

b) What volume of gas was released after 20 seconds.

________________ cm^3

c) Calculate the average rate at which gas is given off during the first 20 seconds of the reaction.

________________ $cm^3\ s^{-1}$



d) Draw a second line on the graph to show the effect of increasing the temperature of the hydrogen peroxide solution.

e) Draw a labelled diagram showing the apparatus that could have been used to obtain the results used to construct this graph.

CONSOLIDATION QUESTIONS D

Q1.

Hydrogen gas can be produced in the laboratory by adding a metal to dilute acid. Heat energy is also produced in the reaction. A student measured the volume of hydrogen gas produced when zinc lumps were added to dilute hydrochloric acid.

Time (s)	0	10	20	30	40	50	60	70
Volume of hydrogen (cm^3)	0	12	21	29	34	36	37	37

a) State the term used to describe all chemical reactions that release heat energy ____________________

b) Plot these results as a line graph

c) Calculate the average rate of reaction, in $cm^3\ s^{-1}$, between 10 and 30 seconds. ____________________

d) Estimate the time taken, in seconds, for the reaction to finish. ____________________

e) The student repeated the experiment using the same mass of zinc.

Plot a dotted line on your graph showing how the rate of the reaction would change if zinc powder was used instead of lumps.