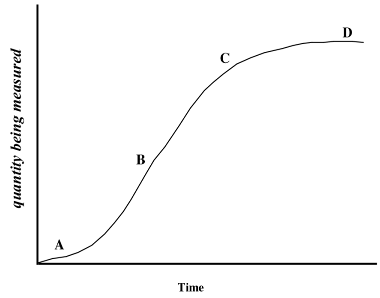
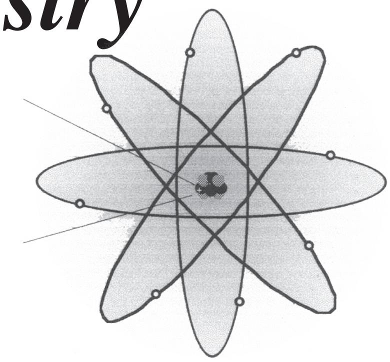
National 5 Chemistry



Unit 1:



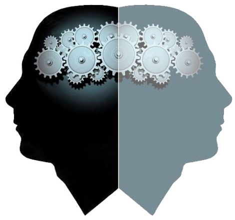
Chemical Changes & Structure

Student:

Topic 1
Reaction Rates & Atomic Structure

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: /		
1.3 *Atomic Structure*	1.	Atomic Models			
	2.	Important Numbers			
	3.	Nuclide Notation			
	4.	Isotopes			
	5.	Relative Atomic Mass (RAM) & Mass Spectometer			
	6.	Isotopic Ions			
		Self -Check Questions 1 - 6	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

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 ***increase the temperature*** of the reacting chemicals the ***reaction gets faster***

Concentration

If any of your reacting chemicals are ***solutions*** then ***increasing the concentration*** of the solution will make the ***reaction faster***

Surface area

(Particle Size)

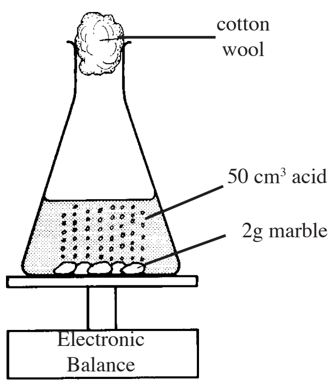
If any of your reacting chemicals are ***solids*** then breaking the solid into ***smaller lumps*** will ***increase the surface area*** of the solid and make the ***reaction faster***.

Catalysts

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

To find the rate of a reaction, some ***change*** is measured, eg weight loss, gas volume, cloudiness, at ***regular time intervals***.

Weight Loss



Any reaction that produces a ***gas*** which can ***escape*** into the room will lose ***weight***.

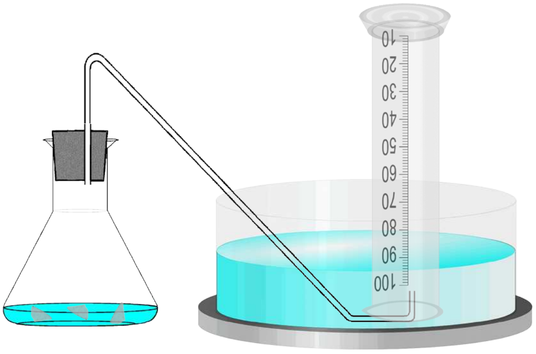
An ***electronic balance*** can be used to ***measure*** the ***weight*** of chemicals and ***apparatus*** and the ***weight of gas*** produced can be ***calculated*** by subtracting from the ***starting*** weight.

Different 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 ***measure*** the ***volume of a gas*** produced during a ***chemical reaction***



The easiest and most common method is to collect the ***gas*** in an upturned ***measuring cylinder*** filled with ***water***.

As the ***gas*** goes in it pushes the ***water*** out allowing the ***volume of gas*** to be measured using the ***scale*** on the measuring cylinder.

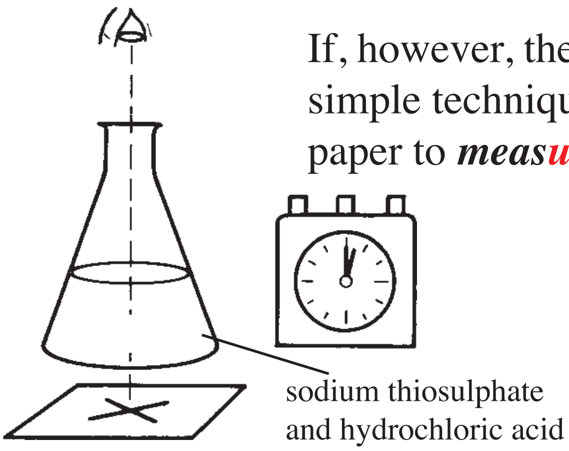
Different concentrations of *hydrochloric acid* were compared using this apparatus and it was found that:-

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

Cloudiness

Many reactions produce ***solid precipitates*** and go ***cloudy*** but most do so ***immediately***.

If, however, the reaction is ***slow*** enough, we can use a simple technique involving a ***cross*** drawn on a piece of paper to ***measure*** the ***rate of the reaction***.



The ***rate*** of this reaction was measured at ***different temperatures*** and it was found that:-

higher the temperature the ***faster*** the reaction

Catalysts

A ***catalyst*** is a substance that, when *added* to a reaction, can ***speed up the reaction*** but is ***not used up*** by the reaction.

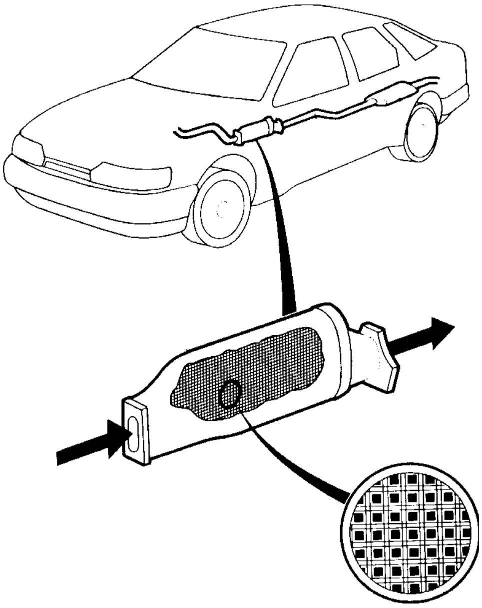
Catalysts can be very important in making ***chemicals*** on a large scale.

Using ***catalysts*** allows the Chemical Industry to produce chemicals ***faster*** and ***cheaper*** (less ***heat energy*** needed).

Anything from *margarine* to *rubber* can be made with the help of a ***catalyst***.

Reactions in *living things* (***plants*** and ***animals***) are helped by ***catalysts*** called ***Enzymes***. Some of these ***enzymes*** are used in ***industry*** to make *cheese*, *yoghurt*, *beer* and, in *'biological' detergents*, to clean your clothes

One of the most important uses of ***catalysts*** is to help ***control pollution***, in particular, ***exhaust fumes*** from cars which contain ***poisonous*** chemicals, ***cancer causing*** chemicals and gases that help form ***acid rain***.



Exhaust fumes normally ***pollute*** the air with a mixture of ***unburnt oil*** and ***petrol***, ***carbon monoxide*** and ***oxides of nitrogen***.

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

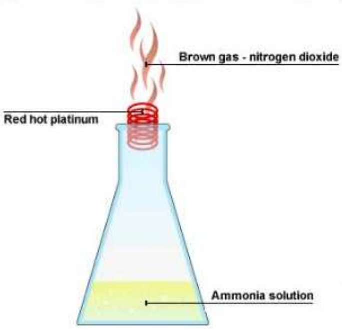
Nitrogen, ***oxygen***, ***water vapour*** and ***carbon dioxide*** are produced and released into the air instead.

Catalysts make use of very expensive ***Transition Metals*** like ***platinum***

Homogeneous & Heterogeneous

In the example above, the platinum coated honeycomb in the catalytic chamber is **solid**, whereas all the reactants are **gases**.

Hetero - different



A catalyst that is in a ***different state*** from the ***reactants*** is described as ***heterogeneous***.

Another example is using **solid** *platinum wire* in the *oxidation of ammonia* **gas** or adding **solid** *manganese dioxide* to *hydrogen peroxide* **solution**.

Homo - same

A catalyst that is in the ***same state*** as the ***reactants*** is described as ***homogeneous***.

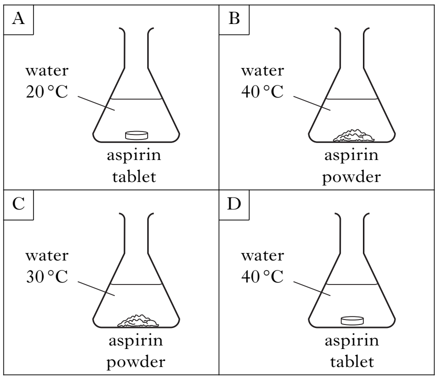
Examples include adding *cobalt (II)* **solution** to a mixture of *rochelle salt / hydrogen peroxide* **solutions**

and

salivary amylase **solution** added to *starch* **solution**.

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

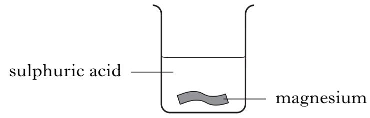
(*b*) Identify the **two** experiments which should be compared to show the effect of particle size on the speed of dissolving.

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.

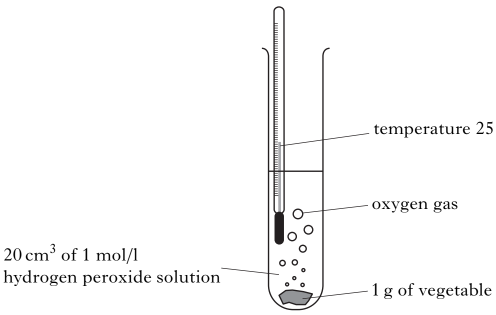
____

____

Q3. SG

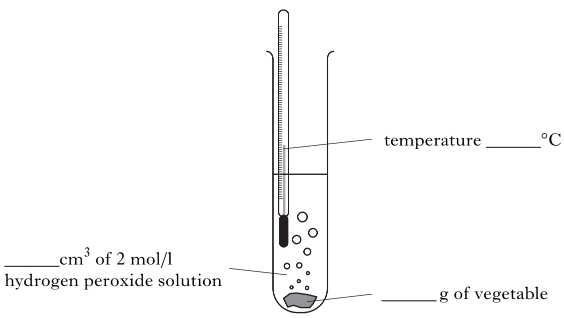
A student investigated the amount of the biological catalyst, catalase, in different vegetables.

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.

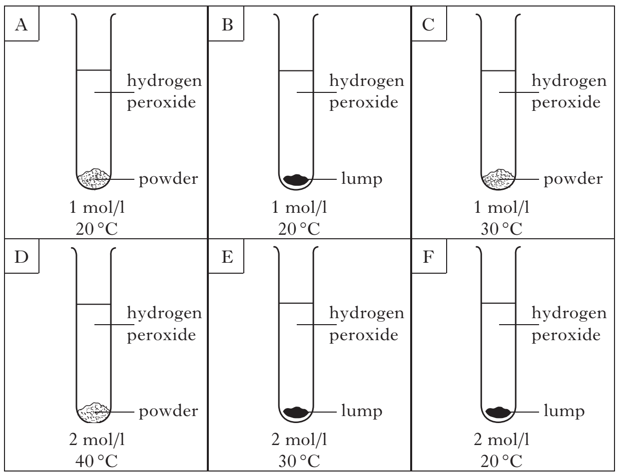


Q4. SG

A catalyst speeds up the following reaction:

hydrogen peroxide ⟶ 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.

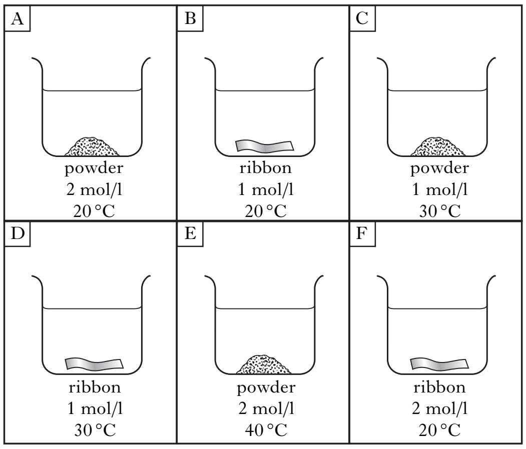
A	B	C
D	E	F

(*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

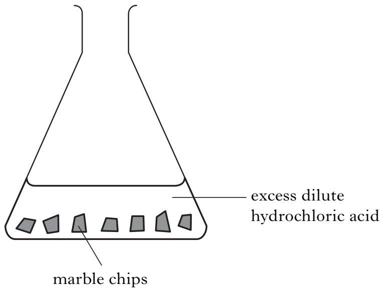
B Magnesium ribbon and 2 mol l^{-1} acid

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

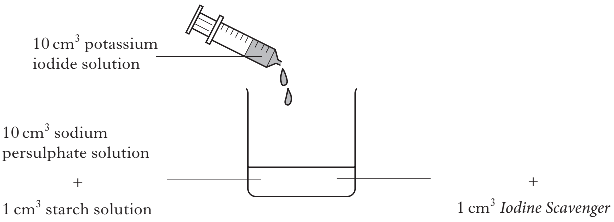
B Decreasing the size of the marble chips

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 rate of reaction determined?

____

____

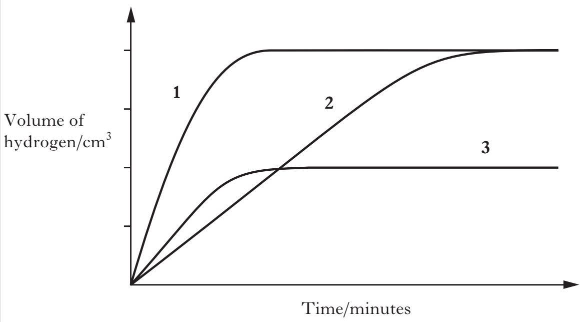
(*c*) Apart from using a timer, what allowed the accurate measurement of reaction times?

____

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

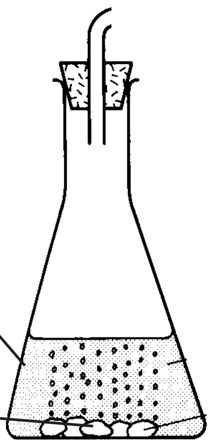
1.2 Reaction Progress

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

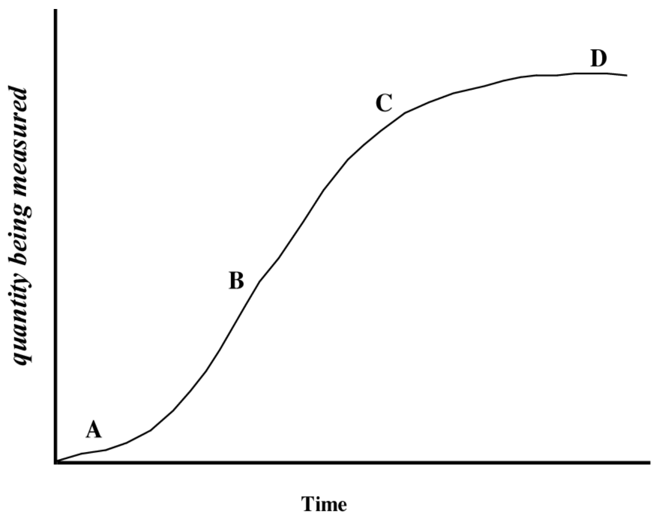
Progress of a Reaction

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

calcium carbonate	+	*hydrochloric acid*	→	*calcium chloride*	+	*water*	+	*carbon dioxide*
$CaCO_3$	+	$2HCl$	→	$CaCl_2$	+	H_2O	+	CO_2 acid



Time (s)		*Time (s)*	
0			



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

B ***steep slope*** - fast reaction rate

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

D ***level 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.

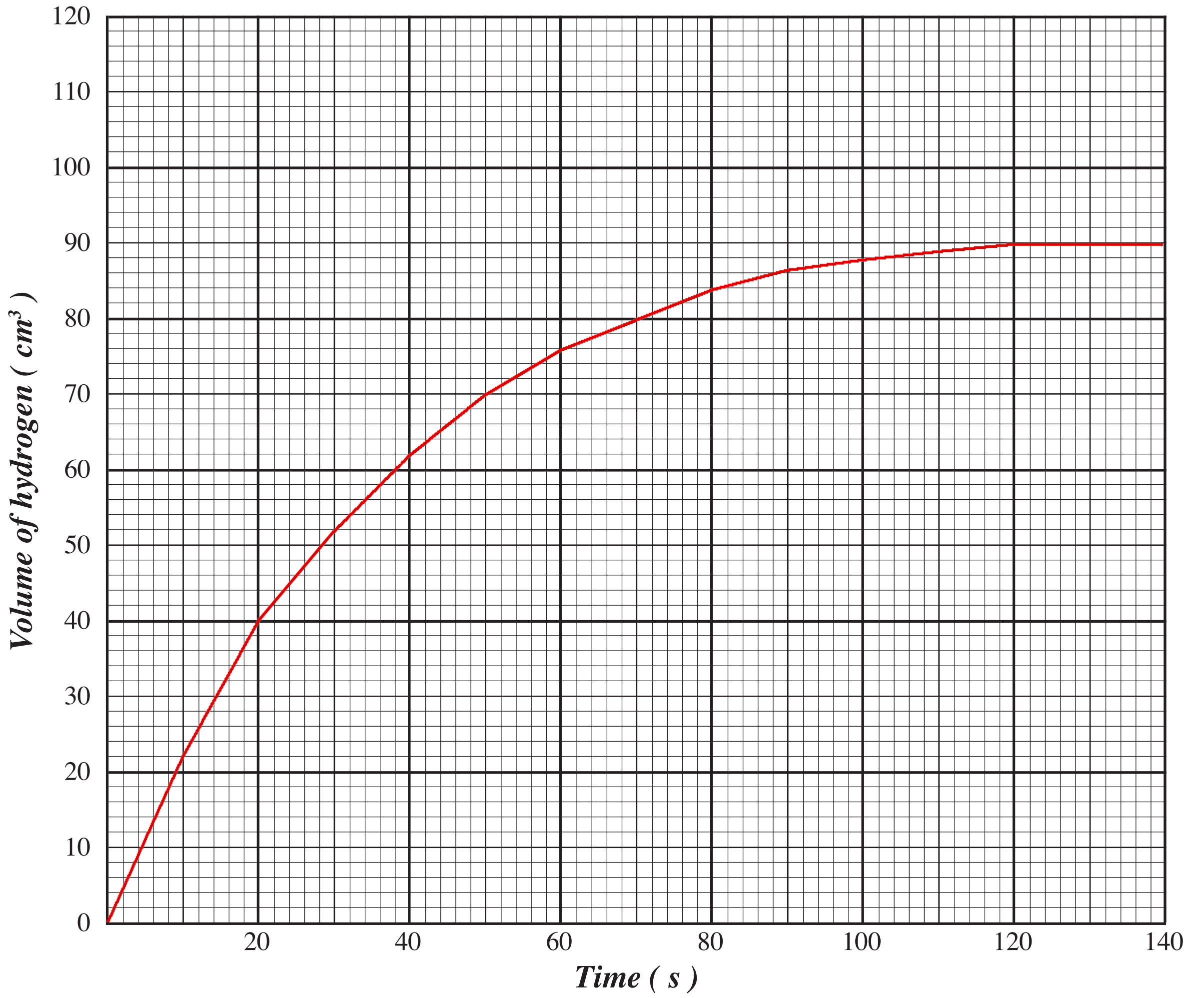
Rate of reaction *is the* ***change*** *in* ***quantity*** *of a* ***reactant*** *or* ***product*** *per unit of* ***time****.*

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

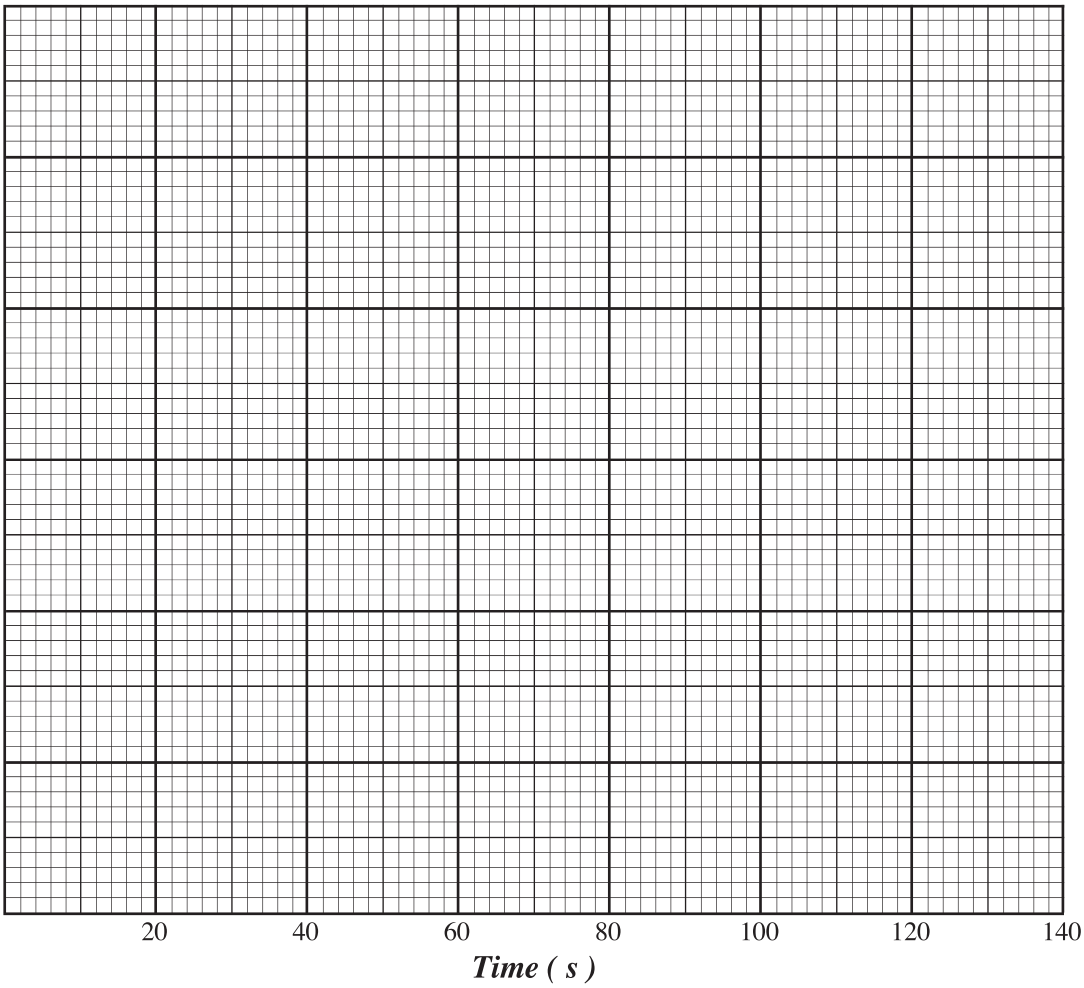
The ***unit*** used for ***rate*** depends on the ***quantity*** of the ***reactant***/***product*** that is being measured, and the ***time scale*** for the reaction.

e.g	***weight loss***	(electrical balance)	***grammes***	g/s , g/min, g/hour
	gas volume	(syringe)	ml or cm^3	cm^3/s etc.
	concentration	(colourimeter)	moles/litre	moles/l/s etc.

The reaction between ***sulphuric acid*** and ***magnesium*** produces ***hydrogen*** gas. The progress of the reaction can be monitored by ***measuring*** the ***volume*** of gas produced. The ***Progress Graph***, below, can be used to ***calculate*** 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		

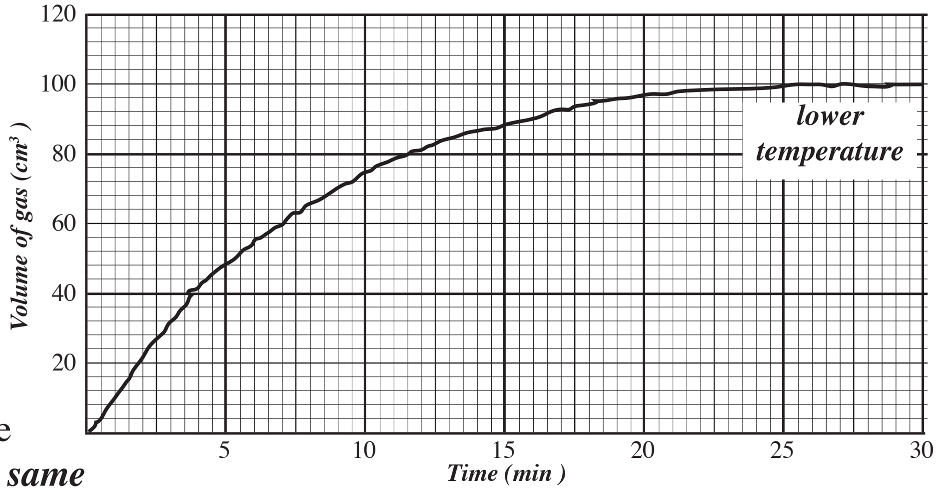


The rate will be at a ***maximum*** near the ***beginning*** of the reaction, (when the ***concentrations*** of the ***reactants*** are at their ***highest*** level), will usually ***drop*** quite steadily (as the ***reactant*** concentrations ***decrease***) and will eventually reach ***zero*** (once 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 graph

Ex 1- Higher Temperature



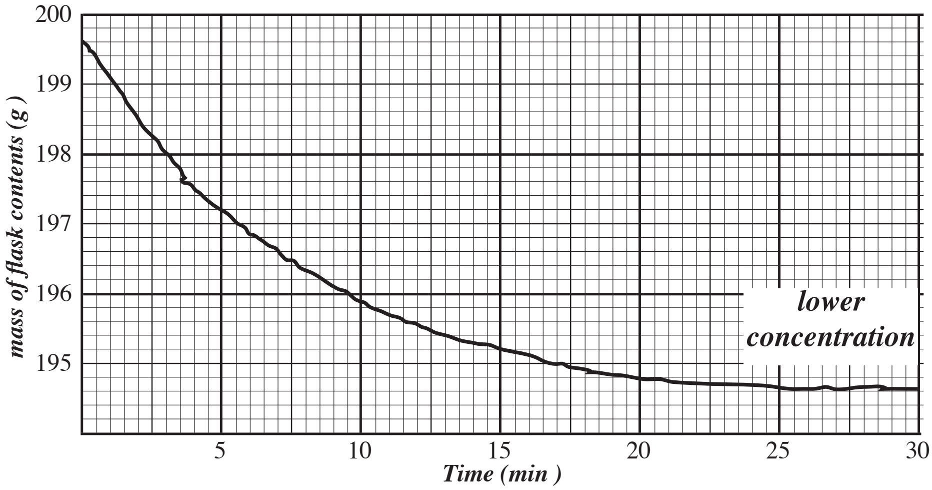
The *faster reaction* will produce ***more gas*** over the ***same time*** interval:- the slope will be ***steeper***.

The *faster reaction* will ***finish first***.

Both reactions have used the ***same mass*** of *zinc*, with the ***same particle size***, with the ***same volume*** and ***concentration*** of *hydrochloric acid*. The ***final volumes*** of *hydrogen gas* will, therefore, be the ***same*** .

The *faster reaction* was at the ***higher temperature***

Ex 2 - Higher Concentration

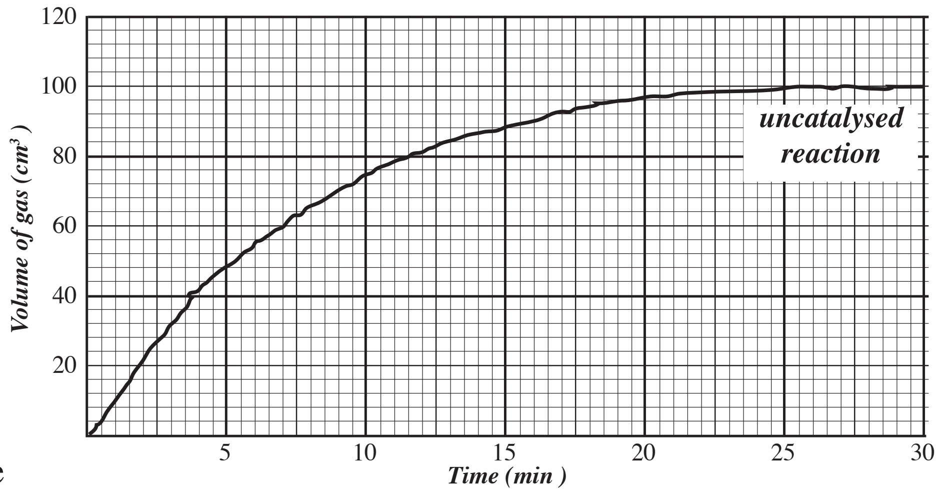


The *faster reaction* will lose ***more mass*** over the ***same time*** interval:- the slope will be ***steeper***.

The *faster reaction* will ***finish first***.

Both reactions have used the ***same mass*** of *marble*, with the ***same particle size***, with the ***same volume*** of *hydrochloric acid* at the ***same temperature***. The ***final masses*** of the *flask & contents* will, therefore, be the ***same*** . The *faster reaction* was at a ***higher concentration***

Ex 3 - Catalysed Reaction



The *catalysed reaction* will be the ***faster reaction*** and will produce ***more gas*** over the ***same time*** interval:- the slope will be ***steeper***.

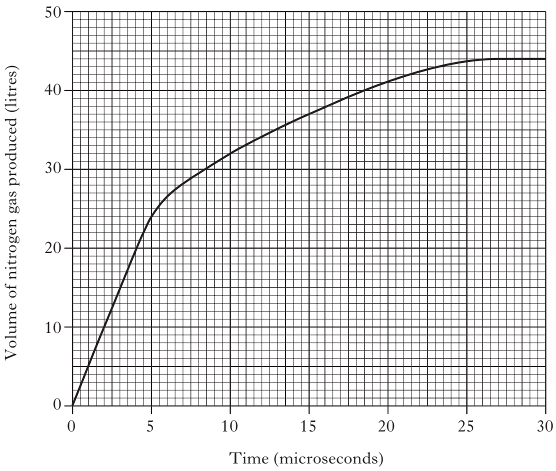
The *catalysed reaction* will ***finish first***.

Both reactions have used the ***same mass*** of *zinc*, with the ***same particle size***, with the ***same volume*** and ***concentration*** of *sulphuric acid* at the ***same temperature***, so the ***final volume of gas*** will be the ***same***.

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?

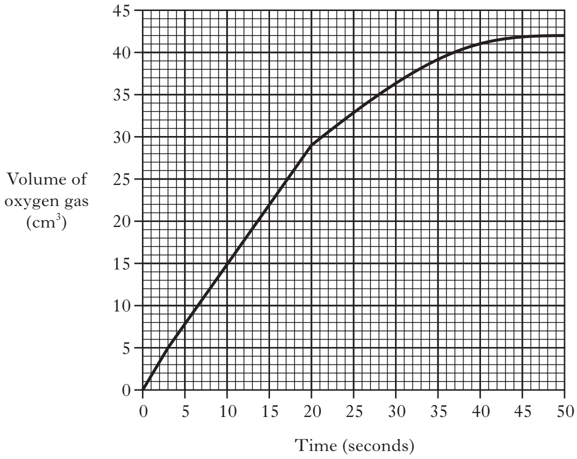
____________________ microseconds

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.



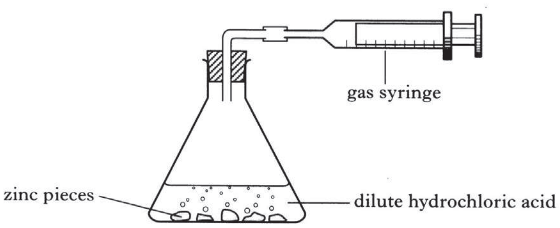
Calculate the average rate of reaction between 0 and 20 seconds.

$cm^3 s^{-1}$

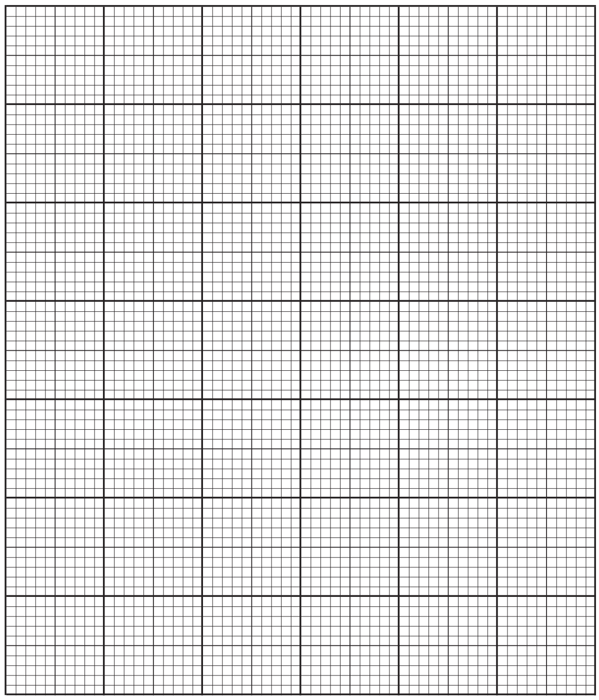
Q3. Int2

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	



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

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?

____

____

1.3 Atomic Structure

This lesson topic revises and extends your understanding of Atomic Structure.

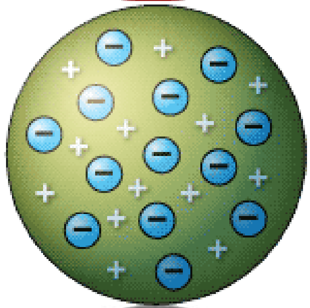
Atomic Models

Dalton Model

Early models of the atom imagined hard indestructible spheres similar to "***Snooker Balls***" colliding and bouncing off each other. This Model remains effective as part of our ***Particle Model of Matter***.

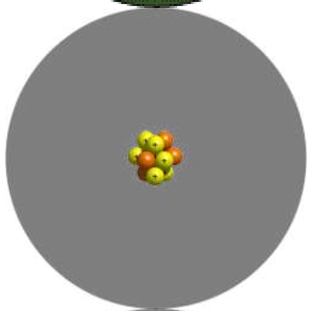
Thompson Model

Scientists such as ***JJ Thompson*** were able to show, firstly, that atoms contained very small ***negatively charged*** particles (***electrons***) and later that they also contained ***positive*** particles (***protons***). The "***Plum Pudding***" model.



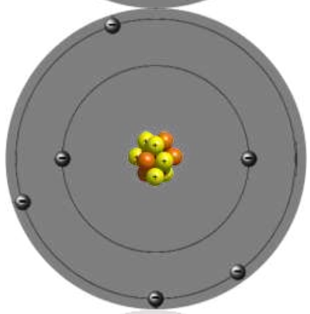
Rutherford Model

Rutherford then showed that all the ***protons*** were concentrated in a tiny ***nucleus*** in the centre of the atom. and that over 99% of an atom was ***empty space***. Finally the presence of ***neutral*** particles (***neutrons***) was proven.



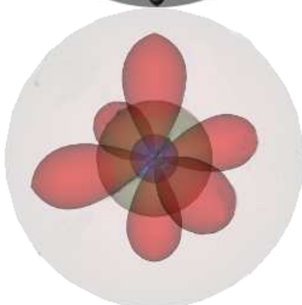
Bohr Model

Bohr put forward the theory that electrons orbited the nucleus in ***shells*** rather like planets around the sun. This is the model most often used, though we now know that electrons do not move like this.



Cloud Model

We can also imagine electrons occupying ***cloud-like regions in space*** called "***orbitals***". This model is particularly useful when trying to visualise the ***shape*** of molecules and when dealing with multiple bonds.



SUMMARY

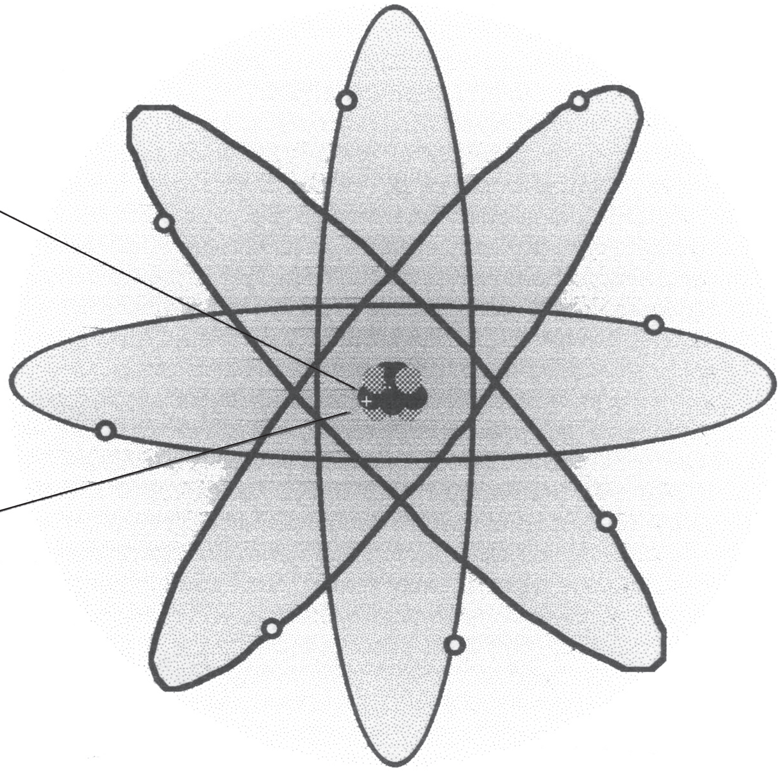
3 types of particles; ***protons*** (+ve), ***neutrons*** and ***electrons*** (–ve).

The ***protons*** and ***neutrons*** are squashed together in the ***nucleus***. The ***nucleus*** is extremely small, heavy and ***positively charged***.

The ***electrons*** 'move' around the ***nucleus*** in a complex pattern

Important Numbers

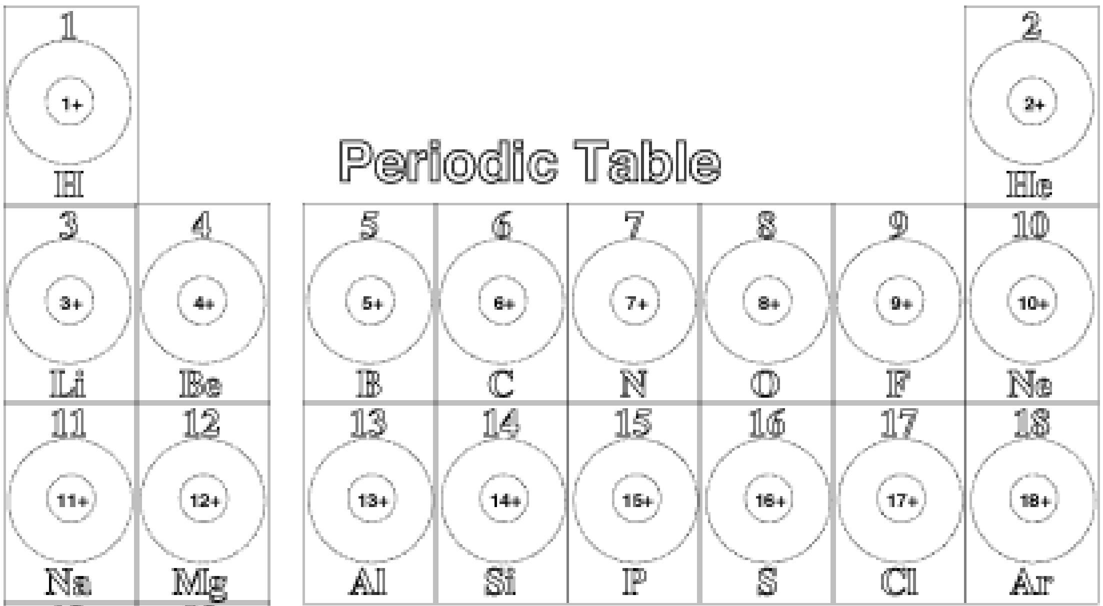
Atomic* *Number - is the number of ***protons*** in the ***nucleus*** of ***all*** atoms in an element

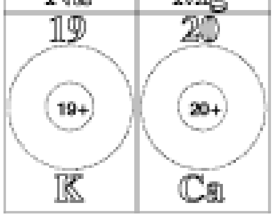


Mass* *Number - is the total number of ***protons*** and ***neutrons*** in the ***nucleus*** of ***an*** atom

Electrons - In neutral atoms the number of ***electrons*** is equal to the number of ***protons*** so we can usually use the ***Atomic Number*** to tell us the number of ***electrons*** as well.

Neutrons - The number of ***neutrons*** is simply the number of ***protons*** (***Atomic Number***) subtracted from the ***Mass Number***.





Each ***element*** has a different ***atomic number*** and they are listed in order of this number. Elements with similar ***properties*** are found in the same ***group***.

Element	Symbol	Atomic Number	Mass Number	number of protons	number of electrons	number of neutrons
Nitrogen	N	7	14	7	7	14 - 7 = 7
Oxygen	O	8	16	8	8	16 - 8 = 8
Neon	Ne	10	20	10	10	20 - 10 = 10
Sodium	Na	11	23	11	11	23 - 11 = 12
Magnesium	Mg	12	24	12	12	24 - 12 = 12
Silicon	Si	14	28	14	14	28 - 14 = 14
Phosphorus	P	15	31	15	15	31 - 15 = 16
Sulphur	S	16	32	16	16	32 - 16 = 16
Potassium	K	19	39	19	19	39 - 19 = 20
Nickel	Ni	28	59	28	28	59 - 28 = 21
Zinc	Zn	30	66	30	30	66 - 30 = 36
Silver	Ag	47	108	47	47	108 - 47 = 61
Tin	Sn	50	119	50	50	119 - 50 = 69
Platinum	Pt	78	195	78	78	195 - 78 = 117
Mercury	Hg	80	201	80	80	201 - 80 = 120

Number of protons = Atomic Number

Number of electrons = Number of protons = Atomic Number

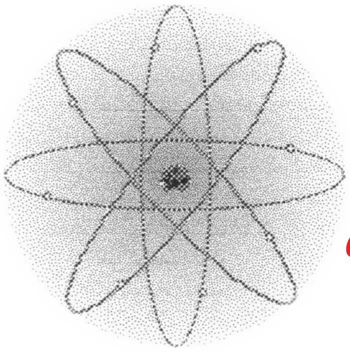
Number of neutrons = Total in nucleus - Number of protons
= Mass Number - Atomic Number

The Mass Number can only ever refer to one particular atom. However, when we want to talk generally about the mass of the atoms of an element, we can usually safely assume that the ***average mass (RAM)*** *rounded to the* ***nearest whole number*** can safely be used as the 'most likely' Mass Number for an atom of this element - but be careful, Br has ***RAM*** 79.9 so we would assume 'most likely' Mass Number = 80, but only ^{79}Br and ^{81}Br exist naturally.

Nuclide Notation

Nuclide Notation is the system which adds information about an atom to its ***Symbol***.

Name of particle	*Where found in atom*	*Relative mass*	*Charge*
proton	*in the nucleus*	**1**	+ 1
neutron	*in the nucleus*	**1**	**0**
electron	*orbiting around the nucleus*	0	**- 1**

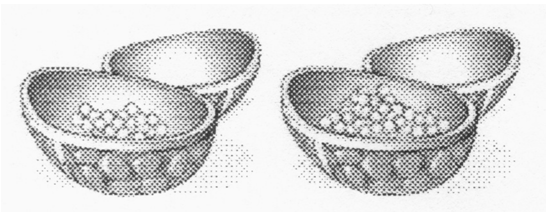


mass number ⟶ 7

atomic number ⟶ 3

$${}^{7}_{3}\mathrm{Li}$$

Isotopes



$${}^{1}_{1}\mathrm{H}$$

Ordinary hydrogen

$${}^{2}_{1}\mathrm{H}$$

Heavy hydrogen (deuterium)

$${}^{3}_{1}\mathrm{H}$$

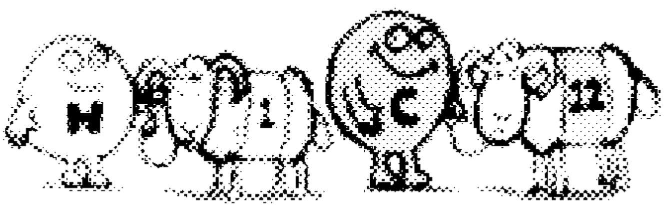
Very heavy hydrogen (tritium)

Isotopes are atoms of the ***same*** element which have the ***same*** number of ***protons*** but have ***different*** numbers of ***neutrons***.

This means that atoms of the ***same element*** can have ***different masses*** .

> ***Iso*** are atoms of the ***same at*** ***number*** but ***different m*** ***numbers*** .

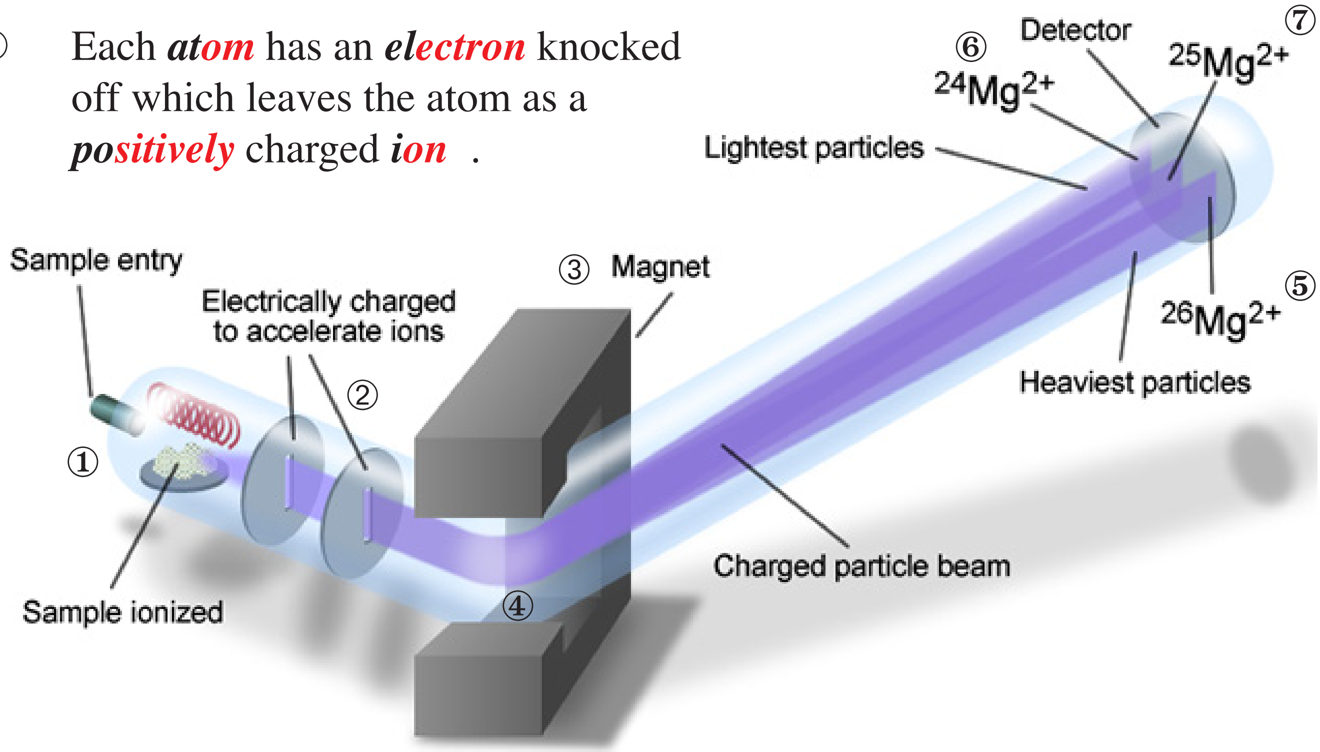
Relative Atomic Mass (RAM)



Since atoms of the ***same element*** can have ***different masses***, it is necessary to know the ***average*** mass - the ***relative atomic mass*** of an element.

Information provided by a machine called a ***mass spectrometer*** can be used to calculate the ***RAM*** of an element.

① Each ***atom*** has an ***electron*** knocked off which leaves the atom as a ***positively*** charged ***ion*** .



② The ***ions*** are ***accelerated*** by an ***electric*** field; repelled by a ***positive*** plate, attracted towards a ***negative***.

③ The strength of the ***magnetic*** field is gradually ***increased***.

④ Any ***ions*** that are of the correct ***mass*** will be deflected 'round the corner'.

⑤ Any ***ions*** which are still too ***heavy*** for the ***magnetic*** field will crash into the wall of the chamber. They will be ***detected*** later when the field is ***stronger***.

⑥⑦ Any ***ions*** which are too ***light*** will be deflected too far. They would have been ***detected*** earlier when the field was ***weaker***.

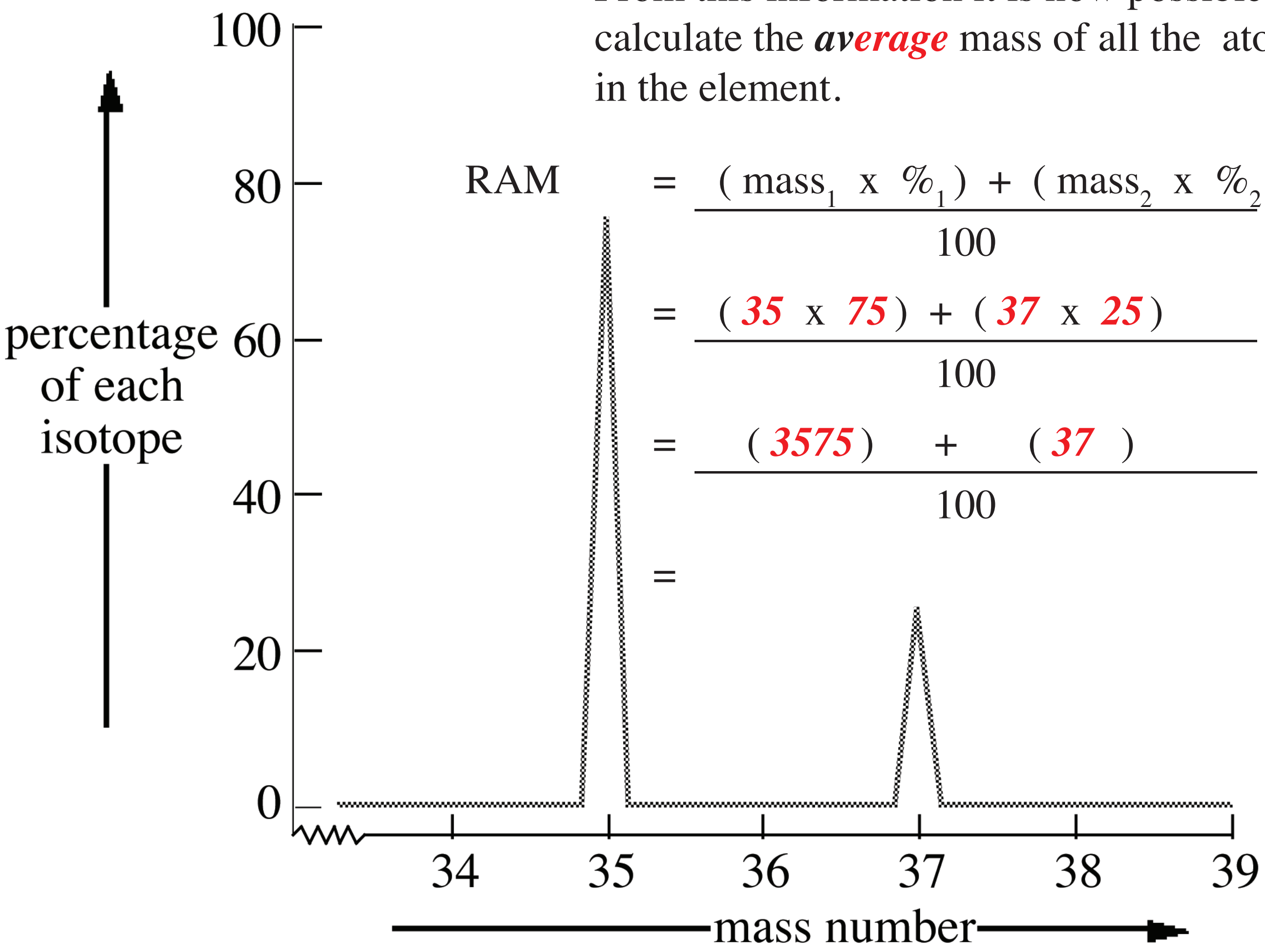
⑦ Any ***ions*** arriving here are ***detected*** and ***counted***.

The ***mass spectrometer*** is able to tell us 3 things about an element:

1. the ***number*** of ***isotopes*** that element has,
2. the ***mass number*** of each ***isotope***, and
3. the ***relative amounts*** of each ***isotope***.

The information is printed out in the form of a ***mass spectrum***.

From this information it is now possible to calculate the ***average*** mass of all the atoms in the element.



$$\text{RAM} = \frac{(\text{mass}_1 \times \%_1) + (\text{mass}_2 \times \%_2)}{100}$$

$$= \frac{(35 \times 75) + (37 \times 25)}{100}$$

$$= \frac{(3575) + (37\ \ )}{100}$$

$$=$$

Atomic No. (Z)	*Name*	*Symbol*	*% Abundance*	*RAM (Relative Atomic Mass)*
3	Lithium	^{6}Li	7.59	
		^{7}Li	92.41	
5	Boron	^{10}B	19.90	
		^{11}B	80.10	
12	Magnesium	^{24}Mg	78.99	
		^{25}Mg	10.00	
		^{26}Mg	11.01	
14	Silicon	^{28}Si	92.23	
		^{29}Si	4.68	
		^{30}Si	3.09	
24	Chromium	^{50}Cr	4.35	
		^{52}Cr	83.79	
		^{53}Cr	9.50	
		^{54}Cr	2.36	

* Some values within this table have been rounded / modified for simplicity

Isotopic Ions

It is not just the ***number of neutrons*** that can be different in atoms of the ***same element***. Atoms can also change their ***number of electrons***.

${}^{7}_{3}\text{Li}$	${}^{6}_{3}\text{Li}$	${}^{7}_{3}\text{Li}^{+}$	${}^{6}_{3}\text{Li}^{+}$
protons = ***3***	*protons* = ***3***	*protons* = ***3***	*protons* = ***3***
neutrons = ***4***	*neutrons* = ***3***	*neutrons* = ***4***	*neutrons* = ***3***
electrons = ***3***	*electrons* = ***3***	*electrons* = ***2***	*electrons* = ***2***

The ***number of protons*** never changes. This is why the ***Atomic Number*** for an element is defined as the ***number of protons***.

Element	*Symbol*	*Atomic Number*	*Mass Number*	*number of protons*	*number of neutrons*	*number of electrons*
Lithium	${}^{7}_{3}\text{Li}^{+}$	***3***	***7***	***3***	***4***	***2***
Oxygen	${}^{16}_{8}\text{O}^{2-}$	***8***	***16***	***8***	***8***	***10***
Chlorine	${}^{37}_{17}\text{Cl}^{-}$	***17***	***37***	***17***	***20***	***18***
Sodium	${}^{23}_{11}\text{Na}^{+}$	***11***	***23***	***11***	***12***	***10***
Phosphorus	${}^{31}_{15}\text{P}^{3-}$	***15***	***31***	***15***	***16***	***18***
Iron (II)	${}^{56}_{26}\text{Fe}^{2+}$	***26***	***56***	***26***	***30***	***24***
Iron (III)	${}^{58}_{26}\text{Fe}^{3+}$	***26***	***58***	***26***	***32***	***23***
Hydrogen	${}^{2}_{1}\text{H}^{+}$	***1***	***2***	***1***	***1***	***0***
Tin (II)	${}^{116}_{50}\text{Sn}^{2+}$	***50***	***116***	***50***	***66***	***48***
Tin (IV)	${}^{119}_{50}\text{Sn}^{4+}$	***50***	***119***	***50***	***69***	***46***

Q1. SC

The grid shows information about some particles.

	Number of		
Particle	*protons*	*neutrons*	*electrons*
A	**11**	**12**	**11**
B	**9**	**10**	**9**
C	**11**	**13**	**11**
D	**19**	**20**	**18**
E	**9**	**10**	**10**

a) Identify the particle which is a negative ion.

____

a) Identify the ***two*** particles which are isotopes.

_______ and _______

Q2. Int2

An atom has 26 protons, 26 electrons and 30 neutrons. The atom has.

A atomic number 26, mass number 56

B atomic number 26, mass number 52

C atomic number 30, mass number 56

D atomic number 30, mass number 82

Q3. Int2

Which line in the table describes a ***neutron***?

	Mass	*Charge*
A	1	- 1
B	negligible	0
C	1	+ 1
D	1	0

Q4. Int2

The isotopes of carbon and oxygen are given in the table.

Isotopes of carbon	${}^{12}_{6}C$	${}^{13}_{6}C$	${}^{14}_{6}C$
Isotopes of oxygen	${}^{16}_{8}O$	${}^{17}_{8}O$	${}^{18}_{8}O$

A molecule of carbon dioxide with mass 46 could contain

A one ${}^{12}C$ atom and two ${}^{16}O$ atoms

B one ${}^{14}C$ atom and two ${}^{18}O$ atoms

C one ${}^{12}C$ atom, one ${}^{16}O$ atoms and one ${}^{18}O$ atom

D one ${}^{14}C$ atom, one ${}^{16}O$ atoms and one ${}^{18}O$ atom

Q5. Int2

In the manufacture of glass, other chemicals can be added to alter the properties of the glass. The element boron can be added to glass to make oven proof dishes.

Information about an atom of boron is given below.

Particle	*Number*
proton	*5*
electron	*5*
neutron	*6*

Use this information to complete the nuclide notation for this atom of boron.

$${}^{\cdots\cdots}_{\cdots\cdots}\mathbf{B}$$

Atoms of boron exist which have the same number of protons but a different number of neutrons from that shown in the table.

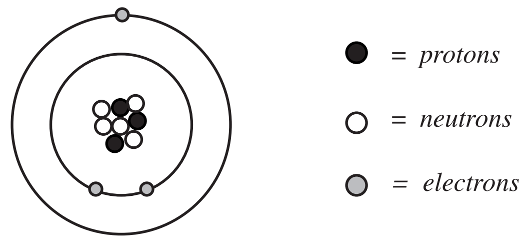
What name can be used to describe the different atoms of boron?

____

Q6. Int2

Elements are made up of atoms.

An atom of an element is represented by the diagram below.



What name is given to the part of the atom which contains protons and neutrons?

____

Using the information in the diagram:

a) state the mass of this atom;

____

b) explain why this atom is electrically neutral;

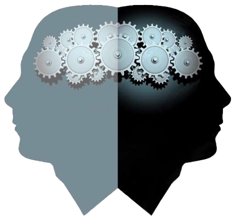
____

____

c) name the ***family*** of elements to which this atom belongs.

____

Learning Outcomes Section 1



Knowledge Met in this Section

Atoms

- Every element is made up of small particles called ***atoms***.
- Atoms of different.elements are different.
- Atoms of different elements are given a different number called the ***atomic number***.
- The atoms of different elements differ in size and mass.

Atomic structure

- All atoms have an extremely small positively charged central part called the ***nucleus***.
- Negatively charged particles, called ***electrons***, move around outside the nucleus.
- All atoms are electrically ***neutral*** because the ***positive charge*** of the nucleus is ***equal*** to the ***negative charges*** of all the electrons added together.

Protons, Neutrons, Mass numbers, etc.

- The ***nucleus*** of every atom is ***positively charged*** due to the presence of ***protons.***
- The atoms of ***different elements*** have ***different numbers of protons***
- Almost all atoms have ***neutrons***, which have ***no charge***, in their nucleus
- Protons and neutrons are much heavier than electrons.

particle	***charge***	***mass***
proton	+ 1	1
neutron	0	1
electron	— 1	0

- The number of ***protons*** in the atoms of a particular element is ***fixed***.
- The number of ***neutrons*** in the atoms of an element can ***vary***.
- Most elements are made up of more than one kind of atom.
- The ***atomic number*** of an atom is the ***number of protons*** in its nucleus.
- The ***mass number*** of an atom is the ***total number of protons and neutrons*** in its nucleus.
- ***Isotopes*** are atoms of the same element that have different numbers of neutrons. They have the ***same atomic number*** but ***different mass numbers***

- For any ***isotope***, a special symbol, using ***nuclide notation***, can be written to show its mass number and atomic number, e.g.:

mass number → 7
atomic number → 3

$$^{7}_{3}\mathrm{Li}$$

- ***Nuclide notation*** can also be used to represent ***ions*** - atoms which have ***gained*** or ***lost*** some of their ***electrons*** and become ***charged*** e.g.

$$^{37}_{17}\mathrm{Cl}^{-}$$ ← ***charge on ion*** (*1 electron* ***gained***)

$$^{25}_{12}\mathrm{Mg}^{2+}$$ ← ***charge on ion*** (*2 electrons* ***lost***)

Relative Atomic Mass (RAM)

- The relative atomic mass of an element is the ***average of the mass numbers*** of its isotopes, taking into account the ***proportions of each***.
- The relative atomic mass of an element is rarely a whole number.
- The relative atomic mass of an element can be calculated using information from a ***Mass Spectrometer***.

$$\textbf{\textit{RAM}} = \frac{(\text{mass}_1 \times \%_1) + (\text{mass}_2 \times \%_2) + \ldots}{100}$$

Measuring Reaction Rates

- Reactions can be followed by ***measuring*** changes in *concentration*, *mass* or *volume* of *reactants* or *products*.
- The ***progress of a reaction*** can be shown graphically.
- Graphs can be used to show the effect of ***changes*** in ***reaction conditions*** and ***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***.
- Where suitable, the ***time taken*** to reach a certain point in a reaction can be used to calculate the ***relative rate***, where

relative rate = 1 / time (units = s^{-1} or min^{-1})

CONSOLIDATION QUESTIONS A

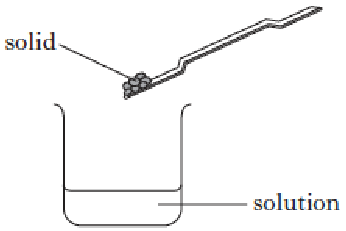
Q1. Int2

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?

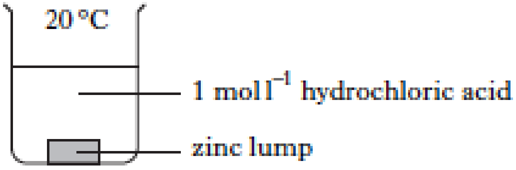
	Adding solute	Adding solvent
A	concentration falls	concentration rises
B	concentration falls	concentration falls
C	concentration rises	concentration falls
D	concentration rises	concentration rises

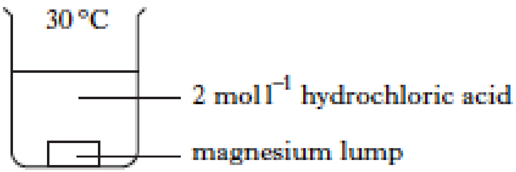
CONSOLIDATION QUESTIONS B

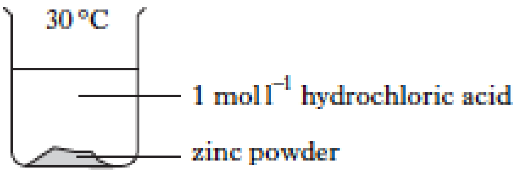
Q1. Int2

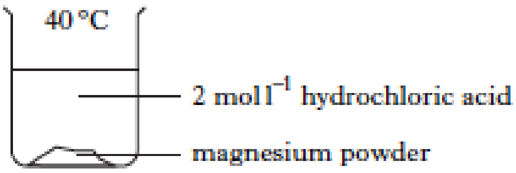
Magnesium and zinc both react with hydrochloric acid.

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

A


B


C


D


Q2. Int2

The table shows the numbers of protons, electrons and neutrons in four particles, W, X, Y and Z.

Particle	Protons	Electrons	Neutrons
W	17	17	18
X	11	11	12
Y	17	17	20
Z	18	18	18

Which pair of particles are isotopes?

A W and X

B W and Y

C X and Y

D Y and Z

Q3. Int2

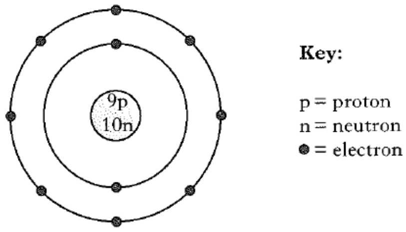
The alkali metals, the halogens and the noble gases are the names of groups of elements in the Periodic Table.

Complete the table by circling a word in each box to give correct information about each group.

(*Two pieces of correct information have already been circled.)*

Group		
alkali metals	(metals) / non-metals	reactive / non-reactive
halogens	metals / non-metals	reactive / non-reactive
noble gases	metals / non-metals	reactive / (non-reactive)

Complete the table for the particle shown below.



Atomic number	Symbol for the element	Mass number	Overall charge of the particle

Q4. Int2

Atoms and ions contain particles called protons, neutrons and electrons.

The nuclide notation of a sodium ion is shown.

$$^{24}_{11}\mathrm{Na}^{+}$$

a) What is the difference between an atom and an ion?

____

b) Complete the table to show the number of each type of particle in this sodium ion.

Particle	*Number*
electron	
proton	
neutron	

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

____

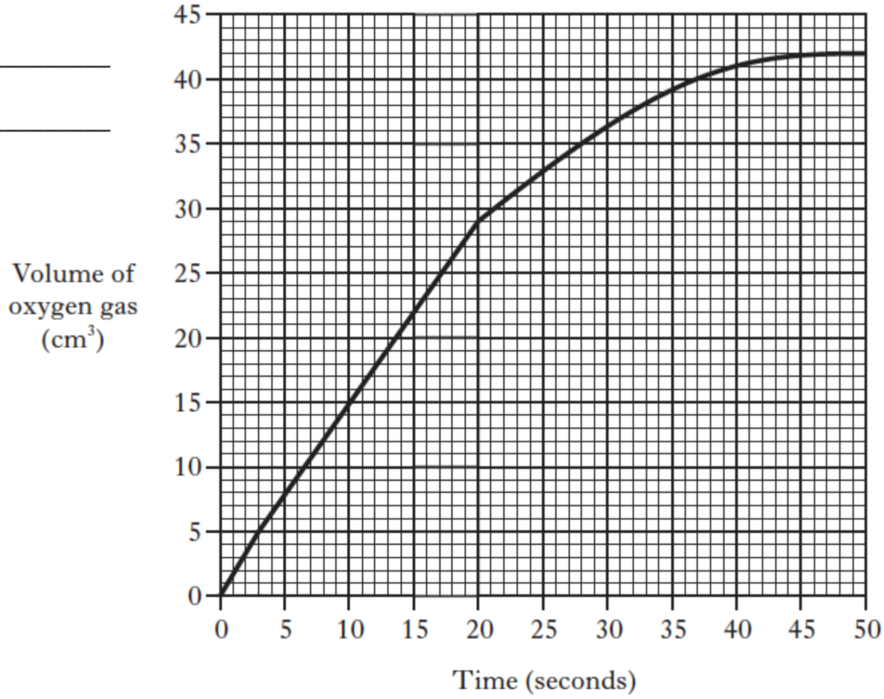
____

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

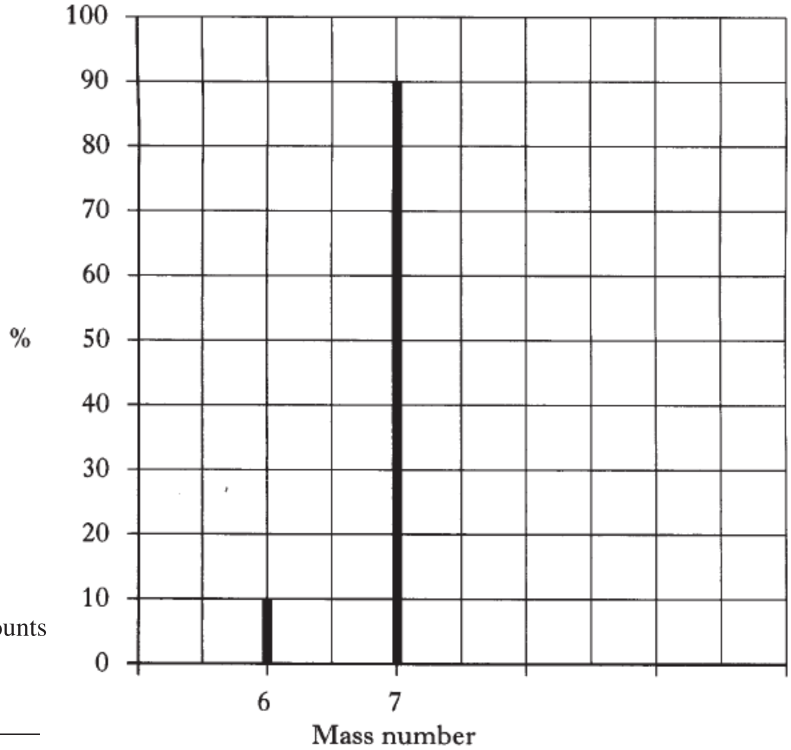
Q1. SGC

The following graph was obtained for a sample of lithium.

a) How many isotopes are present in the sample of lithium?

____

b) Using the information in the graph, calculate the relative atomic mass of lithium.



c) ***If*** the relative atomic mass of lithium was 6.5 what would that suggest about the relative amounts of the two isotopes.

____

d) ***If*** the relative atomic mass of lithium was 6.80, ***calculate*** the % abundance of each isotope.

Hint 1: let **x** = % abundance of ^{6}Li

let **y** = % abundance of ^{7}Li

Hint 2: In maths, you can solve ***two unknowns*** (x and y) if you have ***two equations*** that link x and y.