This revision workbook covers the properties of Acids and Bases

Properties include

- acids release hydrogen ions in water
- reactions (of acids with bases) to form salts
- pH and effects on indicators.

Introduction - Acids

Highlight (or circle) the acids you have met in this topic or at home.

nitric	acetic / ethanoic	citric	hydrochloric	sulfuric
HNO_3	CH_3COOH	$C_6H_8O_7$	HCl	H_2SO_4

Idea 1

- All acids release hydrogen ions H^+ in water. Another ion is formed as well.

We can write simple equations to show what happens.

Use the table of ions to name the ions released in water in each case.

Also name the acid on the left of each arrow.

HCl	→	H^+	+	Cl^-
Hydrochloric acid				

HNO_3	→	H^+	+	

H_2SO_4	→	$2H^+$	+	

Sulfuric acid has 2 hydrogen ions it can release

Idea 2

- The more H^+ ions released (the higher the concentration of H^+ ions) then the acid is said to be more acidic.
- This can be shown by using Universal Indicator.
- We use the indicator to give the acid a pH number.

Complete the table below for Universal indicator to show the colours and the matching pH numbers. Remember the indicator has a continuous merging of colours form one to the next.

1	2	3	4	5	6	7	8	9	10	11	12	13	14
red													

Idea 3

- Pure water has a pH of 7. Universal indicator will be green in pure water.
- In pure water there will be the same concentration of H^+ ions as OH^- ions.
- OH^- is the formula of the hydroxide ion.
- We say that $H_2O \rightleftharpoons H^+ + OH^-$

When the pH is 7, the concentration of hydrogen ions is the same as the concentration of the hydroxide ions. The solution is said to be NEUTRAL

If the concentration of H+ is more than the concentration of hydroxide ions then we write $[H^+] > [OH^-]$ " > " means "greater than"
If the concentration of H+ is less than the concentration of hydroxide ions we could write $[H^+] < [OH^-]$ " < " means "less than"
The [ ] brackets means "concentration". They must be square and not ( ) or { }.

So, if the solution is ACID (ACIDIC) the concentration of hydrogen ions is greater than the concentration of hydroxide ions.
If the solution is ALKALINE (BASIC) then the concentration of hydroxide ions is greater than the concentration of the hydrogen ions.

NEUTRALISATION REACTIONS

In chemistry, neutralisation is a chemical reaction in which an acid and a base react with each other. A new substance called a SALT is formed.

Acids are restricted to HCl, H_2SO_4, HNO_3 at Level 1. You need to memorise their names and chemical formulae.

Bases are classed as metal oxides, hydroxides, carbonates and hydrogen carbonates. These are bases because they can react with acids and "neutralise" them.
If a base is soluble (dissolves in water) then it is called an alkali.

In a reaction in water, neutralisation results in there being no excess of hydrogen or hydroxide ions present in the solution.

Summary Table of the reaction patterns you must learn!

ACID	+	METAL	→	SALT	+	HYDROGEN		*Not examined in this AS*	
ACID	+	BASE	→	SALT	+	WATER			
ACID	+	CARBONATE	→	SALT	+	WATER	+	CARBON DIOXIDE	
ACID	+	HYDROGEN CARBONATE	→	SALT	+	WATER	+	CARBON DIOXIDE	

Note: A base can be a hydroxide or oxide.

Revision task - classify the following compounds by placing them into the correct place in the table.

Mg MgO $MgCO_3$ $NaHCO_3$ $NaOH$ K_2O Ag_2O $Ca(OH)_2$
$CaCO_3$ $KHCO_3$ Na_2CO_3 Al Fe_2O_3 Fe CuO $Cu(OH)_2$

METAL	BASE	CARBONATE	HYDROGEN CARBONATE

Extra revision - name all the metals and the compounds in the above table!

NCEA 2018 AS90944 Question 2 - a worked example. Here is an exam question.

Solutions of potassium hydroxide, KOH, and sulfuric acid, H_2SO_4, are added together in a beaker.

This is a reaction between an acid and a base (hydroxide) so will be a neutralisation (or acid – base) reaction)

(a) Name the type of reaction occurring.
NEUTRALISATION

(b) Write the word equation and the balanced symbol equation for this reaction.

What is the word equation pattern?

Answer:

The **word equation** is based on this reaction pattern shown below.

ACID	+	BASE	→	SALT	+	WATER

Sulfuric acid + potassium hydroxide → potassium sulfate + water

Balanced symbol equation

Step 1	Write the correct formulae of the substances in the word equation; you will need to memorise the formulae of the three acids.
Step 2	Balance atoms on each side of the arrow by using whole numbers in front of chemical formulae
Answer	H_2SO_4 + 2KOH → K_2SO_4 + H_2O

K^+ ions have a +1 charge and sulfate ions have a 2- charge so the formula of potassium sulfate is K_2SO_4. This means 2 x KOH is needed to balance the equation - put a 2 in front of the KOH

You are going to have to learn the SALTS table to work out what the products will be

Salts Table

If my acid is…..	…	my salt is a….
Hydrochloric	HCl	CHLORIDE
Sulfuric	H_2SO_4	SULFATE
Nitric	HNO_3	NITRATE

(c) A solution of potassium hydroxide is placed in a beaker. Universal indicator is added to it. The solution is purple, as shown in the diagram below.
Sulfuric acid is slowly added to the beaker until no more colour changes are seen.

KOH and universal indicator before adding H_2SO_4

H_2SO_4

Explain in detail what happens to the colour of the solution while the sulfuric acid is being added to the potassium hydroxide.
Link your answer to the concentration of ions and the changing pH of the solution.

Answer Decide what you have to discuss first.

- How will the colour of the indicator change?
- How will the pH change?
- How is this linked to the concentrations of the ions present?

Plan from the start - break your thinking into stages - a summary is shown here.

At the start

Potassium hydroxide is in the beaker and it is a base so ……..

The colour is purple (we are told this) so the pH will be approximately 12 to 14.

The concentration of hydroxide ions will be much higher than the concentration of hydrogen ions.

As the acid is added

Hydrogen ions from the acid react with hydroxide ions to make water and the salt, potassium sulfate.

The colour will change from purple to blue to pale blue as the pH changes

purple = pH 14 blue = pH 10 pale blue = pH 8-9

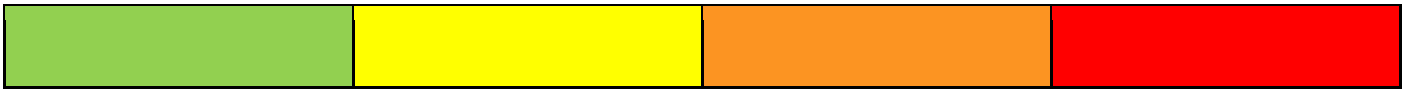
The concentration of hydroxide ions goes down as they are used up (reacted) with the hydrogen ions added from the sulfuric acid.

Because the solution is still alkaline (basic), the concentration of hydroxide ions will still be higher than the concentration of hydrogen ions.

When all of the hydroxide ions have reacted with the (added) hydrogen ions from the acid the colour of the universal indicator solution is GREEN and the pH = 7.
Now the concentration of hydroxide ions = the concentration of hydrogen ions.

If more acid is added, the universal indicator colour will now change in the following way

green = pH 7 yellow = pH 5-6 orange = pH 3-4 red = pH 1-2



If the pH is less than 7, the solution is ACIDIC and the concentration of hydroxide ions is less than the concentration of hydrogen ions, $[OH^-] < [H^+]$.

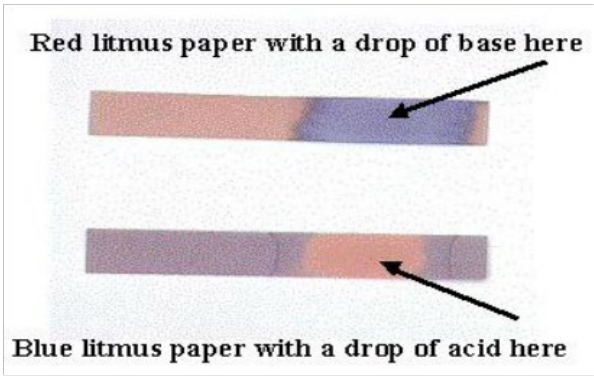
We could also say "the concentration of hydrogen ions is more than the concentration of hydroxide ions", $[H^+] > [OH^-]$.

Extra Revision Task Complete the following table to summarise the link between the pH , colour and hydroxide : hydrogen ion concentrations.
pH 7 has been done for you. You can colour in or name the colours in the table.

pH of solution	Universal indicator solution colour	Acid, neutral or alkali	Complete the statement comparing the hydrogen and hydroxide ion concentrations
1-2			
3-4			
5-6			
7	green	neutral	$[H^+] = [OH^-]$
8-9			
10-11			
12-14			

Be careful! Young players can be tricked if they are not paying attention.
Litmus indicator only has 2 colours - red and blue.
It cannot be used to measure pH values!

It can only indicate acidic and alkaline solutions (if used carefully).
Here are the possible colour combinations for using red and blue litmus



Solution	Red Litmus	Blue Litmus
Acid	stays red	turns red
Neutral	stays red	stays blue
Base (alkali)	turns blue	stays blue

Questions

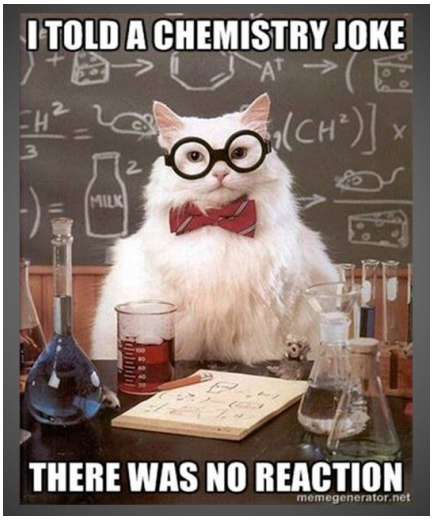
1. A student tests a solution with red litmus and it stays red. The student concludes the solution is acidic. Is the student correct? Explain your thinking. What would the student have to do to check their answer?

2. Another student uses blue litmus paper and it changes colour. The student says the solution must be an acid. Is the student correct? Explain your thinking.

3. Another student tests a solution with red and blue litmus and cannot get the paper to change colour. What conclusion should the student make about the solution?

Online Help:
pH and colour changes
YouTube Video Science Scribe

Rates of Reaction: Notes and main ideas.



What is Collision Theory?

The 3 key ideas to explain collision theory are:

1. Particles of reactants must collide
2. Particles must collide with enough energy to react
3. Particles must collide with the correct "orientation" (angle)

If a collision between particles has #2 and #3 then we say that the collision was successful. This means a reaction has taken place and a new substance (product) has been made.

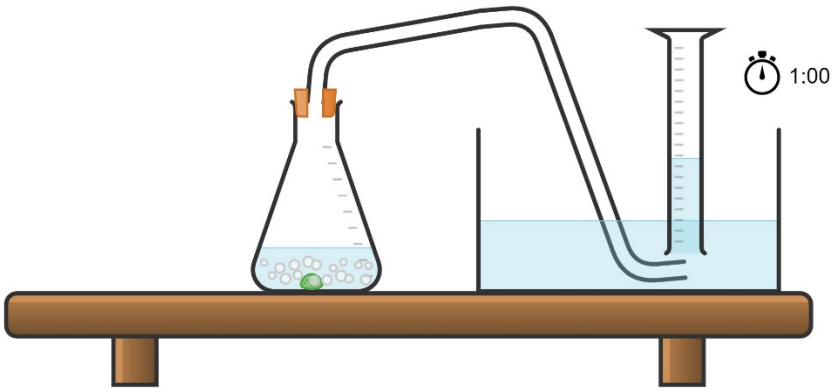
Rate of reaction

The rate of a reaction is a **measure of how much product is made divided by the time taken** for the reaction, or think of it as how much product is made in a given amount of time. Reaction rates can be high (think of explosions / burning magnesium in air) or very slow (think of milk going sour or rusting of iron on a car).

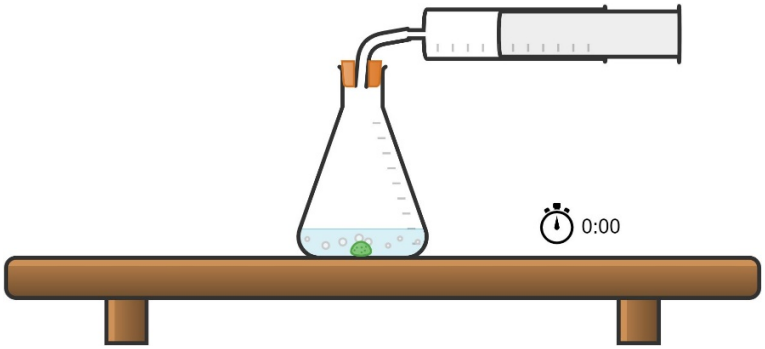
To **measure the rate of a reaction** we need to find a way to measure something that changes in the reaction and the time it takes for that change to happen.

- We could measure the change in concentration of reactants as they turn into products or we measure the change in concentration of products as time goes by.
- We could measure the amount of product by collecting it if it is a gas or measure the change in mass of a gas is lost.

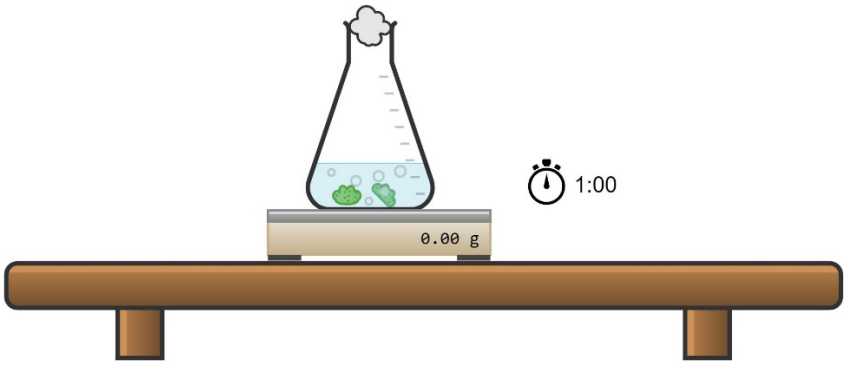
Some examples are given below.



The volume of gas collected is measured in mL and recorded as time passes. Rate: mL/s	The gas must have low solubility in water



The volume of gas collected is measured in mL and recorded as time passes. Rate: mL/s	The density of the gas does not matter.

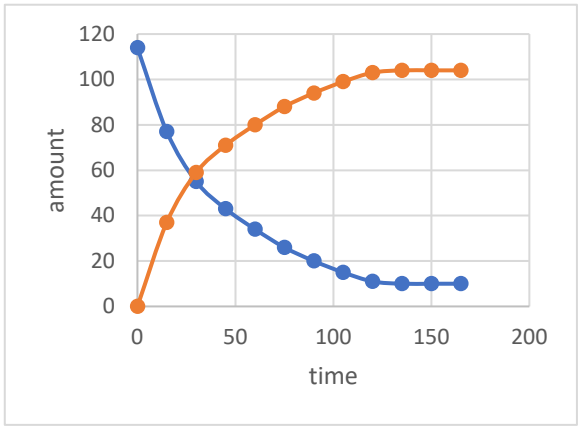


The loss in mass as the gas escapes is measured and recorded as time passes. Rate: g/s	Cotton wool allows the gas out but stops any acid splashing out

Plotting Rate of Reaction Graphs

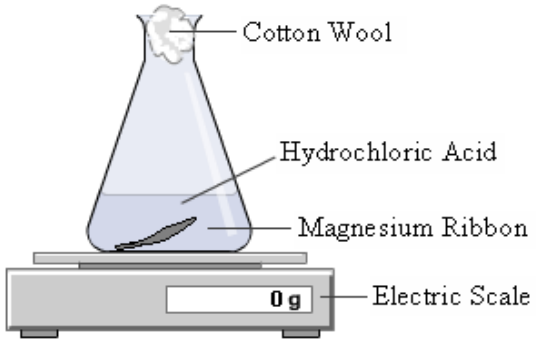
The reactant or product being measured is put on the y (to the sky) axis.
Time is put on the x (across) axis
Plots can look like this

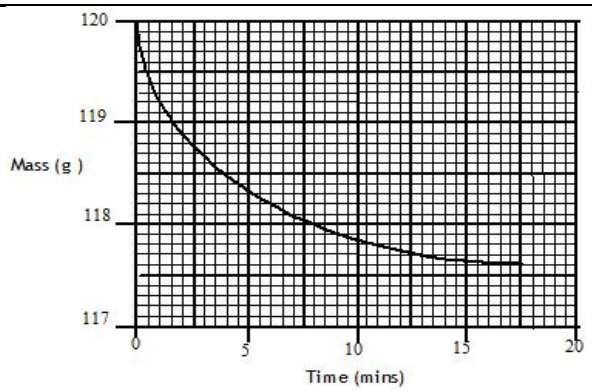
Example 1



We can see that :-
The amount of B is **increasing** with time
- **it must be a product**
The amount of A is **decreasing** with time - it must be a **reactant.**
The **steeper the slope means a higher reaction rate** (more product made in a short time).
The **graph is steeper at the start** (high reaction rate) but gets **less steep with time** (reaction rate is decreasing).
When there is **no slope to the graph** (horizontal) there is **no reaction rate - the reaction has stopped** - it has run out of a reactant.

Example 2





As time passes the product (hydrogen gas) is lost from the flask so the mass of the flask and contents gets smaller.

Hydrochloric acid particles react with magnesium metal particles to make hydrogen gas (which escapes) and magnesium chloride.

The concentration of the acid will decrease as it is used up.

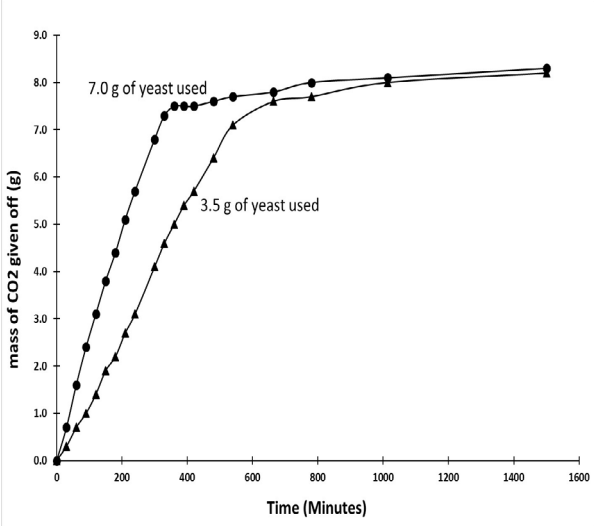
The total mass of the experiment will go down because gas is lost from the flask.

A graph of results might look like this.

- The slope is steeper at the start - the reaction rate is highest. This means a lot of gas is lost in a short space of time. (More gas lost per unit of time).
- As time passes, the slope becomes less steep. The rate of reaction is decreasing - meaning less gas is lost in each unit of time.
- When there is no slope (horizontal part of the graph) the reaction has stopped. The reaction rate is zero.
- No more product (gas) is being made. The reaction has either run out of either magnesium *or* acid.

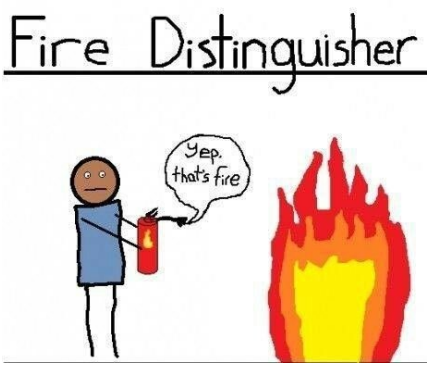
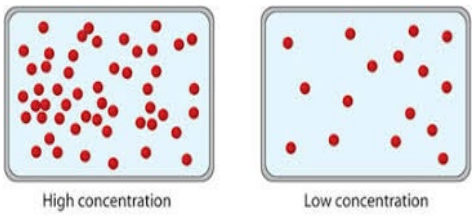
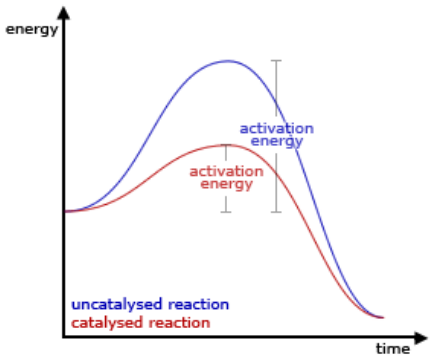
This apparatus can also be used to follow the rate of reaction between hydrochloric or nitric acid with calcium carbonate (marble chips). The gas lost would be carbon dioxide gas.

Skills task - try this question - graph interpretation.



- What 2 measurements are being made to measure the reaction rate?
- What is the product?
- Which experiment has the higher rate of reaction at the start?
- Approximately how long does it take for one of the reactants to run out? How can you tell?

There are FOUR (4) factors that can affect the rate of a chemical reaction.

Factor	Idea	Reason
Temperature (all reactions)		Heat energy gives particles **more kinetic** (movement) energy. • They **move faster** and **collide more often** (more collisions per second) • More particles have the **minimum energy needed to react (activation energy)** • So there are ***more successful collisions per second*** and the <u>reaction rate is higher</u>
Concentration (acids and any reactants in solution and gases)		• A **higher concentration has more particles in a given volume (e.g. more particles per mL)** • There will be **more collisions per second between particles** • So there are ***more successful collisions per second*** and the <u>reaction rate is higher</u>.
Surface Area (for solids)		• **Increasing the surface area** (chopping reactants into smaller pieces) **exposes more particles available to collide.** • There will be **more collisions per second between particles.** • So there are ***more successful collisions per second*** and the <u>reaction rate is higher</u>.
Catalysts (many reactions) This is more common in L2 Chemistry, but many teachers will teach it at L1 too)		• A catalyst provides a **different reaction path with a lower activation energy** • **More particles** now have the **minimum energy needed to react** • So there will be **more collisions per second between particles; With *more successful collisions per second*** and the <u>reaction rate is higher</u>.

NCEA 2018 AS90944 Question 3 - a worked example

Some magnesium carbonate powder is added to dilute nitric acid in an open conical flask. The flask is on an electronic balance, as shown in the illustration.

(a) Write the word equation AND the balanced symbol equation for the reaction between the nitric acid and magnesium carbonate.

Answer - you need to know the word equation pattern for the reaction before using table of ions to work out the formula before balancing.

Word equation pattern acid + carbonate → salt + water + carbon dioxide

Gives us

nitric acid + magnesium carbonate → magnesium nitrate + water + carbon dioxide

Balanced Equation

Either learn the formulae as you go along or work them out using the ions table

(a) Magnesium carbonate Formula **Mg^{2+} ion** and **CO_3^{2-} ion (read off ions table) -** we need 1 of each to cancel charges so formula will be **$MgCO_3$** (remember - no charges as they have been cancelled).

(b) Magnesium Nitrate Formula Magnesium is **Mg^{2+} ion,** nitrate is **NO_3^- ion** so we will need **2 x nitrate ions** to cancel out / balance the charge on the Mg^{2+} ion. Because the formula of nitrate contains NO_3^- (2 different atoms) we must put it in brackets first before using the subscript 2. So we have **$Mg(NO_3)_2$** (Remember there should be no charges in the formula - the charges cancelled out).

(c) Nitric acid formula - learn it! **HNO_3** or from table of ions H^+ requires 1 x NO_3^- ion to cancel the opposite charges so the formula is **HNO_3**

(d) Water - learn it! **H_2O**

(e) Carbon Dioxide - learn it! **CO_2**

When you have all the formula - line them up to match the word equation. Then balance by using whole numbers in front and trial and error until you have the same number of each type of atom on opposite sides of the arrow.

nitric acid + magnesium carbonate → magnesium nitrate + water + carbon dioxide

HNO_3 + $MgCO_3$ → $Mg(NO_3)_2$ + H_2O + CO_2

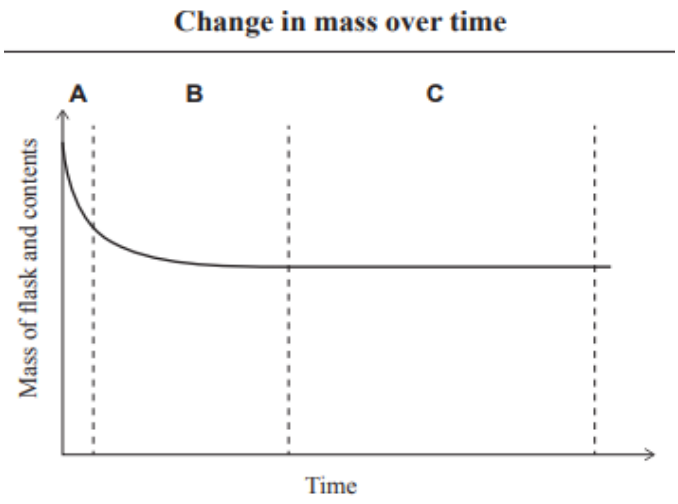
We can quickly see that we have 2 x nitrates in magnesium nitrate but only 1 nitrate in the nitric acid - to make this balance we could try putting 2 in front of the nitric acid.

$2HNO_3$ + $MgCO_3$ → $Mg(NO_3)_2$ + H_2O + CO_2

We can now check to see if we have the SAME NUMBER OF EACH ATOM TYPE ON BOTH SIDES of the →.

$2HNO_3$ + $MgCO_3$	→	$Mg(NO_3)_2$ + H_2O + CO_2
2 x H (in the $2HNO_3$) 2 x N (in the $2HNO_3$) 6 x O (2 x 3) (in the $2HNO_3$) 1 x Mg 1 x C 3 x O	→	2 x H (in the H_2O) 2 X N (in the 2 x NO_3) 6 x O (in the 2 x NO_3) 1 x Mg 1 x C 3 x O (1 in H_2O and 2 in CO_2)

The total mass of the flask and its contents is measured over time and recorded on the graph.



(b) (i) Why does the mass of the flask and its contents decrease during the reaction?

Answer

We are making a gas (carbon dioxide) which escapes from the flask. The flask will lose mass.

(ii) Explain what is happening in sections A, B, and C of the graph. Link your answer to rates of reaction and particle collisions.

Hint - use the graph to state what is happening - look at the labels and slope. Then use the particle theory to explain what is going on.

Part	What is happening?	Explanation
A	The flask is losing mass quickly as carbon dioxide is lost. The slope of the graph is steep The reaction rate is at its highest	There are more reactant particles, so more collisions per second between magnesium carbonate and nitric acid particles. (The acid concentration is at its highest so more H^+ particles per mL. Means more successful collisions per second.
B	Less product is being made, so the mass decreases less quickly. The slope of the graph is not as steep as part A - the reaction is slowing down.	There are fewer reactant particles, so fewer collisions per second between magnesium carbonate and nitric acid particles. (The acid concentration is decreasing as it is used up).
C	The reaction has stopped - no more gas is made. The flask does not lose more mass. The gradient (slope) of the graph is horizontal.	One of the reactants has been used up. There are no more collisions per s between reactant particles.

NCEA 2018 AS90944 Question 3 - a worked example

(c) Explain how increasing the temperature will make the reaction between magnesium carbonate and nitric acid faster.
Link your answer to rates of reaction and particle collisions.

(Hint - remember that increasing temperature will affect the reactant particles in 2 ways).

Answer

Increasing the temperature will:

(a) **Increase the speed (kinetic energy)** of the magnesium particles and nitric acid particles.
They will **collide more often (frequently) /** there will be **more collisions per second.**

(b) Give more particles of magnesium and nitric acid **more than the minimum (activation) energy** needed to react.
This will mean there will be **more successful collisions per second** and the **reaction will take place in less time (= higher reaction rate).**

Note - always give the reactant particles names (look at the information in the question).

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And
Rates of reaction - how to write detailed answers
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