JAMES COOK HIGH SCHOOL

ENDEAVOUR

Year 11 Lockdown Workbook

Science

This is Free

Please Take This Home to your Year 11 Child

Acids and Bases



ACIDS AND BASES

SCIENCE LEVEL 1

Strategy Guide

Acids and bases is one of the largest standards in Level One Science, with the most concepts to learn. Howeve if you aim to understand the concepts rather than rote learn them, the standard becomes a lot easier. Most of the questions will test your ability to understand the concepts, and a common mistake is that because the questions are similar between years, students try to memorise answers. A better strategy is to use this strategy guide in conjunction with our checklists, walkthrough guides and practice exams to try and get a deej understanding of the topic.

OVERVIEW OF THE STANDARD/STRUCTURE OF THE EXAM

This standard is broken into four key parts:

1. Electron configuration and ions
2. Acids and bases
3. Balancing chemical equations
4. Rates of reaction

Everything you learn will be under one of these four parts!

The exam is likely to have questions on electron configuration and ions, acids and bases, and rates of reaction - with an emphasis on balancing equations throughout!

CONCEPTS AND SKILLS TO FOCUS ON

Although every aspect of the exam is equally important, here are some key concepts to focus your study on:

How and why ions form, and why ions have a certain charge:

This comes up a lot - so it's important you understand this concept indepth. A handy way of doing this is by drawing a flow diagram, covering up certain parts of the flow diagram, and seeing if you can still explain it to yourself. Mix up which parts of the diagram you cover up, until you are confident to cover up the whole diagram and explain it from scratch.

Balancing chemical equations:

If you can nail this skill, it is an achievable excellence mark. Students either: (a) get freaked out by balancing chemical equations, or (b) underestimate the trickiness of balancing chemical equations and get untied in the actual exam. We cover how to balance chemical equations in our walkthrough guide and every past exam paper has a couple of questions you can practice with. Know this skill inside out and so you are guaranteed at least one Excellence mark. Even if you are an achieved student, an Excellence mark can make passing much easier.



© 2017 STUDY TIME

Learn how to make a salt in the lab:

Although this is a straightforward question, students haven't always covered the practical work in class (or didn't take the lesson seriously and didn't take notes - oops). We suggest you learn this - as it is another very achievable M/E mark!

COMMON MISTAKES:

From the NCEA gods themselves:

Not being to relate why ions form to the need for a completely full or empty valence shell

Using the word 'faster' rather than 'increased rate of reaction' or 'frequency of collisions':

They aren't the same thing in chemistry!

Not learning the name in the table of ions:

Lots of students can use the ions in equations but they can't link the symbols to the names of the ions. Even though the table of ions is given to you in the exam, the names of the ions aren't. This causes mix-ups between similar sounding ions like 'sulfide' and 'sulfate' -- which sound similar but refer to completely different ions.

Not seeing the link between hydroxide ion concentration and pH values:

Remember that acids produce H^+ ions in water, and the higher the concentration of H^+ ions then the lower the pH.

Not understanding ionic bonding properly:

Remember, ionic bonding is the transfer of electrons between elements to attain stable valence electron shells and an overall neutral molecule, with ions retaining charges to give electrostatic attraction. If this all seems like gibberish to you, go to pages x to y of our walkthrough guide.

- One particularly common misconception is that ions get/give back electrons when forming a compound, presumably because the compound is neutral they assume that the ions need to be neutral again.
- The NZQA markers commented that this 'seems to be linked to the use of the swap and drop method'. Ouch.

Thinking that hydroxide or hydrogen ions are simply outnumbered by the other to change pH, rather than there being any interaction:

This one is a little bit more abstract, but basically H^+ and OH^- ions don't just sit there! They actually interact with each other by forming water!

OVERALL STUDY AND EXAM STRATEGY:

A decent grade is definitely achievable for this paper with a bit of hustle and grind. The key is to not rote learn, but try to understand the concepts. Pay careful attention to the wording of your explanations, and use the NCEA exemplars and marking schedules, as well as our walkthrough guides to get that M/E-level wording.

COLLATED QUESTIONS – ACIDS, BASES AND SALTS

2019:1

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

2019:3

(a) Three unlabelled bottles containing different colourless solutions are known to be:

- hydrochloric acid, HCl
- sodium chloride, NaCl
- sodium hydroxide, NaOH.

These unlabelled solutions can be identified using red litmus paper and baking soda, $NaHCO_3$. (

(i) Complete the table

Unlabelled solution	Observation (if any)	
	with red litmus paper	with baking soda, NaHCO3
hydrochloric acid, HCl		
sodium chloride, NaCl		
sodium hydroxide, NaOH		

(ii) Explain how the observations allow you to identify each solution, giving reasons for any changes or reactions occurring.

(b) In an investigation, copper sulfate can be made by reacting solid copper carbonate with sulfuric acid, H_2SO_4.

(i) Name the type of reaction occurring.

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

(iii) Describe how you could make solid copper sulfate crystals in a school laboratory. In your answer, include how you would know the reaction had been completed.

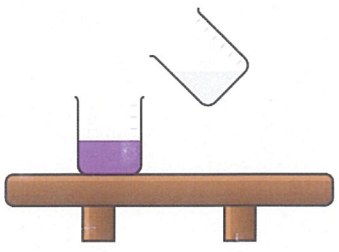
2018:2

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

(a) Name the type of reaction occurring.

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

(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.



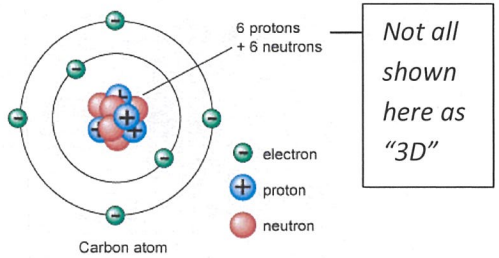
Explain in detail what happens to the colour of the solution while the sulfuric acid is being added to the potassium hydroxide. Link your answer to the concentration of ions and the changing pH of the solution.

Atomic structure

- $^{24}_{12}Mg$ – the big number (#) is mass number, the smaller # is atomic number.
- Mass number = # of protons PLUS # of neutrons
- Atomic number = # of protons
  - Protons are positive (+), neutrons are neutral, electrons are negative (-)
- Atoms are neutral overall since the # of protons (+) = # of electrons (-)

Periodic table

- Rows are periods, columns are groups
- The group # tells us how many valence (outer shell electrons) an atom has
  - Group 1 – has 1, Group 2 – have 2
  - Groups 13, 14, 15 etc have 3, 4 & 5 etc
  - Group 18 have 2 (He) & the rest have 8
- Metals (m) on the left and middle of the table, non-metals (nm) on the right
- KNOW how to draw in the "stairs" to separate metals & non-metals (H is nm too)



$^{12}_{6}C$ mass number 12, atomic number 6

6 p, 6 e & 6 n (12 - 6 = 6). Elec. configuration 2,4

Atomic particles

- The mass of the atom depends on the # of protons and neutrons in the nucleus since the electrons are very very light (about 1/2000 as heavy).
- Electrons are arranged in shells / energy levels
  - First shell can hold up to 2
  - Second shell can hold up to 8
  - Third shell can hold up to 8
- E.g. Mg (atomic # 12) has electron configuration (arrangement) of 2,8,2

ACIDS & BASES



SURVIVAL SHEET – PART 1 OF 2

Ionic compounds

Ions come together to make ionic compounds, where the overall charges cancel out / add up to zero.

e.g. magnesium oxide Mg^{2+} ion and O^{2-} ion make MgO (as 2+ and 2- = 0); Ratio of ions is 1:1

e.g. magnesium chloride Mg^{2+} ion and Cl^- ion; this one needs 2 x Cl^- ion to make $MgCl_2$ (as 2+ + 1- +1- = 0); Ratio of ions is 2 : 1

e.g. aluminium oxide Al^{3+} ion and O^{2-} ion; needs to be Al_2O_3 as (2 x 3+) + (3 x 2-) = 0

Isotopes

- Are different forms of the same element
- Are chemically identical (as they have the same electron arrangement)
- Have same atomic # but different mass #
- Have a slightly different <u>mass</u> to each other because of different numbers of neutrons in the nucleus

E.g. $^{24}_{12}Mg$ and $^{26}_{12}Mg$, $^{35}_{17}Cl$ and $^{37}_{17}Cl$

Ions

- *Some* elements form ions
- Metals lose electrons and form positive ions, non-metals gain electrons and form negative ions
- Atoms lose or gain electrons to achieve a full valence shell because this is a stable arrangement.

E.g. Mg (2,8,2) will lose 2 electrons and become Mg^{2+}, Cl (2,8,7) will gain 1 electron to become Cl^-.

Ionic formulae (and brackets)

- Brackets are needed when a polyatomic ion is used *more than once*.
  - NH_4^+ ammonium OH^- hydroxide
    HCO_3^- hydrogen carbonate NO_3^- nitrate
    SO_4^{2-} sulfate CO_3^{2-} carbonate
- E.g. Cu^{2+} & OH^- makes the formula $Cu(OH)_2$ but Cu^{2+} & CO_3^{2-} is just $CuCO_3$
- E.g.iron (III) hydroxide is $Fe(OH)_3$

You get given a table of ions but need to learn their names

Balanced chemical equations

# of atoms on left (reactants) of the → must equal # of atoms on right (products)

1. Write the correct formulas (use table of ions)
2. Balance by adding numbers in front of formula – you can't change a formula!
3. Sometimes it won't need balancing at all

$Mg + 2HCl \rightarrow MgCl_2 + H_2$ ✓

$Mg + HCl_2 \rightarrow MgCl_2 + H$ × (not HCl_2 or just H)

$CuCO_3 + H_2SO_4 \rightarrow CuSO_4 + H_2O + CO_2$ ✓

General equations – memorise these

Acid + metal → salt + hydrogen

Acid + base→ salt + water

Acid + carbonate → salt + water + carbon dioxide

<u>Acids – memorise these</u>

HCl – hydrochloric acid – forms salts called chlorides

HNO_3 – nitric acid – forms salts called nitrates

H_2SO_4 – sulfuric acid – forms salts called sulfates

Rates of reaction

Rate is an amount / time. E.g. mL of gas produced per second.

Collision theory

To react, particles must

- colllide with sufficient energy & the correct orientation
- a collision that leads to a reaction is called a sucessful collision

Bases and carbonates

- Bases are metal oxides e.g. CuO and metal hydroxides e.g. NaOH
- Carbonates & hydrogen carbonates contain the CO_3^{2-} & HCO_3^- ion e.g. Na_2CO_3 & $NaHCO_3$
- Bases and carbonates will neutralise acids.
- When a carbonate or hydrogen carbonate reacts with an acid the VISIBLE SIGN of the reaction is bubbles of a colourless gas; the gas is CO_2. It will turn limewater milky/cloudy.

ACIDS & BASES



SURVIVAL SHEET – PART 2 OF 2

Concentration

Increasing the concentration of a solution e.g. acid means more particles / volume

So there will be <u>*more frequent*</u> collisions between particles of acid and a solid, e.g. Mg

So the rate of reaction will increase

Surface area

Increasing the surface area of a solid e.g. Mg, means more Mg particles are exposed for reaction

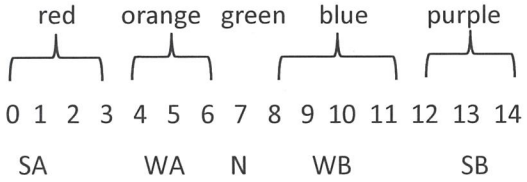
So there will be <u>*more frequent*</u> collisions between particles of acid and Mg

So the rate of reaction will increase

The pH scale (0-14) & indicators

pH < 7 = acid, pH = 7 neutral, pH> 7 alkaline/basic

Universal indicator colours



Red litmus stays red in acid, turns blue in alkali

Blue litmus turns red in acid, stays blue in alkali

The rate of a reaction can be increased by

- Increasing the concentration of a solution
- Increasing the surface area of a solid
- Heating
- Adding a catalyst

Catalyst

Lowers the energy needed for a reaction to occur so more particles have enough energy to react. <u>*More of the collisions will be successful collisions*</u>. So the rate of reaction will increase.

Temperature

Increasing the temperature of a solution e.g. acid means the particles have more E_K (move faster.)

So there will be <u>*more frequent collisions*</u> or <u>more collisions /s</u> between particles of acid and a solid, e.g. Mg

Also the collisions will have more energy so <u>*more of the collisions will be successful collisions*</u> (lead to a reaction)

So the rate of reaction will increase

AVOID "forceful" and avoid "chance / likelihood"

2017:1

(d) Write a word equation AND a balanced symbol equation for the reaction between sodium hydrogen carbonate ($NaHCO_3$) and sulfuric acid (H_2SO_4).

2017:2

(b) Three unlabelled colourless solutions are known to be:

- nitric acid (HNO_3)
- sodium chloride (NaCl)
- sodium hydrogen carbonate ($NaHCO_3$).

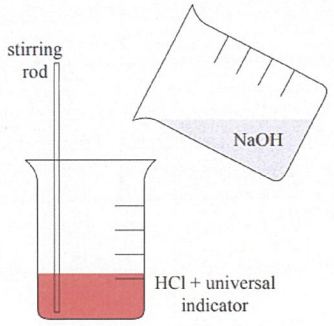
How could each of these unlabelled solutions be identified using only potassium carbonate (K_2CO_3) solution, and red litmus paper? In your answer you should:

- complete the table
- explain how the observations allow you to identify each solution
- include balanced symbol equation(s) for any reactions.

Unlabelled solution	Observation (if any) with red litmus paper	Observation (if any) with potassium carbonate (K_2CO_3)
Nitric acid (HNO_3)		
Sodium chloride (NaCl)		
Sodium hydrogen carbonate ($NaHCO_3$)		

2017:3

(b) A solution of sodium hydroxide (NaOH) is slowly stirred into a beaker of hydrochloric acid (HCl) with universal indicator added. The HCl and universal indicator solution starts out red.



Explain the changes in the colour of the universal indicator as the sodium hydroxide solution is slowly added until no further colour changes occur. In your answer, you should:

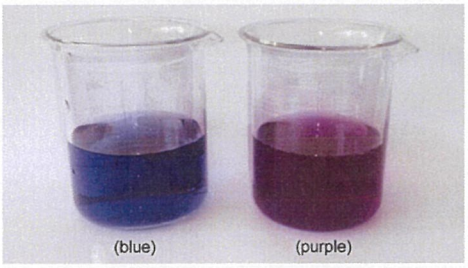
- relate the changes in the colour of the universal indicator to the approximate pH of the solution
- link the pH to the relative concentrations of hydrogen ions and hydroxide ions in solution
- explain the neutralisation reaction occurring.

2016:1

(d) Write a word equation AND a balanced symbol equation for the reaction between sodium hydroxide and sulfuric acid.

2016:3

A student added universal indicator to the solutions in two beakers as shown below.



Beaker 1
Potassium carbonate

Beaker 2
Potassium hydroxide

(a) Explain why the solutions are different colours.

The student then adds hydrochloric acid to each of the beakers until there are no more changes in colour.

(b) Write a word equation AND a balanced symbol equation for the reaction between hydrochloric acid and potassium carbonate in Beaker 1.

(c) Explain what will happen to the indicator colour in Beaker 2 (potassium hydroxide) as the hydrochloric acid is added. Relate this to the changing pH, the ions present in the beaker, and the type of reaction occurring.

2015:1

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

2015:3

The chemical equation below represents the reaction between hydrochloric acid and sodium hydroxide:

$$HCl + NaOH \rightarrow NaCl + H_2O$$

(a) Complete the table below to show the approximate pH for each of the three solutions.

	Colour when UI is added	pH
HCl	red	
NaOH	purple	
H_2O	green	

(b) Water is formed in the reaction above. Explain what ions form water in this reaction, and where they come from. *You may use an equation but this is not required.*

(c) NaOH is gradually added to a solution of HCl with universal indicator present, until no further colour change occurs. Discuss what is occurring in the beaker at each of the pH's shown, as the NaOH is added. In your answer you should refer to:

- the colours that would occur at each pH
- the relative amounts of hydrogen and hydroxide present at each of the pH's shown.

pH = 1 (before any NaOH is added):
pH = 4:
pH = 7:
pH = 10:
pH = 13:

(d) In a different chemical reaction, hydrochloric acid reacts with magnesium hydroxide. Write a word equation and a balanced chemical equation for this reaction.

2014:1 BALLOONS

(c) Write a word equation AND a balanced symbol equation for the reaction between calcium carbonate and hydrochloric acid.

2014:3 INDICATORS AND pH

A student has three unlabelled beakers each containing a colourless liquid. One contains **water**, one contains a solution of baking soda (**sodium hydrogen carbonate**), and one contains white vinegar (a solution of **ethanoic acid**).

To work out which liquid is which, the student put a drop from each beaker onto a piece of blue litmus paper and a piece of red litmus paper. She then added universal indicator to each beaker.

The following results were obtained:

	Colour of blue litmus paper	Colour of red litmus paper	Colour with universal indicator	Name of liquid
Beaker 1	stays blue	stays red	turns green	
Beaker 2	turns red	stays red	turns orange	
Beaker 3	stays blue	turns blue	turns blue	

(a) Complete the last column of the table above to identify the three liquids.

(b) Use the information in the table to show how each of the liquids can be identified.

In your answer you should:

- use all of the observations for each beaker
- state the approximate pH from the colour of the universal indicator.

(c) Another student was given two beakers (Beaker 4 and Beaker 5) each containing different liquids. The liquid in Beaker 4 had a pH of 1. The liquid in Beaker 5 had a pH of 6. Discuss which liquid is more acidic and how you know this.

In your answer you should:

- use the pH to determine which liquid is more acidic
- compare the amount of hydrogen ions AND hydroxide ions in Beaker 4 (pH 1) with the amount of hydrogen ions AND hydroxide ions in Beaker 5 (pH 6).

2014:4 ADDING SULFURIC ACID TO SODIUM HYDROXIDE

A beaker contains sodium hydroxide solution and 5 drops of universal indicator.

Sulfuric acid was added to the beaker until no more changes were observed.

(a) Write a word equation AND a balanced symbol equation for the reaction between sulfuric acid and sodium hydroxide.

(b) Describe how the indicator colour changes as the sulfuric acid is added to the beaker, AND explain what this tells you about the changing pH of this solution.

(c) Explain the relationship between the changing **pH** of the solution and the **ions** in the solution as the sulfuric acid is added to the beaker.

2013:2 ACIDS AND BASES

Potassium hydroxide (KOH) was added to a solution of sulfuric acid containing universal indicator until no further change was observed.
The experiment was repeated, but a piece of red litmus paper and a piece of blue litmus paper were each dipped into the solution after each 5 mL of potassium hydroxide was added.
The results of the experiments are shown in the table below.

Volume of KOH added (mL)	Colour of solution with universal indicator	Colour of red litmus paper	Colour of blue litmus paper
0	red	stays red	turns red
5	orange-yellow	stays red	turns red
10	green	stays red	stays blue
15	blue	turns blue	stays blue
20	purple	turns blue	stays blue

(a) Write a word equation AND a balanced symbol equation for the reaction between sulfuric acid and potassium hydroxide.
(b) Discuss what happened in this reaction as the potassium hydroxide was added to the sulfuric acid.
In your answer you should:
- relate the colours of the solution observed to the acidity and pH of the solution
- explain why the different colours of the solution were produced AND link these colours to the ions present during the reaction.
- explain the advantages of using universal indicator compared to litmus paper.

2013:4 INVESTIGATING REACTIONS

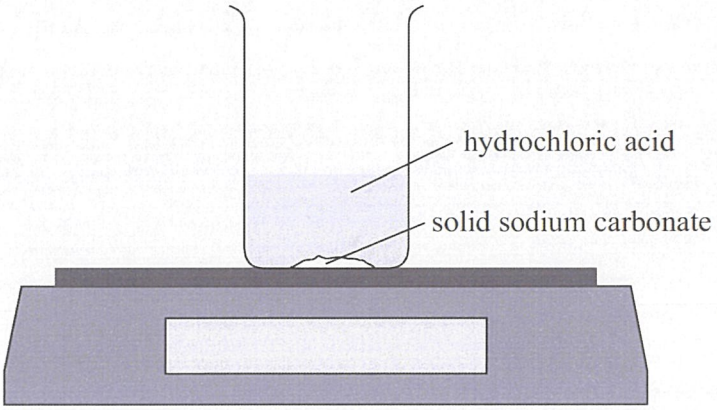
Experiment One
A student carried out an experiment in the lab using the following method:
Step one: Universal indicator was added to a solution of hydrochloric acid in a beaker.
Step two: Calcium hydroxide was added slowly until the solution turned green.
Step three: The contents of the beaker were then poured into an evaporating dish and left in a sunny place for several days.
(a) Write a scientific aim for this experiment.
(b) Explain the purpose of each step in the method and how the equipment and chemicals used achieve that purpose.
Step one
- Purpose:
- Explanation:

Step two
- Purpose:
- Explanation:

Step three
- Purpose:
- Explanation:

Experiment Two
In another experiment the following method was used:
Step one: A beaker was placed on a balance as shown in the diagram below.

Step two: Hydrochloric acid was added to solid sodium carbonate in the beaker.
Step three: The mass was recorded over time.



(c) Write a word equation AND a balanced symbol equation for the reaction between hydrochloric acid and sodium carbonate.

(d) Explain why the mass of the beaker and contents would decrease over time.
In your answer you should:
- state any other observations that would be made as hydrochloric acid reacts with the sodium carbonate
- explain how the products formed by the reaction lead to the decrease in mass of the beaker and contents. Fizzing would be observed.

2012: TWO SALTS

A student wanted to make the neutral salt, sodium nitrate.

(a) Explain how to make sodium nitrate by mixing sodium carbonate and nitric acid solutions using school laboratory equipment (your explanation may use notes and diagrams).

(b) Explain how litmus paper could be used during the process described to show the salt being produced is **neutral**.

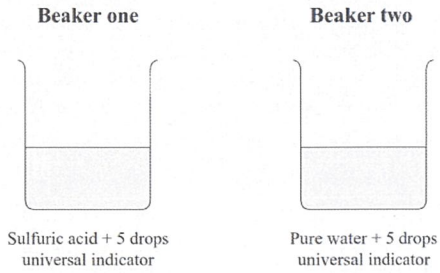
(c) Write a word equation AND a balanced symbol equation for the reaction between sodium carbonate and nitric acid.

2012:3 ACIDS AND BASES

Two beakers are shown below. Beaker one contains sulfuric acid solution and 5 drops of universal indicator.

Beaker two contains pure water and 5 drops of universal indicator.

Sodium hydroxide solution was added to both beakers until no more changes were observed.



(a) Write a word equation AND a balanced symbol equation for the reaction between sulfuric acid and sodium hydroxide.

(b) What is the colour of universal indicator in each solution at the start?

(c) Describe the colour changes as sodium hydroxide solution is added to each beaker, AND explain what this tells you about the changing pH of each solution.

(d) Explain the relationship between the pH of the solutions and the ions in the solutions, as the sodium hydroxide is added to each of the beakers.

2011:3 MAKING A SALT

A student wanted to make the salt, magnesium chloride.
Discuss how the student would make magnesium chloride salt from hydrochloric acid and magnesium oxide.
In your answer you should:

- state what type of reaction occurs
- write a word equation AND a balanced symbol equation for the reaction between hydrochloric acid and magnesium oxide
- explain how you would make magnesium chloride in a school lab from hydrochloric acid and solid magnesium oxide (this can be done by drawing labelled diagrams).
    - Type of reaction:
    - Word equation:
    - Balanced symbol equation
    - Diagrams

2011:4 pH AND INDICATORS

A student put 10 mL of dilute nitric acid in a boiling tube with five drops of universal indicator. Sodium hydroxide of the same concentration was then added. The following observations were recorded.

Amount of sodium hydroxide added (mL)	Colour of solution
0	red
10	green
20	purple

Discuss the reaction occurring as sodium hydroxide is added to the nitric acid.
In your answer you should:

- explain the relationship between the colours observed and the pH of the solution
- explain which ions cause the different colours of the solution
- write a word equation for the reaction AND a balanced symbol equation for the reaction.

2011:3 ACID AND BASE REACTIONS (SAMPLE)

A student puts 5 mL of dilute hydrochloric acid into a boiling tube and adds five drops of universal indicator to the solution. The student then takes a solution of sodium hydroxide of the same concentration as the acid and adds it one drop at a time to the acid until the colour stops changing.

(a) (i) Describe the colour of the universal indicator solution:
- in the hydrochloric acid before any sodium hydroxide was added.
- when the sodium hydroxide was added and the colour of the solution **stopped changing**.

(ii) As the sodium hydroxide is added several colour changes occur.
Explain how the colour changes relate to pH AND what ions are present in the solution colour changes.

(b) The student combines **equal** volumes of nitric acid solution and sodium carbonate solution. Both solutions have the **same concentration**.
Discuss what happens in this reaction. In your answer, you should:

- name the type of reaction involved and the ions involved
- describe what the student would observe
- state the products of the reaction and link these to the observations made
- write a word equation for the reaction
- write a balanced symbol equation for the reaction.

2009: 3 BALANCING IT UP (expired AS90189)

A student reacted zinc oxide with sulfuric acid, and wrote the following incorrect equation to represent the reaction:

$$ZnO_2 + H_2SO_4 \rightarrow 2H_2O + ZnSO_4 + H_2$$

The equation contains THREE errors.

(a) Rewrite the equation so that it is a correctly balanced chemical equation.

(b) Discuss the reasons for the three changes made to correctly balance the chemical equation.

2009: 4 BASE REACTIONS (expired AS90189)

A student carried out an experiment to neutralise sulfuric acid by adding sodium hydroxide to it.
Discuss how the student could have determined when the sulfuric acid had been neutralised and what effect adding the sodium hydroxide has on the pH of the solution.
In your answer include:

- an explanation of neutralisation in terms of an acid-base reaction
- the name of the indicator used
- observations that the student would make as the sodium hydroxide is added to the acid
- a word and balanced chemical equation for the reaction.

2010: 4 ACID AND HYDROGEN CARBONATE (expired AS90189)

A student reacted dilute sulfuric acid solution with solid sodium hydrogen carbonate.
Discuss the reasons for any observations the student would make for this reaction.
In your answer you should:

- Describe any observations the student would make for this reaction.
- Write a word equation and balanced symbol equation for the reaction of sulfuric acid with sodium hydrogen carbonate.
- Explain how the observations link to the products formed.

2008: 3 (expired AS90189)

An important part of keeping swimming pools safe is to keep the pH of the water balanced in the range 7.0 to 7.6.
Three chemicals used in pools are chlorine compounds (that react with water to produce hydrochloric acid), sodium hydrogen carbonate and aluminium sulfate.

(a) Complete the following table to show the characteristics of the solutions listed in the table below.

Solution	Estimated pH	Colour when tested with Universal indicator
Hydrochloric acid	1	(i)
Sodium hydrogen carbonate	(ii)	blue
Aluminium sulfate	5	(iii)
Water	(iv)	green

(b) The pool was tested and found to have a pH of 6.5. Sodium hydrogen carbonate was used to raise the pH of the water.
Discuss how sodium hydrogen carbonate raised the pH of the water, and include in your answer a word equation **and** a symbol equation for the reaction of sodium hydrogen carbonate with hydrochloric acid.

COLLATED QUESTIONS – ACIDS, BASES AND SALTS
ANSWERS

2019:1

(a) Nitric acid + calcium carbonate → calcium nitrate + water + carbon dioxide

$2HNO_3 + CaCO_3 \rightarrow Ca(NO_3)_2 + H_2O + CO_2$

2019:3

(a) (i)

Unlabelled solution	Observation (if any)	
	with red litmus paper	Baking Soda $NaHCO_3$
hydrochloric acid, HCl	stays red / no change	fizzes / bubbles / heat / reacts
sodium chloride, NaCl	stays red	no reaction
sodium hydroxide, NaOH	turns blue	no reaction

(ii) Only the sodium hydroxide will turn the litmus blue, since it is a base. Add baking soda to the remaining two solutions. Since hydrochloric acid is an acid, it will undergo a (neutralisation) reaction with the baking soda to produce bubbles / fizzing / heat of carbon dioxide. No changes will be observed with the sodium chloride since it is a neutral salt.

(b) (i) Acid-base reaction or neutralisation.

(ii) Sulfuric acid + copper carbonate → copper sulfate + water + carbon dioxide

$H_2SO_4 + CuCO_3 \rightarrow CuSO_4 + H2O + CO_2$

(iii) Add the solid copper carbonate to the sulfuric acid. The reaction is completed when bubbles (of carbon dioxide) are no longer produced, as the reactant (sulfuric acid) has been used up and neutralised.
Alternatively, the reaction could be followed by measuring the pH using universal indicator or probe, and the reaction would be complete at pH 7. Leave the resultant solution in a warm place / heat until water has evaporated to leave copper sulfate behind.

2018:2

(a) Neutralisation reaction / acid-base.

(b) (b) potassium hydroxide + sulfuric acid → potassium sulfate + water

$2KOH + H_2SO_4 \rightarrow K_2SO_4 + 2H_2O$

(c) *In discussion accept H^+ or H_3O^+.* As the H_2SO_4 is added, the KOH is being neutralised until water is formed. When no H_2SO_4 is added, the solution is purple and has pH 13–14 because there is an excess of OH^- ions. While the H_2SO_4 is being added, the solution becomes blue with a pH of 8–10. There is still an excess of OH^- ions, but not as big. When the numbers of H^+ and OH^- ions are equal, the solution is neutralised, green and the pH is 7. As more H_2SO_4 is added, the solution becomes yellow pH of 4–5. There is a small excess of H^+ ions but not as big. As more H_2SO_4 is added, the solution becomes red with a pH of 1–2. There is a significant excess of H^+ ions

2018:3

(a) Magnesium carbonate + nitric acid → magnesium nitrate + water + carbon dioxide

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

2017:1

(d) Sodium hydrogen carbonate + sulfuric acid → sodium sulfate + water + carbon dioxide

$2NaHCO_3 + H_2SO_4 \rightarrow Na_2SO_4 + 2H_2O + 2CO_2$

2017:2

(b)

Unlabelled solution	Observation (if any) with red litmus paper	Observation (if any) with potassium carbonate
Nitric Acid	Stays red	Fizzes / heat / reacts
Sodium Chloride	Stay red	No reaction
Sodium hydrogen carbonate	Turns blue	No reaction

Only the sodium hydrogen carbonate will turn the litmus blue, since it is a base. Add potassium carbonate to the remaining two solutions. Since nitric acid is an acid, it will undergo a neutralisation reaction with the basic potassium carbonate to produce bubbles / fizzing of carbon dioxide, according to the equation below:

$K_2CO_3 + 2HNO_3 \rightarrow 2KNO_3 + H_2O + CO_2$

No changes will be observed with the sodium chloride since it is a neutral salt.

2017:3

(b) The HCl is initially red since $[H^+]$ is much greater than $[OH^-]$; the pH is 1–2. As NaOH is added, the OH^- start to neutralise some of the H^+. As the pH increases to 3–6, the solution turns orange / yellow and $[H^+] > [OH^-]$. Once enough NaOH has been added such that $[OH^-] = [H^+]$, the UI turns green since all the H^+ have been neutralised by the added OH^- ions to form water, and the pH equals 7.

$H^+ + OH^- \rightarrow H_2O$

As more NaOH is added, the pH increases to pH 8–11 since $[OH^-] > [H^+]$, so the UI turns blue. As yet more NaOH is added, the pH increases to 12–14 since $[OH^-]$ becomes much greater than $[H^+]$, so UI turns purple. [Information may be given in a table.]

2016:1

(d) sodium hydroxide + sulfuric acid → sodium sulfate + water $2NaOH + H_2SO_4 \rightarrow Na_2SO_4 + 2H_2O$

2016:3

(a) KOH has a higher $[OH^-]$ than K_2CO_3 and therefore has a higher pH / is more basic than K_2CO_3. UI is purple at a pH of 12–14, whereas UI is blue for a base with a lower pH of 8–11.

(b) hydrochloric acid + potassium carbonate→ potassium chloride + water + carbon dioxide

$2HCl + K_2CO_3 \rightarrow 2KCl + H_2O + CO_2$

(c) Beaker 2 is initially purple since $[OH^-]$ is much greater than $[H^+]$; the pH is 12–14.

As HCl is added, the H^+ start to neutralise some of the OH^-. As the pH decreases to 8–11, the solution turns blue and $[OH^-] > [H^+]$.

Once enough HCl has been added such that $[OH^-] = [H^+]$, the UI turns green since all the OH^- have been neutralised by H^+ ions to form water, and the pH equals 7. As more HCl is added, the pH decreases to pH 3–6 since $[H^+] > [OH^-]$, so the UI turns yellow / orange. As more HCl is added, the pH decreases to 1–2 since $[H^+]$ becomes much greater than $[OH^-]$, so UI turns red. Information could come from (a).

2015:1

(c) nitric acid + calcium carbonate → calcium nitrate + water + carbon dioxide

$2HNO_3 + CaCO_3 \rightarrow Ca(NO_3)_2 + H_2O + CO_2$

2015:3

(a)

	Colour with UI	pH
HCl	Red	1– 3
NaOH	Purple	12–14
H_2O	green	7

(b) When HCl reacts it donates an H^+ and when NaOH reacts it provides OH^-, and these two ions combine to form (neutral) H_2O.

(c) As the NaOH is added, the HCl is being neutralised until water is formed, then after that the solution becomes more basic. When no NaOH has been added, the solution is red and has a pH of 1–2 and there is an excess of H+ ions. The concentration of hydroxide ions is very low. At pH 4, the solution is orange–yellow and there is still an excess of H^+ ions but not as big an excess as when the pH was lower. At pH 7 the solution is green, which is neutral. At this point, the number of H^+ and OH^- ions is equal and they cancel each other out to form neutral water. At pH 10 the solution is blue, and there is now an excess of OH^- ions. At pH 13 the solution is purple, and there is now a greater excess of OH^- ions than when the solution was blue.

(d) Hydrochloric acid + magnesium hydroxide → magnesium chloride + water

$HCl + Mg(OH)_2 \rightarrow MgCl_2 + 2H_2O$

2014:1 BALLOONS

(c) Write a word equation AND a balanced symbol equation for the reaction between calcium carbonate and hydrochloric acid.

Word equation: Hydrochloric acid + calcium carbonate → calcium chloride + carbon dioxide + water.

Balanced symbol equation: $2HCl + CaCO_3 \rightarrow CaCl_2 + CO_2 + H_2O$

2014:3 Indicators and pH

A student has three unlabelled beakers each containing a colourless liquid. One contains **water**, one contains a solution of baking soda (**sodium hydrogen carbonate**), and one contains white vinegar (a solution of **ethanoic acid**).

To work out which liquid is which, the student put a drop from each beaker onto a piece of blue litmus paper and a piece of red litmus paper. She then added universal indicator to each beaker.

The following results were obtained:

	Colour of blue litmus paper	Colour of red litmus paper	Colour with universal indicator	Name of liquid
Beaker 1	stays blue	stays red	turns green	water
Beaker 2	turns red	stays red	turns orange	vinegar
Beaker 3	stays blue	turns blue	turns blue	baking soda

(a) Complete the last column of the table above to identify the three liquids.

(b) Use the information in the table to show how each of the liquids can be identified.

In your answer you should:

- use all of the observations for each beaker
- state the approximate pH from the colour of the universal indicator.

Beaker 1 = water. The green colour of the universal indicator indicates that this solution has a pH of 7 and therefore is neutral. The fact that both litmus papers stay the same colour also indicates that the liquid is neutral and has a pH of seven, and therefore Beaker 1 must be water.

Beaker 2 = vinegar. The orange colour of the universal indicator indicates that the solution is acidic and has a pH of 4–5. Because the blue litmus turns red, this also indicates that the solution is acidic, and therefore Beaker 2 must be vinegar (ethanoic acid)

Beaker 3 = baking soda. The blue colour of the universal indicator indicates that the liquid is basic and has a pH of 9–10. Because the red litmus turns blue, this also indicates that the liquid is basic, and therefore Beaker 3 must be basic, as baking soda (sodium hydrogen carbonate) is basic.

(c) Another student was given two beakers (Beaker 4 and Beaker 5) each containing different liquids. The liquid in Beaker 4 had a pH of 1. The liquid in Beaker 5 had a pH of 6. Discuss which liquid is more acidic and how you know this.

In your answer you should:

- use the pH to determine which liquid is more acidic
- compare the amount of hydrogen ions AND hydroxide ions in Beaker 4 (pH 1) with the amount of hydrogen ions AND hydroxide ions in Beaker 5 (pH 6).

Beaker with a pH of one is more acidic. In both solutions there are an excess of hydrogen ions compared to hydroxide ions, but in the solution with a lower pH the number of hydrogen ions is much more in excess compared to hydroxide ions; whereas when the pH is 6 the hydrogen ions are still in excess but not by as much.

2014: 4 ADDING SULFURIC ACID TO SODIUM HYDROXIDE

A beaker contains sodium hydroxide solution and 5 drops of universal indicator.

Sulfuric acid was added to the beaker until no more changes were observed.

(a) Write a word equation AND a balanced symbol equation for the reaction between sulfuric acid and sodium hydroxide.

Word equation: Sulfuric acid + sodium hydroxide → sodium sulfate + water

Balanced symbol equation: $H_2SO_4 + 2NaOH \rightarrow Na_2SO_4 + 2H_2O$

(b) Describe how the indicator colour changes as the sulfuric acid is added to the beaker, AND explain what this tells you about the changing pH of this solution.

(c) Explain the relationship between the changing **pH** of the solution and the **ions** in the solution as the sulfuric acid is added to the beaker.

Explanations (b) and (c)

The solution would be purple to start with, as the pH would be 13–14. The pH would be high, as there are a high number of OH^- ions present. At this stage OH^- ions are in excess when compared to H^+ ions. As H_2SO_4 is added, the solution would go blue. At this stage the pH would be 8–12 and OH^- ions are still in excess of H^+ ions, but not by as much as when the solution was purple. When the solution

becomes green, the amount of H^+ ions added (from the H_2SO_4) cancel out the OH^- ions from the sodium hydroxide and form water in a neutralisation reaction. At this stage the pH would be 7.

As more H_2SO_4 is added, the solution then turns yellow, then orange, and then red. When the solution is yellow or orange, the pH is 3–6 as there are now more H^+ ions present than OH^- ions. When it becomes red, the pH is 1–2, as there are now many more H^+ ions present than OH^- ions.

2013: 2 ACIDS AND BASES

Potassium hydroxide (KOH) was added to a solution of sulfuric acid containing universal indicator until no further change was observed.

The experiment was repeated, but a piece of red litmus paper and a piece of blue litmus paper were each dipped into the solution after each 5 mL of potassium hydroxide was added.

The results of the experiments are shown in the table below.

Volume of KOH added (mL)	Colour of solution with universal indicator	Colour of red litmus paper	Colour of blue litmus paper
0	red	stays red	turns red
5	orange-yellow	stays red	turns red
10	green	stays red	stays blue
15	blue	turns blue	stays blue
20	purple	turns blue	stays blue

(c) Write a word equation AND a balanced symbol equation for the reaction between sulfuric acid and potassium hydroxide.

Sulfuric acid + potassium hydroxide → potassium sulfate + water

$H_2SO_4 + 2KOH \rightarrow K_2SO_4 + 2H_2O$

(d) Discuss what happened in this reaction as the potassium hydroxide was added to the sulfuric acid.

In your answer you should:

- relate the colours of the solution observed to the acidity and pH of the solution
- explain why the different colours of the solution were produced AND link these colours to the ions present during the reaction.
- explain the advantages of using universal indicator compared to litmus paper.

As the KOH is added, the H_2SO_4 is being neutralised until water is formed, then after that the solution becomes more basic.

When no KOH has been added, the solution is red and has a pH of 1–2 and there is an excess of H^+ ions. As the solution becomes orange-yellow, the pH becomes 4–6. There is still an excess of H^+ ions but not as big an excess as when the pH was lower. When 10 ml has been added and the solution is green, the pH is 7, which is neutral. At this point, the number of H^+ and OH^- ions is equal and they cancel each other out to form water.

After 15 mL has been added and the solution is blue, the pH is 9–12 and there is now an excess of OH^- ions. When 20 mL have been added and the solution is purple, the pH is 13–14 and there is now a greater excess of OH^- ions than when the solution was blue.

Litmus paper is useful to tell us if a solution is acidic, basic or neutral. (When blue litmus turns red and red litmus stays red, this tells us the solution is acidic. When both blue and red litmus papers stay the same, this tells us the solution is neutral. When red turns blue, this tells the solution is basic.) UI

however tells us more information and tells us how acidic, basic a solution is or if it is neutral. Litmus is limited as it only tells us if it is acid, basic, or neutral whereas UI tells us how acidic or basic it is.

You don't have to keep dipping / adding UI like you do litmus paper. (UI may be answered for solution or paper.)

2013:4 INVESTIGATING REACTIONS

Experiment One

A student carried out an experiment in the lab using the following method:

Step one: Universal indicator was added to a solution of hydrochloric acid in a beaker.

Step two: Calcium hydroxide was added slowly until the solution turned green.

Step three: The contents of the beaker were then poured into an evaporating dish and left in a sunny place for several days.

(a) Write a scientific aim for this experiment.

The purpose of Experiment 1 is to make the neutral salt, calcium chloride.

(b) Explain the purpose of each step in the method and how the equipment and chemicals used achieve that purpose.

Step one

- Purpose:
- Explanation:

Step two

- Purpose:
- Explanation:

Step three

- Purpose:
- Explanation:

UI is used to check the pH of the solution. Calcium hydroxide is added so that it reacts with HCl to form calcium chloride. It is added until the solution is green so that the solution formed is neutral. The contents are put into an evaporating dish so that the water can evaporate to leave the salt calcium chloride. It is left for a few days to ensure that all the water has evaporated as this process takes time.

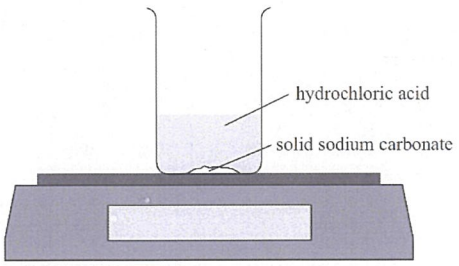
Experiment Two

In another experiment the following method was used:

Step one: A beaker was placed on a balance as shown in the diagram below.

Step two: Hydrochloric acid was added to solid sodium carbonate in the beaker.

Step three: The mass was recorded over time.



(c) Write a word equation AND a balanced symbol equation for the reaction between hydrochloric acid and sodium carbonate.

hydrochloric acid + sodium carbonate → sodium chloride + water + carbon dioxide

$2HCl + Na_2CO_3 \rightarrow 2NaCl + H_2O + CO_2$

(e) Explain why the mass of the beaker and contents would decrease over time.
In your answer you should:

- state any other observations that would be made as hydrochloric acid reacts with the sodium carbonate
- explain how the products formed by the reaction lead to the decrease in mass of the beaker and contents. Fizzing would be observed.

The fizzing observed is due to carbon dioxide gas being released, and therefore because the carbon dioxide gas is leaving the beaker, there is less mass remaining in the beaker and therefore the balance measures less weight.

2012:2 SALTS

A student wanted to make the neutral salt, sodium nitrate.

(a) Explain how to make sodium nitrate by mixing sodium carbonate and nitric acid solutions using school laboratory equipment (your explanation may use notes and diagrams).

(b) Explain how litmus paper could be used during the process described to show the salt being produced is **neutral**.

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

How to make it

Mix the two solutions together, then take the resulting solution and put it in an evaporating dish. It could be heated using a Bunsen burner or left somewhere warm for a few days. The water would evaporate off leaving behind the neutral salt sodium nitrate.

The solution will be neutral when red and blue litmus papers both stay the same colour. When blue paper changes to red the solution is acidic. When red paper changes to blue the solution is basic.

Word Equation: nitric acid + sodium carbonate → sodium nitrate + water + carbon dioxide.

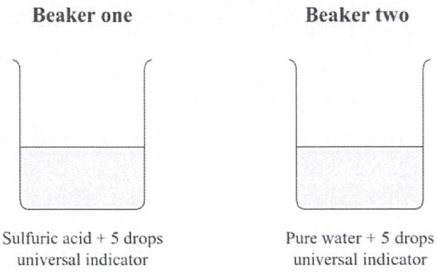
Balanced Equation: $2HNO_3 + Na_2CO_3 \rightarrow 2NaNO_3 + H_2O + CO_2$

2012:3 ACIDS AND BASES

Two beakers are shown below. Beaker one contains sulfuric acid solution and 5 drops of universal indicator.

Beaker two contains pure water and 5 drops of universal indicator.

Sodium hydroxide solution was added to both beakers until no more changes were observed.



(b) Write a word equation AND a balanced symbol equation for the reaction between sulfuric acid and sodium hydroxide.

Sulfuric acid + sodium hydroxide → sodium sulfate + water

$H_2SO_4 + 2NaOH \rightarrow Na_2SO_4 + 2H_2O$

(b) What is the colour of universal indicator in each solution at the start?

(c) Describe the colour changes as sodium hydroxide solution is added to each beaker, AND explain what this tells you about the changing pH of each solution.

(d) Explain the relationship between the pH of the solutions and the ions in the solutions, as the sodium hydroxide is added to each of the beakers.

Beaker one (acid): The solution would be red to start with as the pH would be 1–2. The ions present in solution would be H^+. The pH would be low as there is a high number of H^+ ions present.

As NaOH is added the solution would go orange, then yellow, then green. When the solution is orange and yellow the pH is still less than 7 as there are still more H^+ than OH^- ions. When the solution becomes green the amount of OH^- ions added (from the NaOH) cancel out the H^+ ions from the sulfuric acid and form water in a neutralisation reaction. At this stage the pH would be 7.

As more NaOH is added the solution then becomes blue and then purple. When the solution is blue the pH is 8 -11 as there are now more OH^- ions present than H^+ ions. When it becomes purple the pH is 13 – 14 as there are now many more OH^- ions present than H^+ ions.

Beaker two (water): The solution is green initially as water contains equal numbers of H^+ and OH^- ions and is pH 7. As NaOH is added, the solution would become blue (pH 8 - 11) and then purple (pH 13 – 14). Because the water was neutral to start with, as more OH^- ions are added, the solution becomes more basic as the OH^- ions are immediately in excess.

2011:3 MAKING A SALT

A student wanted to make the salt, magnesium chloride.

Discuss how the student would make magnesium chloride salt from hydrochloric acid and magnesium oxide.

In your answer you should:

- state what type of reaction occurs
- write a word equation AND a balanced symbol equation for the reaction between hydrochloric acid and magnesium oxide
- explain how you would make magnesium chloride in a school lab from hydrochloric acid and solid magnesium oxide (this can be done by drawing labelled diagrams).
  - Type of reaction:
  - Word equation:
  - Balanced symbol equation
  - Diagrams

Type of reaction: Acid-Base reaction or neutralisation.

Word Equation: hydrochloric acid + magnesium oxide → magnesium chloride + water.

Balanced Equation: $2HCl + MgO \rightarrow MgCl_2 + H_2O$

How to make it

Add magnesium oxide to hydrochloric acid in a beaker. Heat slightly and pour this into an evaporating dish and leave somewhere warm (e.g. window sill) for a few days or heat over Bunsen to speed up the reaction, so that the water can evaporate, leaving magnesium chloride salt. Safe lab procedure would include dealing appropriately with chemicals such as HCl or the wearing of safety glasses.

2011:4 pH AND INDICATORS

A student put 10 mL of dilute nitric acid in a boiling tube with five drops of universal indicator. Sodium hydroxide of the same concentration was then added. The following observations were recorded.

Amount of sodium hydroxide added (mL)	Colour of solution
0	red
10	green
20	purple

Discuss the reaction occurring as sodium hydroxide is added to the nitric acid.

In your answer you should:

- explain the relationship between the colours observed and the pH of the solution
- explain which ions cause the different colours of the solution
- write a word equation for the reaction AND a balanced symbol equation for the reaction.

Explanations

When the solution is red, the pH is 1–2. The colour is due to a high concentration of H^+ ions.

When the solution is green, the solution is neutral pH 7 and the hydroxide ions have reacted with the hydrogen ions, forming water.

When the solution is purple, the pH is 12–13 and there is a high concentration of hydroxide ions.

Word equation

Nitric acid + sodium hydroxide → sodium nitrate + water

Balanced equation

$HNO_3 + NaOH \rightarrow NaNO_3 + H_2O$

2011:3 ACID AND BASE REACTIONS (SAMPLE)

A student puts 5 mL of dilute hydrochloric acid into a boiling tube and adds five drops of universal indicator to the solution. The student then takes a solution of sodium hydroxide of the same concentration as the acid and adds it one drop at a time to the acid until the colour stops changing.

(a) (i) Describe the colour of the universal indicator solution:

- in the hydrochloric acid before any sodium hydroxide was added.
- when the sodium hydroxide was added and the colour of the solution **stopped changing**.

red / pink to start with

blue / purple / violet at end.

(iii) As the sodium hydroxide is added several colour changes occur.

Explain how the colour changes relate to pH AND what ions are present in the solution colour changes.

At the beginning the red indicated a low pH due to excess H^+ ions in the solution.

As the NaOH was added, a yellow/green colour indicates a pH of around 7, due to the OH^- ions combining with the H^+ ions to form a neutral solution.

As more NaOH is added the blue/purple indicated a pH of 11 plus, due to excess OH^- ions in the solution.

(c) The student combines **equal** volumes of nitric acid solution and sodium carbonate solution. Both solutions have the **same concentration**.

Discuss what happens in this reaction. In your answer, you should:

- name the type of reaction involved and the ions involved
- describe what the student would observe
- state the products of the reaction and link these to the observations made
- write a word equation for the reaction
- write a balanced symbol equation for the reaction.

Acid-base (or acid-carbonate) neutralisation (the carbonate ions react with the H^+ ions of the acidic solution and neutralise the solution).

Description of observations:

Bubbling in the solution / fizzing / effervescence / frothing / foaming $CaCO_3$ disappears.

Linking observations to products:

The products are CO_2, H_2O and a salt. The CO_2 gas causes the bubbles / fizzing / etc.

Writing a word equation:

Nitric acid + sodium carbonate → sodium nitrate + water + carbon dioxide

Writing a symbol equation: $2HNO_3 + Na_2CO_3 \rightarrow 2NaNO_3 + H_2O + CO_2$

2009:3 BALANCING IT UP (expired AS90189)

A student reacted zinc oxide with sulfuric acid, and wrote the following incorrect equation to represent the reaction:

$$ZnO_2 + H_2SO_4 \rightarrow 2H_2O + ZnSO_4 + H_2$$

The equation contains THREE errors.

(b) Rewrite the equation so that it is a correctly balanced chemical equation.

$ZnO + H_2SO_4 \rightarrow H_2O + ZnSO_4$

(b) Discuss the reasons for the three changes made to correctly balance the chemical equation.

ZnO_2 changed to ZnO, as ZnO has a one to one ratio because Zn forms Zn^{2+} / ion and oxygen a O^{2-} / ion. H_2 was removed from the equation as hydrogen gas is not a product of an acid + base (metal oxide) reaction. Balanced equations show the same amount / number of atoms on each side so '2' is removed from $2H_2O$ as there are 2 H on the left.

2009: 4 BASE REACTIONS (expired AS90189)

A student carried out an experiment to neutralise sulfuric acid by adding sodium hydroxide to it.

Discuss how the student could have determined when the sulfuric acid had been neutralised and what effect adding the sodium hydroxide has on the pH of the solution.

In your answer include:

- an explanation of neutralisation in terms of an acid-base reaction
- the name of the indicator used
- observations that the student would make as the sodium hydroxide is added to the acid
- a word and balanced chemical equation for the reaction.

$2NaOH + H_2SO4 \rightarrow Na_2SO_4 + 2H_2O$

Neutralisation is when a salt and water are produced because the amount of acid = the amount of base. The NaOH increases the pH towards 7 by cancelling out the acid.

Neutralisation is when the products of the reaction are pH 7 and (as amount of H^+ = the amount of OH^-) the amount of acid equals the amount of base (when pH = 7 = $[H^+][OH^-]$).

At the beginning the solution is red due to the H_2SO_4. At neutralisation it is yellow-green / green due to the Na_2SO_4 and H_2O (no H_2SO_4) present.

Add a few drops of Universal Indicator solution. Monitor colour changes as reaction proceeds: red in acid → yellow-green / green when neutral.

2010: 4 ACID AND HYDROGEN CARBONATE (expired AS90189)

A student reacted dilute sulfuric acid solution with solid sodium hydrogen carbonate.

Discuss the reasons for any observations the student would make for this reaction.

In your answer you should:

- Describe any observations the student would make for this reaction.
- Write a word equation and balanced symbol equation for the reaction of sulfuric acid with sodium hydrogen carbonate.
- Explain how the observations link to the products formed.

Fizzing/ bubbling/gas given off. The fizzing (effervescence) is a result of carbon dioxide being formed.

Sodium hydrogen carbonate disappears / solution becomes clear or colourless. The Na_2SO_4 is soluble, so final solution is clear / colourless.

Sodium hydrogen carbonate + sulfuric acid → sodium sulfate + carbon dioxide + water

$2NaHCO_3 + H_2SO_4 \rightarrow Na_2SO_4 + 2H_2O + 2CO_2$

2008:3 (expired AS90189)

An important part of keeping swimming pools safe is to keep the pH of the water balanced in the range 7.0 to 7.6.

Three chemicals used in pools are chlorine compounds (that react with water to produce hydrochloric acid), sodium hydrogen carbonate and aluminium sulfate.

(b) Complete the following table to show the characteristics of the solutions listed in the table below.

Solution	Estimated pH	Colour when tested with Universal indicator
Hydrochloric acid	1	(i)
Sodium hydrogen carbonate	(ii)	blue
Aluminium sulfate	5	(iii)
Water	(iv)	green

Solution	Estimated pH	Colour when tested with

		Universal indicator
Hydrochloric acid	1	(i) red
Sodium hydrogen carbonate	(ii) 8-12	blue
Aluminium sulfate	5	(iii) yellow / orange
Water	(iv) 7	green

(b) The pool was tested and found to have a pH of 6.5. Sodium hydrogen carbonate was used to raise the pH of the water.

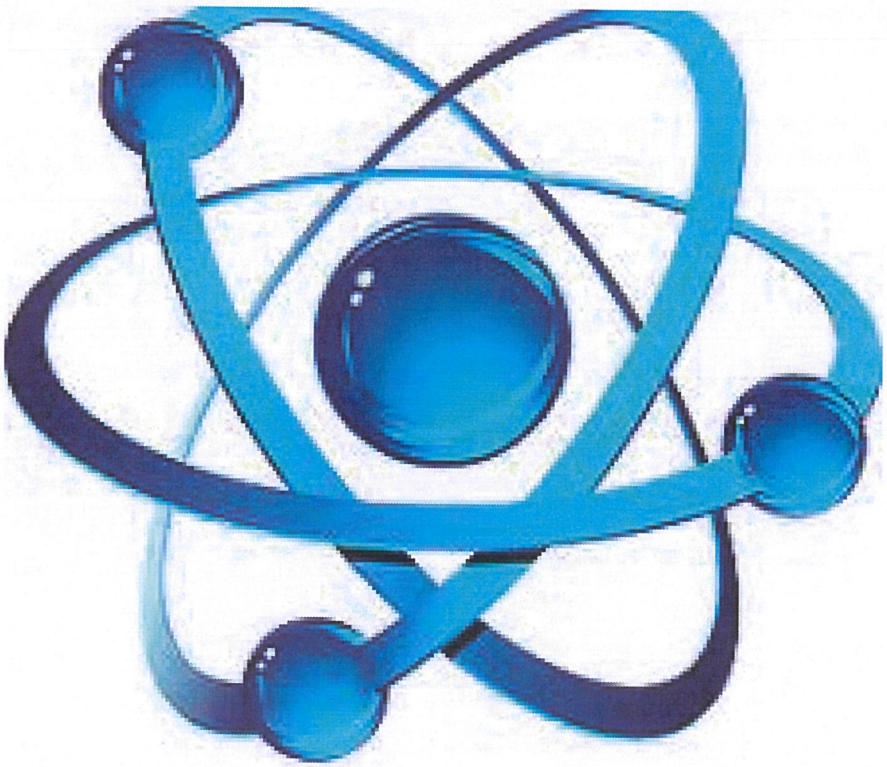
Discuss how sodium hydrogen carbonate raised the pH of the water, and include in your answer a word equation **and** a symbol equation for the reaction of sodium hydrogen carbonate with hydrochloric acid.

Sodium hydrogen carbonate + hydrochloric acid → carbon dioxide + sodium chloride + water

$NaHCO_3 + HCl \rightarrow NaCl + H_2O + CO_2$

At pH 6.5 the pool water is too acidic so sodium hydrogen carbonate is added to raise the pH back to the ideal region of pH 7 to 7.6 as it is a base and it neutralises the acid.

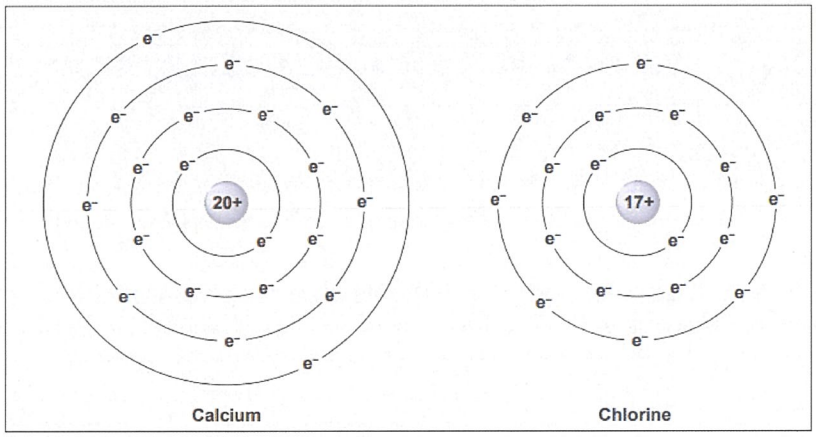
Atoms and Ions



COLLATED QUESTIONS – ATOMS AND IONS

2019:2

The diagram shows models of two atoms.



(a) Write the electronic arrangement of the two atoms.

(b) Calcium and chlorine atoms both form ions with the same electron arrangement.

(i) Write the electronic arrangement of the two ions.

(ii) Explain how each ion, Ca^{2+} and Cl^{-}, is formed.

In your answer you should:

- explain why these elements form ions
- explain the charges on both ions in terms of electron arrangement of atoms and ions, number of protons and number of electrons, and charge.

(c) Calcium reacts with chlorine, forming the ionic compound calcium chloride, $CaCl_2$.

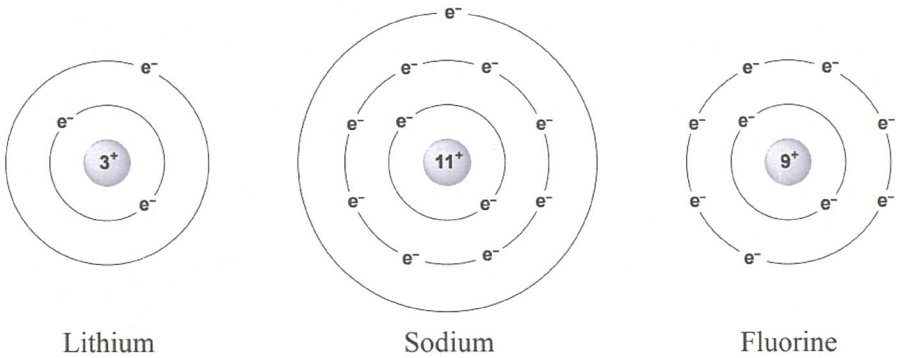
Explain the ratio of calcium ions to chloride ions in $CaCl_2$.

In your answer you should explain:

- how the ratio is related to the charge on the ions
- the number of electrons gained or lost by each atom as it forms the ionic compound

2018:1

The diagrams show models of three different atoms:



Use the diagrams to answer parts (a), (b), and (c).

(a) Why are lithium and sodium in the same group (column) of the Periodic Table, but in different periods (rows)?

(b) Sodium and fluorine form ions that both have the same electron arrangement. How can sodium and fluoride ions have the same electron arrangement but different charges? In your answer you should refer to the number of protons, charge, and electron arrangement of the two atoms and ions.

(c) Magnesium fluoride has the formula MgF_2. Explain how the ratio of ions in the formula is linked to the charge on the ions. In your answer you should include the number of electrons gained or lost by each atom as it forms the ionic compound. A diagram may assist your answer

2017:2

Sodium and potassium are both highly reactive metals that react with oxygen gas. However, sodium and potassium do not react with each other.

(a) Why do sodium and potassium each react with oxygen, but not with each other? In your answer you should:

- refer to the electron arrangements of each of the three atoms and three ions involved
- explain how the electron arrangement of each of the three atoms relates to its position in the periodic table
- explain how an ionic bond forms when sodium or potassium reacts with oxygen.

2017:3

(a) (i) Explain why silver oxide, Ag_2O, has a 2:1 ratio of ions. In your answer you should:

- relate the ratio of ions to the number of electrons lost or gained by each atom when forming ions
- explain how the ratio of the ions in the compound is related to the charge on the ions.

2016:1

(a) Complete the table below.

Element	Atomic number	Electron arrangement of atom	Electron arrangement of ion
F	9		
S	16		
Ca	20		

(b) Write the formulae for the following ionic compounds. Use the table of ions in your resource booklet to help you.

(i) Silver fluoride (ii) Potassium sulfate (iii) Calcium nitrate

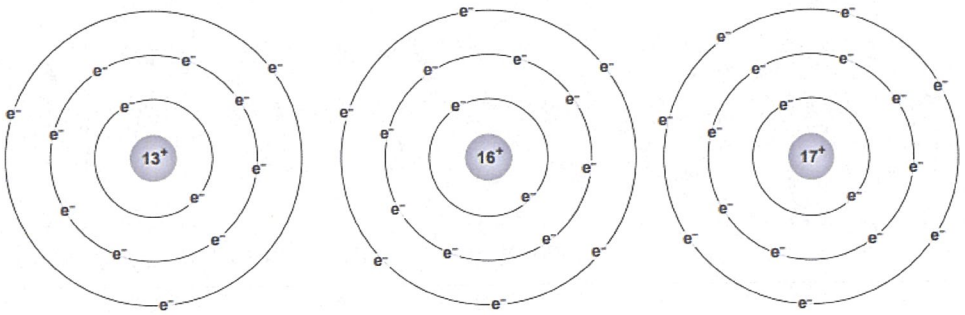
(c) Sodium burns in oxygen gas, O_2, to form sodium oxide, Na_2O.

(i) Explain how the Na and O atoms form Na_+ and O^{2-} ions, in terms of their groups in the periodic table, electron arrangement, AND number of protons.

(ii) Justify the ratio of Na^+ and O^{2-} ions in the formula Na_2O, in terms of the electrons lost or gained, and the charge on each ion. Include an explanation of the type of bonding between the Na^+ and O^{2-} ions.

2015:2

The diagrams below show models of three different atoms.



Aluminium Sulfur Chlorine

(a) Each of these atoms can form ions, as listed below.

- Explain why each of the ions has the charge it does, in terms of electron arrangement and number of protons.
- Ions are charged particles. Explain how each of the ions below reached the charge shown. You should discuss particles gained or lost by the atoms involved, and the reasons for this.
  Aluminium ion, Al^{3+}
  Sulfide ion, S^{2-}
  Chloride ion, Cl^{-}

(b) Explain why an ionic bond would not form between a sulfide ion and a chloride ion. In your answer you should:

- describe an ionic bond
- refer to charges and electron arrangements of the ions involved.

(c) Determine the ionic formulae of the compound that forms when aluminium combines with chlorine, **AND** when aluminium combines with sulfur. In your answer you should:

- consider the ratio of ions in each formula, and explain how the ratio is related to the charge on the ions
- relate the ratio of ions in each formula to the number of electrons lost or gained by each atom when forming ions.

2014:1 ATOMS, IONS AND FORMULAE

(a) Write the formulae for the following ionic compounds.
Use the Table of Ions in your Resource Booklet to help you.
(i) Calcium chloride
(ii) Sodium nitrate
(iii) Zinc nitrate

(b) Complete the table below for the ions formed by magnesium, aluminium, and oxygen.
Use the periodic table in your Resource Booklet to help you.

Atom	Atomic number	Electron arrangement of atom	Electron arrangement of ion	Charge on ion
Mg				
Al				
O	8	2,6	2,8	2-

(c) The formula for magnesium oxide is MgO. The formula for aluminium oxide is Al_2O_3.
Explain why the two formulae are different.
In your answer:
- consider the ratio of ions in each formula and explain how the ratio is related to the charge on the ions
- relate the ratio of ions in the formula to the number of electrons lost or gained by each atom

2013:1 ATOMIC STRUCTURE

F^-, Ne, and Mg^{2+} have the **same** electron arrangement.

(a) Complete the table below.

Use the periodic table in your Resource Booklet.

Atomic number	Number of protons	Number of electrons	Electron arrangement
F^-			
Ne			
Mg^{2+}			

(b) Compare the atomic structure of F^-, Ne, and Mg^{2+}.

In your answer you should:
- describe the difference between an atom and an ion
- explain the charges on F^-, Ne, and Mg^{2+} in terms of electron arrangement and number of protons
- relate the position of F^-, Ne, and Mg^{2+} on the periodic table to the charges and electron arrangement
- explain why all three have the same electron arrangement.

2012:1 ATOMS AND IONS

(a) Complete the table below for ions formed by Ca, F, and Cl.

Atom	Atomic number	Electron arrangement of atom	Electron arrangement of ion	Ion symbol
Ca	20			
F	9			
Cl	17			

(b) Explain the charges on ALL three ions, in terms of electron arrangement and number of protons.

(c) Use their positions on the periodic table to explain why two of the atoms form ions with the same charge, AND two of the atoms form ions with the **same electron arrangement.**

2011:1 IONS AND IONIC FORMULAE

(a) Explain why the ions formed by sodium and oxygen both have the same electron arrangement.
In your answer you should:

- describe an ion
- describe the atomic structures of a sodium ion and an oxide ion
- state the charge on the sodium ion and the oxide ion
- explain the charges on both ions in terms of electron arrangement and number of protons.

(b) Element X is between numbers 11 and 18 on the Periodic Table.
An atom of element X forms an ion. This ion combines with the hydroxide ion to form a neutral compound, $X(OH)_3$.

Determine what element X is and justify your answer. In your answer you should:

- consider the ratio of X ions to hydroxide ions
- use the formula $X(OH)_3$ to determine the charge of the X ion
- explain how you would use the Periodic Table in your Resource Booklet to find out which group element X is in
- name element X.

2011:1 IONIC COMPOUNDS (SAMPLE)

(a) Magnesium and calcium atoms both form ions with a charge of +2. Magnesium atoms form Mg^{2+} ions, and calcium atoms form Ca^{2+} ions.
Explain why magnesium and calcium atoms form ions with the same charge of +2. In your answer, you should:
define an ion
explain why atoms form ions

- identify the group on the periodic table where the two atoms are found
- explain why both magnesium and calcium ions have a charge of +2.

(b) Sodium and beryllium atoms form ions with different charges.
Complete the table below.

Element	Periodic table group number	Electron arrangement of atom	Charge on the ion that the atom forms
Sodium			
Beryllium			

(c) Explain why the ions in sodium hydroxide combine to give the formula NaOH but the ions in beryllium hydroxide combine to give the formula $Be(OH)_2$.
In your answer, you should:

- compare the charges on the individual ions found in the compounds sodium hydroxide and beryllium hydroxide
- explain why the ions combine in the ratios the way they do to form the compounds NaOH and $Be(OH)_2$.

NOTE: Isotopes has been removed from AS90944 v2. However, you might still be asked to describe differences and similarities between two atoms, given their atomic and mass numbers.

2011:2 ISOTOPES AND IONS (SAMPLE)

(a) Lithium atoms can exist in different forms (called isotopes). Two of these are Lithium-6 ($^{6}_{3}$Li) and Lithium-7 ($^{7}_{3}$Li).

Explain why $^{6}_{3}$Li and $^{7}_{3}$Li are both neutral atoms. In your answer, you should fully describe their atomic structure and state their electron configuration.

(b) Berylium can exist as an isotope in the form of beryllium-7 ($^{7}_{4}$Be).

Discuss how the mass of $^{7}_{4}$Be compares with $^{6}_{3}$Li and $^{7}_{3}$Li. In your answer, you should:

- consider the atomic structure of each atom
- consider the meaning of the numbers '6' and '7' in terms of the atomic structures
- explain how the particles within an atom contribute to its overall mass.

You may draw labelled diagrams in the box below to support your answer.

2010:2 ALUMINIUM OXIDE (expired AS90189)

Aluminium reacts with oxygen to form aluminium oxide. The formula of aluminium oxide contains two aluminium ions and three oxide ions.
Discuss why the formula has two aluminium ions and three oxide ions.
In your answer you should:

- State the formula for aluminium oxide.
- State the electron configuration of the aluminium atom, the oxygen atom, the aluminium ion, and the oxide ion.
- Use the electron configurations and numbers of electrons lost or gained when forming ions to justify the formula of aluminium oxide.
  You may support your answer with diagrams.

2009:1 ATOMIC STRUCTURE (expired AS90189)

Some elements have isotopes. Isotopes of an element have the same number of protons, but different numbers of neutrons. Carbon-12 ($^{12}_{6}$C) and carbon-13 ($^{13}_{6}$C) are isotopes of carbon.

(a) Explain why $^{12}_{6}$C and $^{13}_{6}$C are neutral atoms. You should describe their atomic structure, and state their electron configuration.

(b) Explain how the particles within an atom contribute to its overall mass.

(c) Nitrogen can exist as an isotope in the form of nitrogen-13 ($^{13}_{7}$N).

Discuss how the **mass** of $^{13}_{7}$N compares with $^{12}_{6}$C **and** $^{13}_{6}$C.

In your answer consider:

- the atomic structure of each atom
- the relevance of the numbers "12" and "13" in terms of atomic structure.

Diagram(s) may be used to support your discussion.

2008 :1 (expired AS90189)

Oxygen atoms are made of protons, neutrons, and electrons.

One type of oxygen atom can be represented as $^{18}_{8}O$.

(a)

(i) Draw a diagram to show the arrangement of the electrons, protons, and neutrons within the above oxygen atom.

(ii) Explain, with reference to the diagram, why the atom is neutral.

(b) Use the table of ions in the Resource Booklet to fill in the missing name or formula for each of the compounds below.

Scientific name	Formula
(i)	$FeSO_4$
Ammonium nitrate	(ii)
(iii)	KNO_3
Calcium hydrogen carbonate	(iv)

(c) Both potassium and magnesium form compounds with hydroxide ions.

(i) Complete the table below for potassium and magnesium:

Element	Periodic Table Group Number	Electron arrangement of atom	Charge on ion that forms
Potassium			
Magnesium			

(ii) Discuss why potassium hydroxide has the formula KOH, while magnesium hydroxide has the formula $Mg(OH)_2$. Refer to:

- the information in part (i)
- the changes in the electron arrangements of potassium and magnesium when they react.

ANSWERS TO RECENT QUESTIONS

2019:2

(a) Ca: 2,8,8,2 Cl: 2,8,7

(b) (i) Both ions have the electron arrangement 2,8,8

(ii) Ca^{2+} because it has 20 + protons (+ charges) and only 18- electrons (– charges). It has only 18 electrons, as its electron arrangement as an atom was 2,8,8,2, and when it forms an ion, it loses two electrons to form an arrangement of 2,8,8 to have a full outer shell, which is more stable. Cl^- because it has 17+ protons (+ charges) and 18 - electrons (– charges). It has 18 electrons, as its electron arrangement as an atom was 2,8,7 and when it forms an ion, it gains one electron to form an arrangement of 2,8,8 to have a full outer shell, which is more stable.

(c) Calcium loses 2 electrons to form Ca^{2+} ending up with a charge of +2. Chlorine will gain only one electron to become Cl^- and have a charge of –1. As Ca reacts, it loses the 2 electrons in its outer shell; one to each Cl atom to fill their outer shells. In order to have a neutral compound, one calcium ion is needed to cancel out the charge on two chloride ions with a combined charge of –2.

2018:1

(a) Both atoms have the same number of valence electrons, which determines the group (1). The period is determined by the number of electron shells. Li has 2 electron shells so is found in Period 2; Na has 3 electron shells so is found in Period 3.

(b) Na has 11 protons and electron arrangement of 2,8,1. F has 9 protons and electron arrangement of 2,7. Both atoms need to gain or lose electrons to have a full outer shell and become stable. Na loses one electron to form Na^+ ion which has a charge of +1 as it now has 10 negative electrons and 11 positive protons. F gains 1 electron to form F^- ion which has a charge of –1 as it now has 10 negative electrons and 9 positive protons. Therefore, Na^+ and F^- ions now both have the same electron arrangement of 2,8.

(c) Magnesium loses 2 electrons to end up with a charge of +2. Fluorine will gain only one electron to have a charge of –1. As Mg reacts, it loses the 2 electrons in its outer shell; one to each F atom to fill their outer shells. In order to have a neutral compound, one magnesium ion is needed to cancel out the charge on two fluoride ions with a combined charge of –2.

2017:2

(a) Sodium and potassium are both in Group 1 of the periodic table. This means they each have one valence electron. Their atom electron arrangements are shown below:
Na atom: 2, 8, 1 K atom: 2, 8, 8, 1 The Na and K atoms will each lose their one valence electron to gain a stable full outer shell, as shown by the ion electron arrangements below: Na^+ : 2, 8 K^+ : 2, 8, 8
Oxygen is in Group 16 of the Periodic Table. This means it has six valence electrons. Its atom electron arrangement is: O atom: 2, 6 The O atom will gain two electrons to gain a stable full outer shell, as shown by the ion electron arrangement below: O^{2-} : 2, 8
Since Na and K each lose one valence electron whereas O gains two electrons, Na and K can transfer electrons to the O atom. This transfer of electrons causes ions to form; the electrostatic attraction between the oppositely charged ions (Na^+ and O^{2-} , and K^+ and O^{2-}) is called an ionic bond.
Each O atom will need to react with two K / Na atoms to get the two electrons it needs. The Na and K atoms cannot react with each other because they each react by losing one electron. Therefore, electron transfer cannot occur between the Na and K atoms.

2017:3

(a) (i) Each silver (Ag) atom loses one electron to form the Ag^+ ion; however, each oxygen atom requires two electrons to fill its outer shell. Therefore, two Ag atoms react for every O atom, i.e. two Ag atoms lose 2 electrons and one O atom gains 2 electrons. The two Ag^+ ions have a total charge of +2 to balance the –2 total charge of the O^{2-} ion, i.e. an ionic compound has no overall charge.

2016:1

(a)

	Atomic number	Electron arrangement of atom	Electron arrangement of ion
F	9	2, 7	2, 8
S	16	2, 8, 6	2, 8, 8
Ca	20	2, 8, 8, 2	2, 8, 8

(b) (i) AgF
(ii) K_2SO_4
(iii) $Ca(NO_3)_2$

(iii) (i) Na is a group one element, so the Na atom has one valence electron and an electron configuration of 2, 8, 1. The Na atom loses its one valence electron to gain a full outer shell – it now has 1 more proton (11) than electrons; the Na^+ ion is formed. O is a group sixteen element, so the O atom has six valence electrons and an electron configuration of 2, 6. The O atom gains two electrons to gain a full outer shell – it now has 2 less protons (8) than electrons; the O^{2-} ion is formed.

(ii) The Na atom loses one electron to form the Na^+ ion; however, the O atom requires two electrons to fill its outer shell. Therefore, two Na atoms react for every one O atom. The two Na^+ ions have a total charge of +2 to balance the –2 charge of the O^{2-} ion, i.e. an ionic compound has no overall charge. The bonding / attraction between the Na+ ions and the O^{2-} ions is an ionic bond, formed when the electrons lost by the Na are gained by the O.

2015:2

(a) Al^{3+} because it has 13 protons (+ charges) and only 10 electrons (– charges). It has only 10 electrons, as its electron arrangement as an atom was 2,8,3, and when it forms an ion, it loses three electrons to form an arrangement of 2,8 to have a full outer shell, which is more stable.
S^{2-} because it has 16 protons (+ charges) and 18 electrons (– charges). It has 18 electrons, as its electron arrangement as an atom was 2,8,6, and when it forms an ion, it gains two electrons to form an arrangement of 2,8,8 to have a full outer shell, which is more stable.
Cl^- because it has 17 protons (+ charges) and 18 electrons (– charges). It has 18 electrons, as its electron arrangement as an atom was 2,8,7, and when it forms an ion it gains one electron to form an arrangement of 2,8,8 to have a full outer shell, which is more stable.

(b) An ionic bond is the attraction between a positive ion and a negative ion. It is formed because opposite charges will attract one another. An ionic bond would not form between chloride ions and sulfide ions, as they both have negative charges because they have both gained negative electrons in order to form a full valence shell, and the ions with the same charge will repel each other.

(c) Elements 1 and 3: $AlCl_3$

Aluminium has a charge of +3. In order to have a neutral compound overall, one aluminium ion is required to cancel out the charge on three chloride ions with a combined charge of –3. The charge on the aluminium ion arises as it gives away three electrons in order to have a full outer shell. Because it has to give 3 electrons away and each chlorine has to accept one electron, in order to have a full shell, the ratio of ions required is one to three.

Element 1 and 2: Al_2S_3

The aluminium ion has a charge of +3. In order to have a neutral compound overall, two aluminium ions with a combined charge of +6 are required to cancel out the charge on three 2- sulfide ions with a combined charge of – 6. The charge on the aluminium ion arises as aluminium gives away three electrons in order to have a full outer shell. Because it has to give 3 electrons away and sulfur has to accept two electrons in order to have a full shell, the ratio of ions required is two to three.

2014:1

(a) $CaCl_2$ $NaNO_3$ $Zn(NO_3)_2$

(b)

Atom	Atomic number	Electron arrangement of atom	Electron arrangement of ion	Charge on ion
Mg	12	2,8,2	2,8	+2
Al	13	2,8,3	2,8	+3
O	8	2,6	2,8	–2

(c) Magnesium ion has a charge of +2 and oxide ion has a charge of –2. A compound overall has to have no charge. Therefore the +2 charge of magnesium ion cancels out the –2 charge of oxide ion, and so therefore the ratio of ions is one to one. The charge on the ions arises, as magnesium has to lose two electrons in order to have a full outer shell and have a charge of +2, and oxygen has to gain two electrons in order to have a full outer shell and have a charge of –2. In order to do this, magnesium gives its two electrons straight to oxygen and the ratio is one to one of the two ions.
Aluminium ion has a charge of +3. In order to have a neutral compound overall, two aluminium ions with a combined charge of +6 are required to cancel out the charge on three oxide ions with a combined charge of –6. The charge on the aluminium ion arises as it gives away three electrons in order to have a full outer shell. Because it has to give 3 electrons away and oxygen has to accept two electrons in order to have a full shell, the ratio of ions required is two to three.

2013: 1 ATOMIC STRUCTURE

F^-, Ne, and Mg^{2+} have the **same** electron arrangement.

(a) Complete the table below.

Use the periodic table in your Resource Booklet.

Atomic number	Number of protons	Number of electrons	Electron arrangement
F^-	9	10	2,8
Ne	10	10	2,8
Mg^{2+}	12	10	2,8

(b) Compare the atomic structure of F^-, Ne, and Mg^{2+}.

In your answer you should:

- describe the difference between an atom and an ion
- explain the charges on F^-, Ne, and Mg^{2+} in terms of electron arrangement and number of protons
- relate the position of F^-, Ne, and Mg^{2+} on the periodic table to the charges and electron arrangement
- explain why all three have the same electron arrangement.

The difference between an ion and an atom is that an atom has a neutral charge as it has not gained or lost electrons and therefore has the same number of protons (+) and electrons (–) whereas an ion has a charge as the atom it was formed from has either gained or lost electrons to form a full outer shell and therefore has a different number of protons (+) from the number of electrons (–).

Explanation of charges

Fluorine has 9 protons and electron arrangement of 2,7. Neon has 10 protons and an electron arrangement of 2,8. Magnesium has 12 protons and an electron arrangement of 2,8,2.

Fluorine gains one electron to have a full outer shell. This is because it is in group 17 and has 7 valence electrons. For fluorine ion, the electron arrangement is 2,8.

Fluorine has a charge of –1 as it now has 10 electrons (negative charges) and nine protons (positive charges).

Neon has no charge as it has the same number of protons and electrons, as it has not gained or lost electrons, as it has an electron arrangement of 2,8 because it is in group 18 of the periodic table and its valence shell is complete.

Magnesium has 12 protons and electron arrangement of 2,8,2.

Magnesium has two electrons in its outer shell as it is in group 2 of the periodic table, which it loses, so its outer shell is full (2,8) and it has a charge of +2, as it still has 12 protons (positive charges) and now has only 10 electrons (negative charges).

All three have the same electron arrangement as they have gained one electron, lost two electrons or have neither gained or lost electrons. The electron arrangement is 2,8 as this is the nearest possible stable electron arrangement for all three.

2012: 1 ATOMS AND IONS

(a) Complete the table below for ions formed by Ca, F, and Cl.

Atom	Atomic number	Electron arrangement of atom	Electron arrangement of ion	Ion symbol
Ca	20			
F	9			
Cl	17			

Atom	Atomic No	Electron arrangement of atom	Electron arrangement of ion	Ion symbol
Ca	20	2,8,8,2	2,8,8	Ca^{2+}
F	9	2,7	2,8	F^-
Cl	17	2,8,7	2,8,8	Cl^-

(b) Explain the charges on ALL three ions, in terms of electron arrangement and number of protons.
(c) Use their positions on the periodic table to explain why two of the atoms form ions with the same charge, AND two of the atoms form ions with the **same electron arrangement.**

F has 9 protons and electron arrangement of 2,7. Cl has 17 protons and an electron arrangement of 2,8,7. Both atoms are in group 17 of the periodic table as they both have 7 electrons in the valence shell. Both atoms gain one electron to have a full outer shell. For F ion the electron arrangement is 2,8, and for Cl ion it is 2,8,8.
F has a charge of –1 as it now has 10 electrons (–) and 9 protons (+). Cl has a charge of –1 as it now has 18 electrons (–) and 17 protons (+).
Ca has 20 protons and electron arrangement of 2,8,8,2. Ca has two electrons in its outer shell, which it loses, so its new outer shell is full (2,8,8) and it has a charge of +2, as it still has 20 protons (+) and now has only 18 electrons (–). Therefore Ca and Cl ions now both have the same electron configuration of 2,8,8.

2011: 1 IONS AND IONIC FORMULAE

(a) Explain why the ions formed by sodium and oxygen both have the same electron arrangement.
In your answer you should:

- describe an ion
- describe the atomic structures of a sodium ion and an oxide ion
- state the charge on the sodium ion and the oxide ion
- explain the charges on both ions in terms of electron arrangement and number of protons.

Description of ion
An ion is an charged particle formed when an atom or group of atoms that has lost or gained electron(s) and therefore carries a charge / full outer shell / stable.
Explanation of charges
Sodium has 11 protons and electron arrangement of 2,8,1.
Sodium has one electron in its outer shell, which it loses, so its outer shell is full (2,8) and it has a charge of +1, as it still has 11 protons (positive charges) and now has only 10 electrons (negative charges).
Oxygen has 8 protons and electron arrangement of 2,6. Oxygen has 6 electrons in its outer shell, and so it gains two electrons, so its outer shell is full (2,8) and so has a charge –2, as it still has 8 protons (positive charges) and now has 10 electrons (negative charges).

(b) Element X is between numbers 11 and 18 on the Periodic Table.
An atom of element X forms an ion. This ion combines with the hydroxide ion to form a neutral compound, $X(OH)_3$.

Determine what element X is and justify your answer. In your answer you should:

- consider the ratio of X ions to hydroxide ions
- use the formula $X(OH)_3$ to determine the charge of the X ion
- explain how you would use the Periodic Table in your Resource Booklet to find out which group element X is in
- name element X.

Ratio of X ions to OH^- ions 1:3
Charge of X

Hydroxide ion has a charge of –1. Because there are three hydroxide ions overall, the total negative charge is –3. Therefore to form a neutral compound, X must have a charge of +3, as there is only one X ion in the formula. Therefore X loses three electrons to have a charge of +3.

How to find group for X

The only element between 11–18 that has three electrons in its valence shell is aluminium in group 13, OR it must be in group 13 to have three valence electrons.

What is X? Aluminium.

2011: 1 IONIC COMPOUNDS (SAMPLE)

(a) Magnesium and calcium atoms both form ions with a charge of +2. Magnesium atoms form Mg^{2+} ions, and calcium atoms form Ca^{2+} ions.

Explain why magnesium and calcium atoms form ions with the same charge of +2. In your answer, you should:

define an ion

explain why atoms form ions

- identify the group on the periodic table where the two atoms are found
- explain why both magnesium and calcium ions have a charge of +2.

An ion is charged particle formed when an atom or group of atoms have lost or gained an electron and therefore carry a charge.

Explanation of formation of ions:

If the outer shell (valence) of an atom is not filled, the atom is unstable. It will react to gain a full outer shell to become more stable, by either losing or gaining electrons and making it into an ion.

Identification of Group:

Magnesium and calcium are in the same group on the periodic table (Group 2).

Explanation of why both form+2 ions:

The atoms have the same number of electrons (two) in their outer shell. (Students may give the electron configuration instead.)

Both Mg and Ca need to lose two outer electrons to become stable by having a full outer shell. Each ion (Mg^{2+} and Ca^{2+}) ends up with two less electrons than there are protons in its nucleus, so the ion has a charge of +2.

(b) Sodium and beryllium atoms form ions with different charges.

Complete the table below.

Element	Periodic table group number	Electron arrangement of atom	Charge on the ion that the atom forms
Sodium			
Beryllium			

Element	Periodic table group number	Electron arrangement of atom	Charge on the ion that the atom forms
Sodium	1	2.8.1	+1 (or 1+)
Beryllium	2	2.2	+2 (or 2+)

(c) Explain why the ions in sodium hydroxide combine to give the formula NaOH but the ions in beryllium hydroxide combine to give the formula $Be(OH)_2$.

In your answer, you should:

- compare the charges on the individual ions found in the compounds sodium hydroxide and beryllium hydroxide
- explain why the ions combine in the ratios the way they do to form the compounds NaOH and $Be(OH)_2$.

Comparison of charges on ions:
When these elements react, Na loses one electron and forms a +1 ion, while Be loses two electrons and forms a +2 ion in order to adopt the stable electron configuration. The hydroxide carries a charge of -1.
Explanation of formation of compounds:
An ionic compound is electrically neutral therefore all the positive charges must balance the negative charges. Therefore it requires one OH^- for each Na^+ ion but two OH^- ions for each Be^{2+} ion to form a neutral compound/ balance the charges.

NOTE: Isotopes has been removed from AS90944 v2. However you might still be asked to describe differences and similarities between two atoms, given their atomic and mass numbers.

2011 : 2 ISOTOPES AND IONS (SAMPLE)

(a) Lithium atoms can exist in different forms (called isotopes). Two of these are Lithium-6 ($^{6}_{3}Li$) and Lithium-7 ($^{7}_{3}Li$).

Explain why $^{6}_{3}Li$ and $^{7}_{3}Li$ are both neutral atoms. In your answer, you should fully describe their atomic structure and state their electron configuration.

Atomic structure: $^{6}_{3}Li$ – 3p, 3n, 3e $^{7}_{3}Li$ – 3p, 4n. 3e
Electron configuration: Both – 2.1
Explanation of neutrality
Both $^{6}_{3}Li$ and $^{7}_{3}Li$ have equal numbers of protons and electrons, ie 3p and 3e. An atom is neutral when it has equal numbers of protons and electrons.

(b) Berylium can exist as an isotope in the form of beryllium-7 ($^{7}_{4}Be$).

Discuss how the mass of $^{7}_{4}Be$ compares with $^{6}_{3}Li$ and $^{7}_{3}Li$. In your answer, you should:
consider the atomic structure of each atom
consider the meaning of the numbers '6' and '7' in terms of the atomic structures
explain how the particles within an atom contribute to its overall mass.
You may draw labelled diagrams in the box below to support your answer.

Atomic structure: $^{7}_{4}Be$ – 4p, 3n, 4e
See above for $^{6}_{3}Li$ and $^{7}_{3}Li$
Relevance of numbers: 6 and 7 refer to the total mass of the elements.
Explanation of mass: Overall mass of an atom is made up of protons and neutrons, as the mass of electrons is negligible.
Comparison of masses: $^{7}_{4}Be$ will have the same atomic mass as $^{7}_{3}Li$ because the total number of protons and neutrons is the same AND $^{7}_{4}Be$ is heavier than $^{6}_{3}Li$ as it has one more proton.

2010 :2 ALUMINIUM OXIDE (expired AS90189)

Aluminium reacts with oxygen to form aluminium oxide. The formula of aluminium oxide contains two aluminium ions and three oxide ions.
Discuss why the formula has two aluminium ions and three oxide ions.
In your answer you should:

- State the formula for aluminium oxide.
- State the electron configuration of the aluminium atom, the oxygen atom, the aluminium ion, and the oxide ion.
- Use the electron configurations and numbers of electrons lost or gained when forming ions to justify the formula of aluminium oxide.
  You may support your answer with diagrams.

Al_2O_3
Electron configurations: Aluminium 2.8.3 Aluminium ion 2.8 Oxygen 2.6 Oxygen ion 2.8
Because aluminium has three electrons in its outer (valence) shell, it loses 3 electrons, giving it a full outer shell / becomes stable, gaining a positive charge.
Each oxygen has 6 electrons in its outer (valence) shell so giving it 2 electrons gives it a full outer shell / becomes stable gaining a negative charge.
Aluminium loses three electrons, so it has a +3 charge. Oxygen gains two electrons so it has a –2 charge.
As the compound is neutral, three oxide ions are required to balance out the two aluminium ions as $3 \times -2 = 2 \times +3$.

2009 :1 ATOMIC STRUCTURE (expired AS90189)

Some elements have isotopes. Isotopes of an element have the same number of protons, but different numbers of neutrons. Carbon-12 ($^{12}_{6}C$) and carbon-13 ($^{13}_{6}C$) are isotopes of carbon.

(a) Explain why $^{12}_{6}C$ and $^{13}_{6}C$ are neutral atoms. You should describe their atomic structure, and state their electron configuration.

(b) Explain how the particles within an atom contribute to its overall mass.

(c) Nitrogen can exist as an isotope in the form of nitrogen-13 ($^{13}_{7}N$).

Discuss how the **mass** of $^{13}_{7}N$ compares with $^{12}_{6}C$ **and** $^{13}_{6}C$.

In your answer consider:

- the atomic structure of each atom
- the relevance of the numbers "12" and "13" in terms of atomic structure.

Diagram(s) may be used to support your discussion.

(a) ^{12}C: 6 protons, 6 neutrons, electron configuration of 2.4
^{13}C: 6 protons, 7 neutrons, electron configuration of 2.4
^{12}C and ^{13}C are neutral as they both contain equal numbers of protons and electrons.

(b) The overall mass of an atom is made up of protons and neutrons, as the mass of the electrons is negligible.

(c) ^{13}N will have the same atomic mass as ^{13}C because the total number of protons and neutrons is the same. ^{13}N is heavier than ^{12}C because it has one extra proton.

2008 :1 (expired AS90189)

Oxygen atoms are made of protons, neutrons, and electrons.

One type of oxygen atom can be represented as $^{18}_{8}O$.

(a)

(i) Draw a diagram to show the arrangement of the electrons, protons, and neutrons within the above oxygen atom.

(ii) Explain, with reference to the diagram, why the atom is neutral.

Diagram showing 8 protons and 10 neutrons in nucleus, with 8 electrons orbiting, 2 in first shell, six in second.

Atom is neutral as there are the same number of positive particles / charges / protons as negative particles / charges / electrons.

(b) Use the table of ions in the Resource Booklet to fill in the missing name or formula for each of the compounds below.

Scientific name	Formula
(i)	$FeSO_4$
Ammonium nitrate	(ii)
(iii)	KNO_3
Calcium hydrogen carbonate	(iv)

Scientific name	Formula
(i) Iron(II) sulfate	$FeSO_4$
Ammonium nitrate	(ii) $(NH_4)_2SO_4$
(iii) Potassium nitrate	KNO_3
Calcium hydrogen carbonate	(iv) $Ca(HCO_3)_2$

(c) Both potassium and magnesium form compounds with hydroxide ions.

(i) Complete the table below for potassium and magnesium:

Element	Periodic Table Group Number	Electron arrangement of atom	Charge on ion that forms
Potassium			
Magnesium			
Element	Periodic Table Group Number	Electron arrangement of atom	Charge on ion that forms
Potassium	1	2.8.8.1	1+
Magnesium	2	2.8.2	2+

(ii) Discuss why potassium hydroxide has the formula KOH, while magnesium hydroxide has the formula $Mg(OH)_2$. Refer to:

- the information in part (i)
- the changes in the electron arrangements of potassium and magnesium when they react.

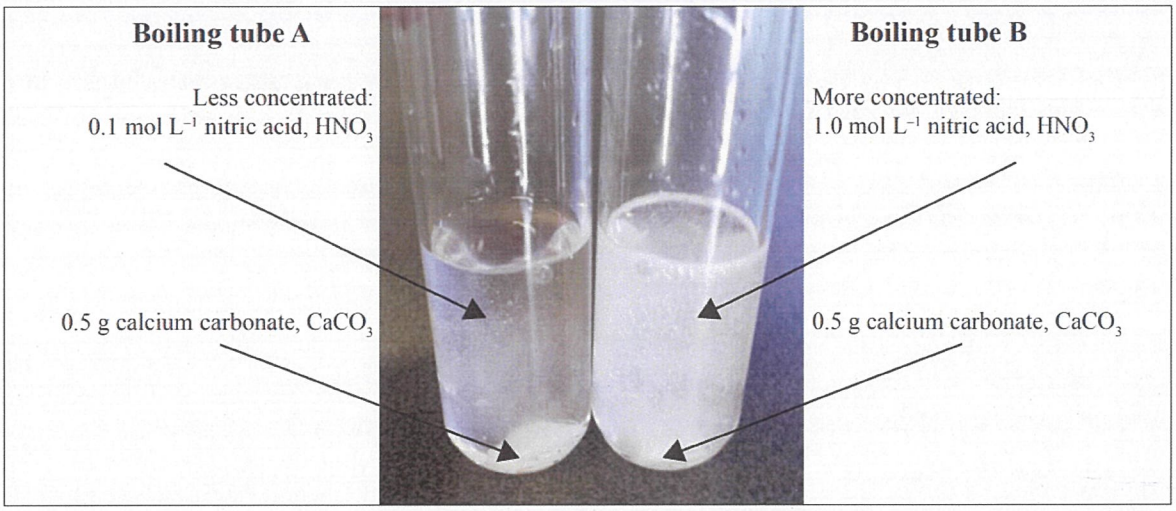
When these elements react, K loses one electron and forms a +1 ion, while Mg loses two electrons and forms a +2 ion, in order to adopt the stable electron configuration 2,8,8 and 2,8 respectively.

Hydroxide carries a charge of –1, therefore it requires one OH^- for each K^+ ion but two OH^- ions for each Mg^{2+} ion to form a neutral compound/ balance out the charges.

COLLATED QUESTIONS – REACTION RATES

2019:1

Two boiling tubes both contain 10 mL of nitric acid, HNO_3. Boiling tube A contains a 0.1 mol L^{-1} solution of nitric acid and boiling tube B contains a more concentrated 1.0 mol L^{-1} solution of nitric acid. A piece of marble chip (calcium carbonate, $CaCO_3$) with a mass of 0.5 g is added to each boiling tube and the reaction is observed and photographed. The temperature of the acid in both boiling tubes is 20°C



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

(b) Explain the effect of using a higher concentration of nitric acid on the rate of this reaction, compared to using a lower concentration of acid. Your answer should refer to particle collisions.

(c) In a second investigation, two different boiling tubes each contain 10 mL of the same concentration 1 mol L^{-1} nitric acid, HNO_3. The nitric acid in boiling tube A is at 20°C and the nitric acid in boiling tube B is at 40°C. A piece of marble chip (calcium carbonate, $CaCO_3$) with a mass of 0.5 g is added to each boiling tube, and the reaction is observed.
Explain the effect of increasing the temperature of the nitric acid from 20°C to 40°C on the rate of reaction. Your answer should refer to particle collisions.

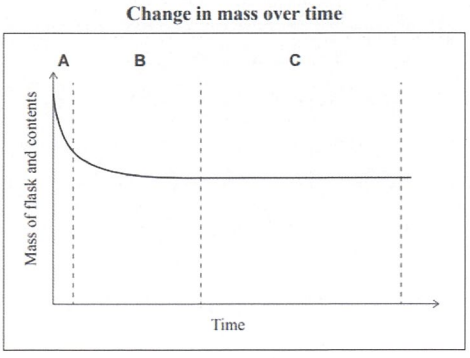
2018:3



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.

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



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

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

(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.

2017:1

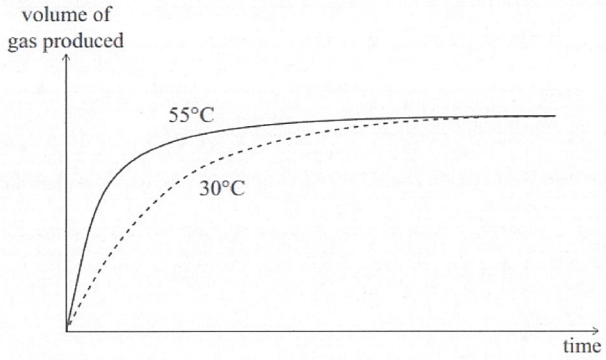
A sample of powdered sodium hydrogen carbonate ($NaHCO_3$) was added to sulfuric acid (H_2SO_4) in a flask, and fizzing was observed. Two experiments were carried out with the acid at different temperatures, using the same amount of powdered sodium hydrogen carbonate and the same concentration and volume of sulfuric acid:

Experiment	Temperature of acid, °C
1	30
2	55

(a) What caused the fizzing?

(b) Why was the fizzing fastest immediately after the sodium hydrogen carbonate had been added? Your answer should refer to particle collisions.

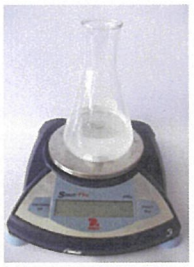
(c) The rate of reaction for each experiment was found by measuring the volume of gas produced over time, as shown in the graph below.



What is the effect of increasing temperature on the rate of reaction? Your answer should refer to particle collisions and explain why both lines finish at the same point.

(d) Write a word equation AND a balanced symbol equation for the reaction between sodium hydrogen carbonate ($NaHCO_3$) and sulfuric acid (H_2SO_4).

2016:2



A sample of calcium carbonate is added to dilute hydrochloric acid in an open conical flask. The total mass of the flask and contents is measured over time. Three experiments are carried out at 25°C using the same mass of calcium carbonate, and the same volume of acid:

	Calcium carbonate pieces	pH of acid
Experiment 1	Chips	1
Experiment 2	Powdered	1
Experiment 3	Powdered	5

(a) For each of the experiments reacting calcium carbonate and dilute acid together, the mass of the flask and its contents decreases over time. Describe why this happens.

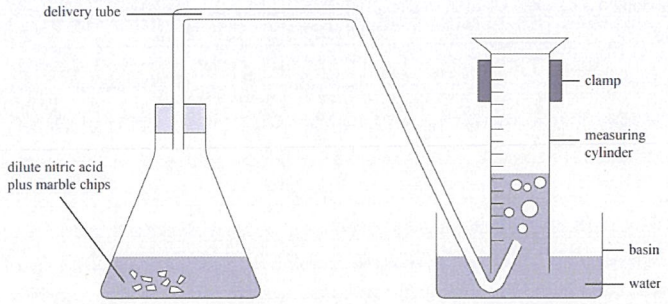
(b) (i) Identify the factor affecting the reaction rate being investigated in Experiments 1 and 2.

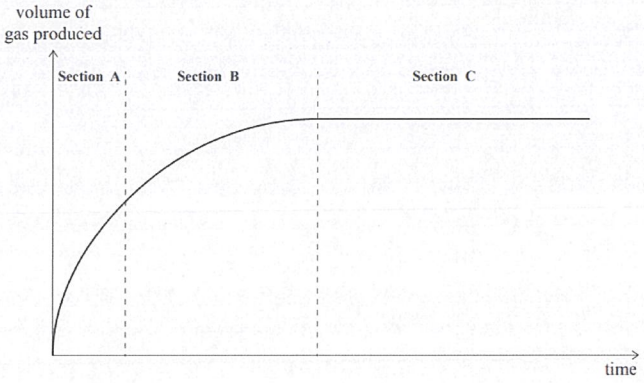
(ii) Explain how this factor affects the rate of reaction in the two flasks, with reference to particle collisions. Explain any observations, including changes in mass, over the course of Experiments 1 and 2 until the reactions are finished.

(c) Compare and contrast the rate of reaction of Experiments 2 and 3, with reference to particle collisions and the concentration of hydrogen ions in the solution.

2015:1

Marble chips (calcium carbonate) were added to nitric acid in a conical flask. The temperature of the acid was 50°C. The flask was connected to an inverted measuring cylinder in a basin of water to measure the volume of gas produced, as shown in the diagram below. The graph below shows the volume of gas produced against time.





(a) Explain what is happening in terms of particle collisions and rate of reaction in each section of the graph.

(b) The reaction was carried out again but this time at 20°C. The mass and size of the marble chips, and the concentration and volume of nitric acid used were kept the same.

(i) Draw a line on the graph that represents the reaction at 20°C.

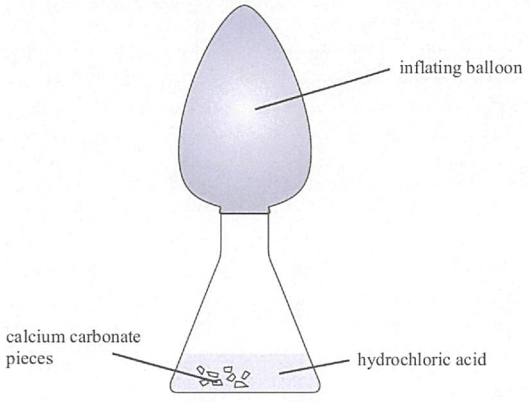
(ii) Explain why you drew this line where you did, and explain if this means that the rate of reaction is slower, the same, or faster. In your answer you should

- discuss why you drew your line with the slope that you did, and why you stopped the line at the point that you did
- explain the effect of temperature on reaction rate, in terms of particle collisions.

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

2014:2 BALLOONS

(a) Calcium carbonate pieces are placed in a flask and hydrochloric acid is added. Immediately a balloon is placed over the top of the flask. The balloon then starts to inflate.



(i) Explain why the balloon inflates.

In a second experiment, the same mass of calcium carbonate in a powdered form is used.

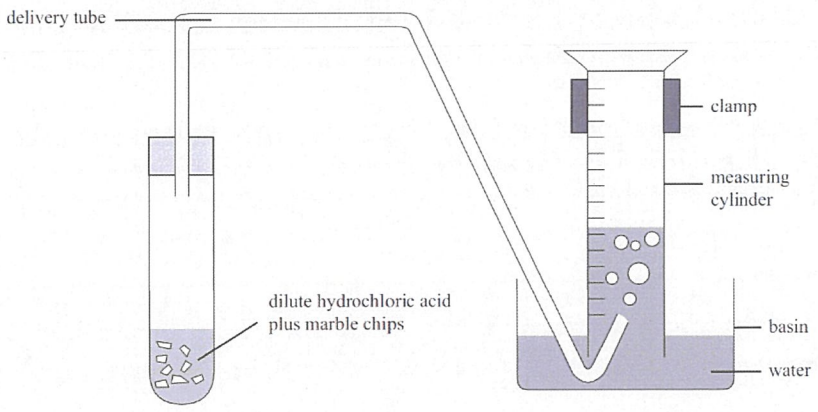
(ii) Explain why the balloon inflates faster when powdered calcium carbonate is used.

(b) Using the same chemical substances (calcium carbonate and hydrochloric acid), discuss a different way to make the balloon inflate faster. In your answer you should refer to rates of reaction and particle collisions.

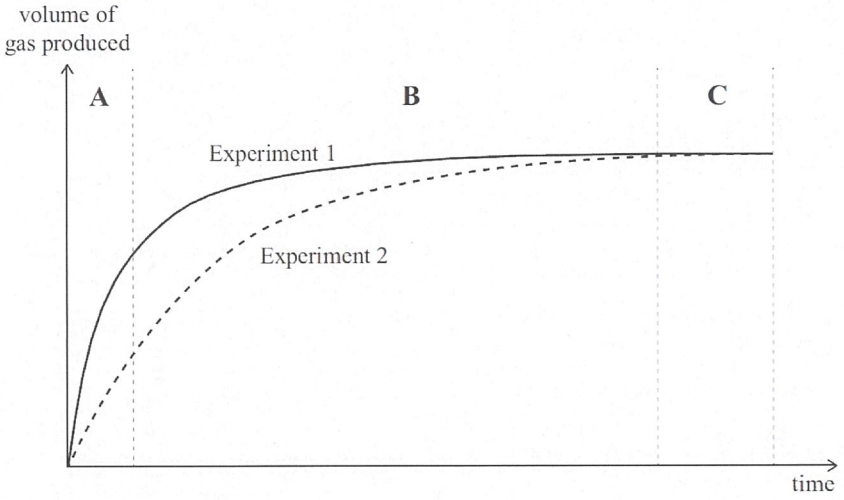
2013:3 REACTION RATES

The table below shows the size of marble chips (calcium carbonate) used in a chemical investigation into factors affecting rate of reaction.

Experiment	Size of marble chips (calcium carbonate)
Experiment 1	small marble chips
Experiment 2	large marble chips



The graph below shows the results for the volume of gas produced over a period of time.



(a) State what factor affecting the rate of reaction is being investigated in this experiment.

(b) Explain what is happening in Experiment 1 in sections A, B, and C of the graph in terms of reaction rate. In your answer you should refer to particle collisions.

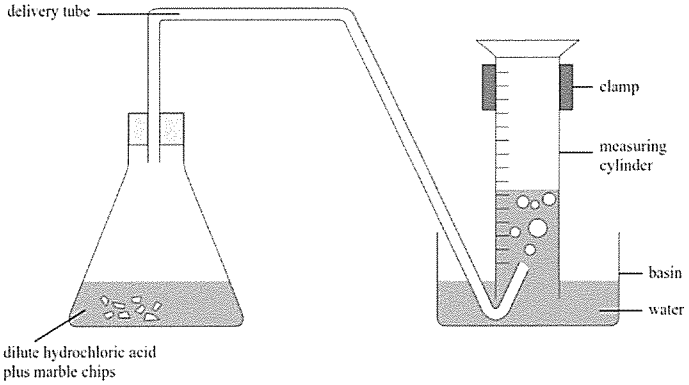
(c) Explain why Experiment 1 was faster than Experiment 2.
In your answer you should:

- explain how the graph shows that Experiment 1 is faster
- explain how the size of the marble chips affects the number of particle collisions.

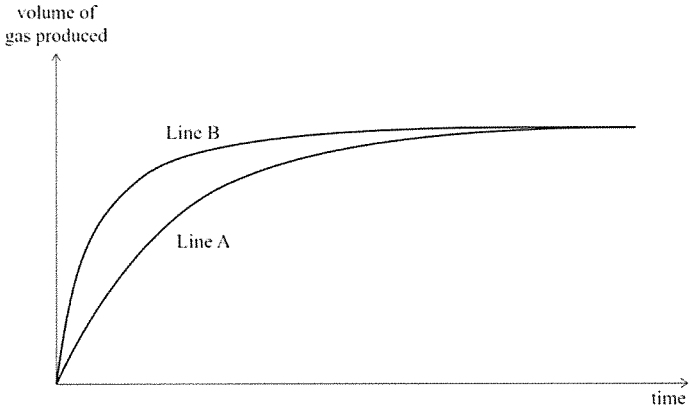
2012:4 REACTION RATES

The following experiment was carried out at 20°C and then repeated at 40°C.

Marble chips (calcium carbonate) were added to hydrochloric acid in a conical flask. The mass and size of marble chips, and the concentration and volume of hydrochloric acid used, were the same for both experiments. The flask was connected to an inverted measuring cylinder in a basin of water, as shown in the diagram below.



The volume of gas produced at the two different temperatures was measured for a few minutes and the results were used to sketch the graph shown below.



State which line on the graph represents the reaction at 40°C and explain how you worked this out.
In your answer you should:

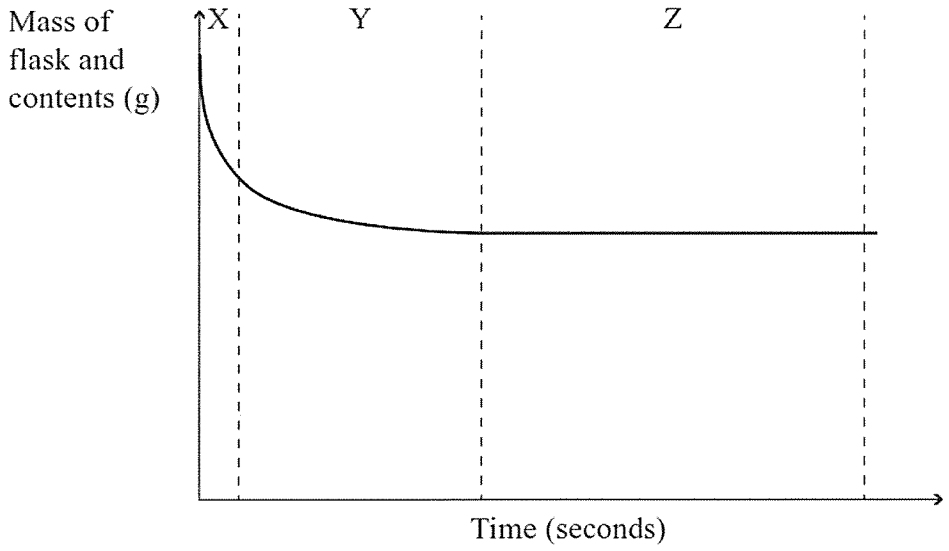
- identify which line represents the reaction at 40°C
- explain why the line you have identified is the reaction at 40°C
- give reasons for the different rates of reaction in terms of particles
- explain why both lines end up horizontal.

2011:2 RATES OF REACTION

Calcium carbonate (marble chips) and hydrochloric acid react together in a conical flask.
The word equation for this reaction is:

calcium carbonate + hydrochloric acid → calcium chloride + water + carbon dioxide gas

(a) Describe an observation you would make when this reaction occurs.
The mass of the flask and contents is measured on a scale over time and recorded on the graph shown below.



(b) Explain why the mass decreases with time.
In your answer you should:

- consider all the products being formed
- explain what is happening, in terms of particles AND the rate of reaction, in **each** section of the graph.

The mass decreases with time because……

In section X:
In section Y:
In section Z:

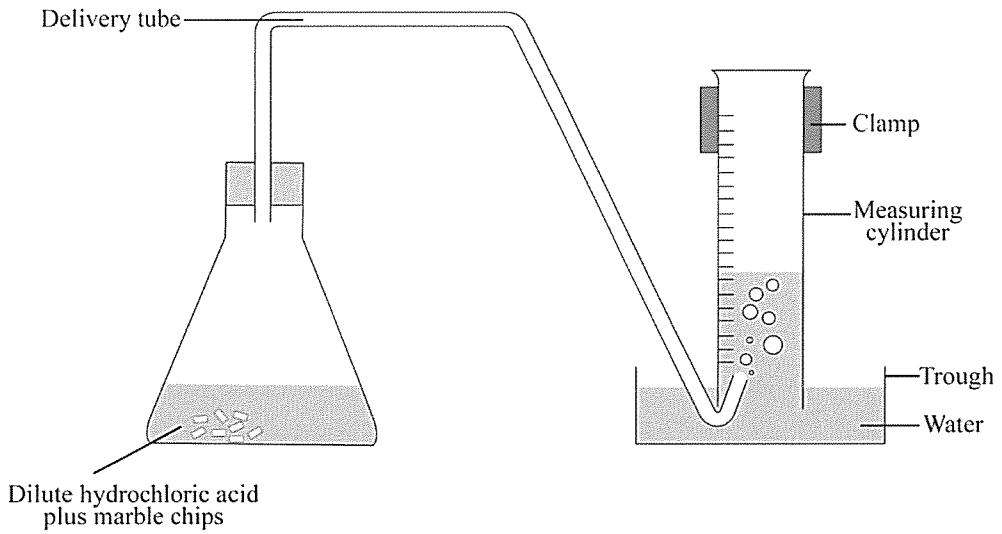
(c) When more concentrated hydrochloric acid is used, the reaction is faster.
Explain the difference in the rate of reaction. In your answer you should refer to:

- particles
- collisions
- reaction rate

2011:4 QUESTION FOUR: RATES OF REACTION (SAMPLE)

Marble chips (calcium carbonate) are added to dilute hydrochloric acid in a conical flask. The flask is connected to an inverted measuring cylinder in a trough of water, as shown in the diagram below.

The volume of gas produced is measured over a few minutes, and the results used to sketch a graph.



(a) The slope of the graph is steep at the beginning and then levels off over time.
Explain what is happening, in terms of particles, during the reaction.

(b) Complete the word and symbol equations below to show the reaction in the experiment.
Word equation:

Hydrochloric acid + calcium carbonate →

Balanced symbol equation:

$HCl + CaCO_3 \rightarrow$

(c) The experiment is repeated but this time the same mass of marble chips is crushed into a powder before it is added to the flask.
Discuss the effect on the reaction rate of using powdered marble with hydrochloric acid compared with using marble chips. In your answer, you should:

- compare the rates of reaction
- explain the differences in the reaction rate by discussing how crushing the marble chips affects the number of particle collisions.

COLLATED QUESTIONS – REACTION RATES
ANSWERS

2019:1

(a) Nitric acid + calcium carbonate → calcium nitrate + water + carbon dioxide
$2HNO_3 + CaCO_3 \rightarrow Ca(NO_3)_2 + H_2O + CO_2$

(b) When more concentrated acid is used, there are more acid particles / H^+ ions / nitric acid particles in (the same volume of) the acid. Because of this, there are more particles available to collide with the calcium carbonate particles. Because there are more to collide, more successful collisions occur per second or per unit time, and the rate of reaction is faster.

(c) As the temperature of the nitric acid increases, the particles move faster and have more (kinetic) energy. There are more collisions per second between the acid and the carbonate particles due to higher speed, and more of these collisions have enough energy to cause a reaction. Therefore, increasing the temperature will cause more successful collisions per second, and the reaction will occur faster.

2018:3

(a) Magnesium carbonate + nitric acid → magnesium nitrate + water + carbon dioxide
$MgCO_3 + 2HNO_3 \rightarrow Mg(NO_3)_2 + H_2O + CO_2$

(b) (i) One of the products is carbon dioxide gas. The gas escapes, and so the mass of the flask and its contents decreases.

(ii) When reactant particles collide successfully, they form product particles. As the reaction progresses, the number of reactant particles decreases, the frequency of successful collisions decreases, leading to a slower rate of reaction.
Section A: There are more reactant particles, so more collisions per second. More product particles are being formed, including more gas, so more gas escapes and the mass decreases quickly. Section B: There are fewer reactant particles, so fewer successful collisions per second and so less product is being made, so the mass decreases less quickly. Section C: The reaction has stopped as one of the reactants has been used up, so there are no more collisions between reacting particles.

(c) As the temperature of the nitric acid increases, the particles move faster and have more (kinetic) energy. There are more collisions per second between the acid and the carbonate particles due to higher speed, and more of these collisions have enough energy to cause a reaction. Therefore, increasing the temperature will cause more successful collisions per second, and the reaction will occur faster.

2017:1

(a) A gas / carbon dioxide released.

(b) The concentration of reactants is highest at the start of the reaction, i.e. greatest number of reactant particles per unit volume at the start. As a result, there is a higher frequency of successful / effective collisions at the start and therefore a faster rate of reaction than later as reactants run out.

(c) As the temperature increases from 30°C to 55°C, the reactant particles gain kinetic energy, i.e. the average kinetic energy of particles increases. This causes the particles to move more quickly, and therefore increases the frequency of collisions. In addition, more of the collisions are effective / successful because the particles have more energy / force. This leads to a faster rate of reaction. Since the same amounts of each reactant are used at both temperatures, the total volume of gas produced is the same for each temperature, and therefore both lines finish at the same point.

(d) Sodium hydrogen carbonate + sulfuric acid → sodium sulfate + water + carbon dioxide
$2NaHCO_3 + H_2SO_4 \rightarrow Na_2SO_4 + 2H_2O + 2CO_2$

2016:2

(a) The mass of the flask and its contents decreases over time because one of the products is carbon dioxide gas. Since the reaction takes place in an open conical flask, the mass of the CO_2 gas is lost to the surroundings.

(b) (i) Surface area.

(ii) The mass of the flask and its contents will decrease faster with the powder (experiment 2) compared to the chunks (experiment 1), and the gas production will be faster. This is because the powder has a larger surface area than the large chips, so more particles of calcium carbonate are exposed for the acid to react with / collide with, and therefore experiment 2 has a higher frequency of successful collisions, and subsequently a faster rate of reaction. Both reactions will get to the same mass, as both have the same amount of reactants and therefore release the same amount of CO_2, but at different rates.

(c) An acid with a pH of 1 has a higher $[H^+]$ than an acid with a pH of 5. Since experiment 2 has more H^+ ions per unit volume / a higher concentration of H^+ ions, it will have a higher frequency of successful collisions (more successful collisions per second) and subsequently a higher / faster rate of reaction.

2015:1

(a) As the reactant particles collide, they form product particles. As the reaction proceeds, there are fewer and fewer reactant particles left to collide, and so the rate of reaction becomes slower. At the start (section A) of the reaction, more product particles are being formed. This is because at the start of the reaction there are many particles present; therefore there will be many collisions, and the more collisions (per unit time), the faster the rate of reaction, and the more gas produced. In section B, there are now fewer (less) reactants, and so there are fewer collisions per second (unit time); therefore a slower rate of reaction and so less product is formed. In section C, the reaction has stopped, as one of the reactants (marble chips or nitric acid) has run out, so there are no particles left to react.

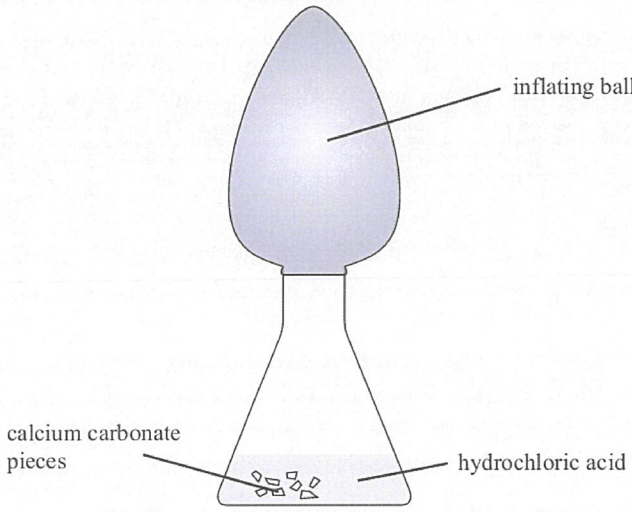
(b) A line is drawn with a less steep gradient but levelling out at the same volume of gas produced. The reaction is slower at the lower temperature, because the particles have less kinetic energy, and therefore are moving slower. When they are moving slower, there will be less frequent collisions, and less of these collisions will be effective, as the particles will collide with less energy. The line drawn represents this slower reaction, as it is less steep at the start. Both lines become horizontal at the same point on the Y-axis, as this is when both reactions have finished, i.e. one of the reactants has been completely used up and therefore no more gas is produced. Both finished with same amount of gas produced, as both reactions had the same amount of reactants to start with.

(c) nitric acid + calcium carbonate → calcium nitrate + carbon dioxide + water

$2HNO_3 + CaCO_3 \rightarrow Ca(NO_3)_2 + H_2O + CO_2$

2014: 2 BALLOONS

(b) Calcium carbonate pieces are placed in a flask and hydrochloric acid is added. Immediately a balloon is placed over the top of the flask. The balloon then starts to inflate.



(i) Explain why the balloon inflates.

When a metal carbonate reacts with an acid, carbon dioxide gas is released. This gas causes the balloon to inflate.

In a second experiment, the same mass of calcium carbonate in a powdered form is used.

(ii) Explain why the balloon inflates faster when powdered calcium carbonate is used.

It is faster when powder is used, because the surface area of the powder is greater. Because there is more surface area, there is more surface (exposed calcium carbonate particles) with which the HCl particles can collide. Because more collisions occur more frequently, the rate is faster, and CO_2 will be generated more quickly.

(b) Using the same chemical substances (calcium carbonate and hydrochloric acid), discuss a different way to make the balloon inflate faster. In your answer you should refer to rates of reaction and particle collisions.

One way of making the reaction occur faster is to increase the concentration of the acid used. When this happens there are more HCl particles in the same volume of acid, and therefore there is a greater chance of collisions occurring more frequently, and so the rate of reaction is faster. Because the rate is faster, CO_2 is produced more rapidly, and the balloon inflates faster.

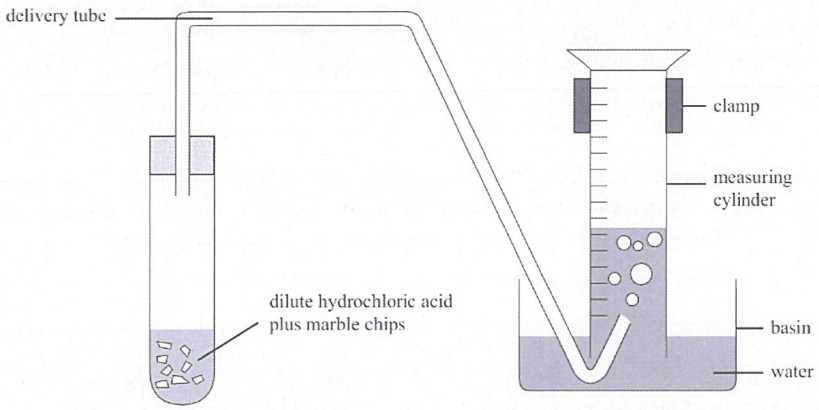
OR

The other way is to increase the temperature of the acid. When this happens, the HCl particles move faster; because they are moving faster, there is a greater chance of collisions occurring more frequently, and so the rate of reaction is faster. Because the rate is faster, CO_2 is produced more rapidly, and the balloon inflates faster.

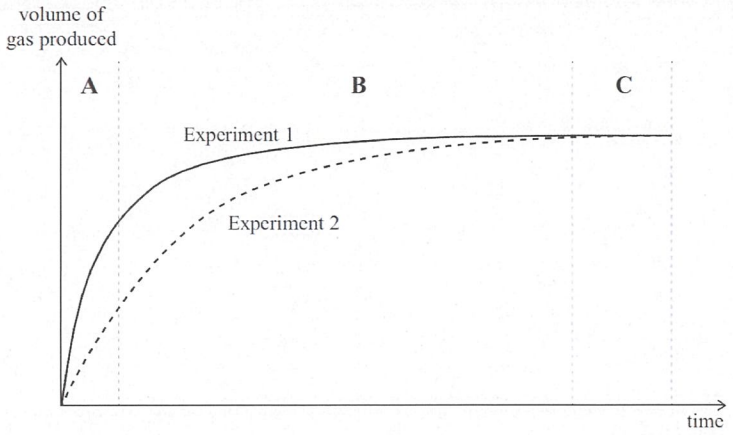
2013:3 REACTION RATES

The table below shows the size of marble chips (calcium carbonate) used in a chemical investigation into factors affecting rate of reaction.

Experiment	Size of marble chips (calcium carbonate)
Experiment 1	small marble chips
Experiment 2	large marble chips



The graph below shows the results for the volume of gas produced over a period of time.



(a) State what factor affecting the rate of reaction is being investigated in this experiment.
The factor being investigated is surface area of the calcium carbonate / marble chips.

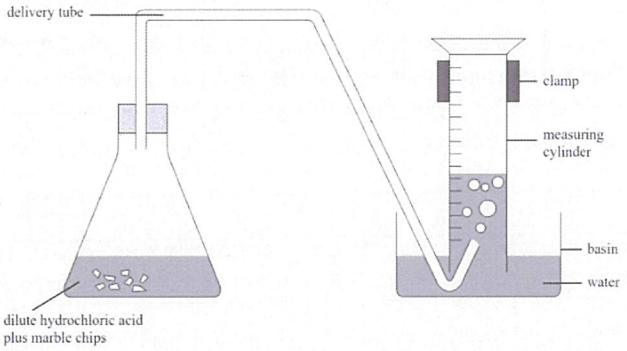
(b) Explain what is happening in Experiment 1 in sections A, B, and C of the graph in terms of reaction rate. In your answer you should refer to particle collisions.
In section A of the graph the rate is fastest as there are more collisions between the HCl and $CaCO_3$. This is because at the start of the reaction there are more particles available for collision. In section B the rate of reaction is slowing down as the number of particles available for collision is becoming fewer as some of the HCl and $CaCO_3$ have already collided and have been used up, therefore fewer particles and therefore fewer collisions.
In part C the reaction has stopped, as all of the reactants (or one of them) have reacted, and therefore there are no particles present that can collide and react.

(c) Explain why Experiment 1 was faster than Experiment 2.
In your answer you should:
- explain how the graph shows that Experiment 1 is faster
- explain how the size of the marble chips affects the number of particle collisions.

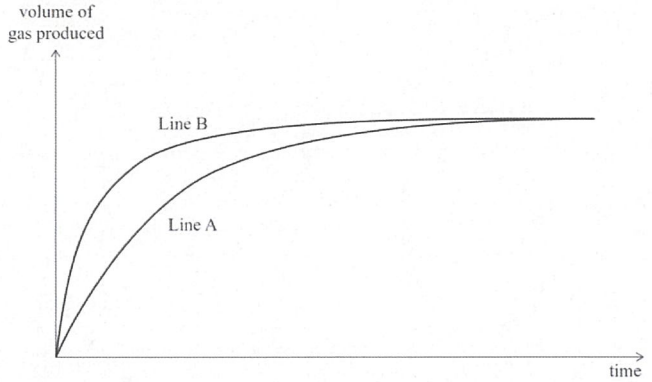
The rate of Experiment 1 is faster as the slope in section A of the graph is steeper than in Experiment 2. It is faster because when smaller chips are used, the surface area of the chips is greater. Because there is more surface area, there is more surface for the HCl particles to collide. Because there are more collisions occurring more frequently, the rate is faster.

2012:4 REACTION RATES

The following experiment was carried out at 20°C and then repeated at 40°C.
Marble chips (calcium carbonate) were added to hydrochloric acid in a conical flask. The mass and size of marble chips, and the concentration and volume of hydrochloric acid used, were the same for both experiments. The flask was connected to an inverted measuring cylinder in a basin of water, as shown in the diagram below.



The volume of gas produced at the two different temperatures was measured for a few minutes and the results were used to sketch the graph shown below.



State which line on the graph represents the reaction at 40°C and explain how you worked this out.
In your answer you should:

- identify which line represents the reaction at 40°C
- explain why the line you have identified is the reaction at 40°C
- give reasons for the different rates of reaction in terms of particles
- explain why both lines end up horizontal.

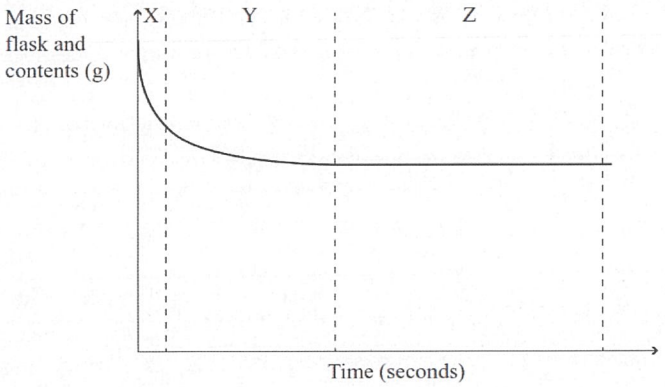
The reaction is faster at the higher temperature because the H+ ions have more kinetic energy, and therefore are moving faster. When they are moving faster, there will be more collisions, and more of these collisions will be effective, as the particles will collide with more energy.
Line B represents the faster reaction, as it is steeper at the start. This represents the reaction carried out at 40°C.
Both lines become horizontal at the same point on the Y-axis, as this is when both reactions have finished, i.e. one of the reactants has been completely used up and therefore no more gas is produced. Both finished with same amount of gas produced, as both reactions had the same amount of reactants to start with.

2011:2 RATES OF REACTION

Calcium carbonate (marble chips) and hydrochloric acid react together in a conical flask.
The word equation for this reaction is:

calcium carbonate + hydrochloric acid → calcium chloride + water + carbon dioxide gas

(a) Describe an observation you would make when this reaction occurs.
The mass of the flask and contents is measured on a scale over time and recorded on the graph shown below.



Fizzing / bubbling occurs, marble chips decrease in size.

(b) Explain why the mass decreases with time.
In your answer you should:

- consider all the products being formed
- explain what is happening, in terms of particles AND the rate of reaction, in **each** section of the graph.

The mass decreases with time because.....

In section X:
In section Y:
In section Z:

Why mass decreases
The marble chips decreases as one of the products is CO_2 gas. This gas escapes and so the mass of the flask and contents is reduced.
What's happening
As the reactant particles collide, they form product particles. As the reaction proceeds, there are fewer and fewer reactant particles left to collide and so the rate of reaction becomes slower.
At the start (section X) of the reaction, more product particles are being formed, then more gas is being formed, therefore more gas escapes at first and so the mass of the flask and contents decreases more rapidly. At X, the rate of reaction is fast but decreasing with time.
In section Y there are now fewer (less) reactants and so there are fewer collisions per second (unit time) and so less product is formed, ie less gas being released, so the mass does not decrease as rapidly. At Y, the rate of reaction is slow and slowing.
In section Z the reaction has stopped, as one of the reactants (marble chips or HCl) has run out, so there are no particles left to react.

(c) When more concentrated hydrochloric acid is used, the reaction is faster.

Explain the difference in the rate of reaction. In your answer you should refer to:

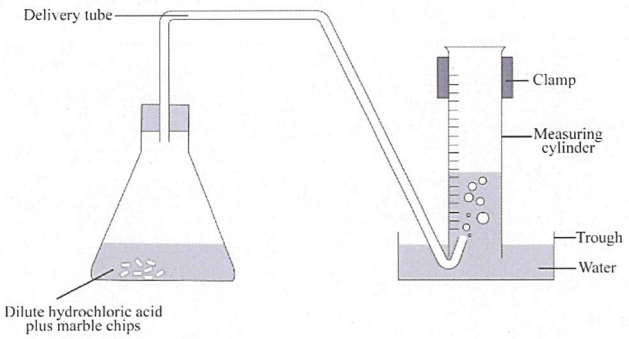
- particles
- collisions
- reaction rate

When more concentrated acid is used, there are more acid particles in the same volume of the acid. Because of this, there are more particles to collide with the calcium carbonate. Because there are more to collide, the rate of reaction is faster (as more collisions/ unit time).

2011:4 QUESTION FOUR: RATES OF REACTION (SAMPLE)

Marble chips (calcium carbonate) are added to dilute hydrochloric acid in a conical flask. The flask is connected to an inverted measuring cylinder in a trough of water, as shown in the diagram below.

The volume of gas produced is measured over a few minutes, and the results used to sketch a graph.



(d) The slope of the graph is steep at the beginning and then levels off over time.
Explain what is happening, in terms of particles, during the reaction.

Explanation of leveling of graph:
As the reactant particles collide, they are converted into product particles. Initially many gas molecules are produced, but as the reaction proceeds there are fewer and fewer reactant particles available to collide, so the volume of gas produced decreases and eventually no gas is produced.
(Most likely the supply of H+ ions in the solution will be exhausted before the marble chips disappear.)

(e) Complete the word and symbol equations below to show the reaction in the experiment.
Word equation:

Hydrochloric acid + calcium carbonate →

Hydrochloric acid + calcium carbonate → calcium chloride + water + carbon dioxide

Balanced symbol equation:

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

(f) The experiment is repeated but this time the same **mass** of marble chips is crushed into a **powder** before it is added to the flask.

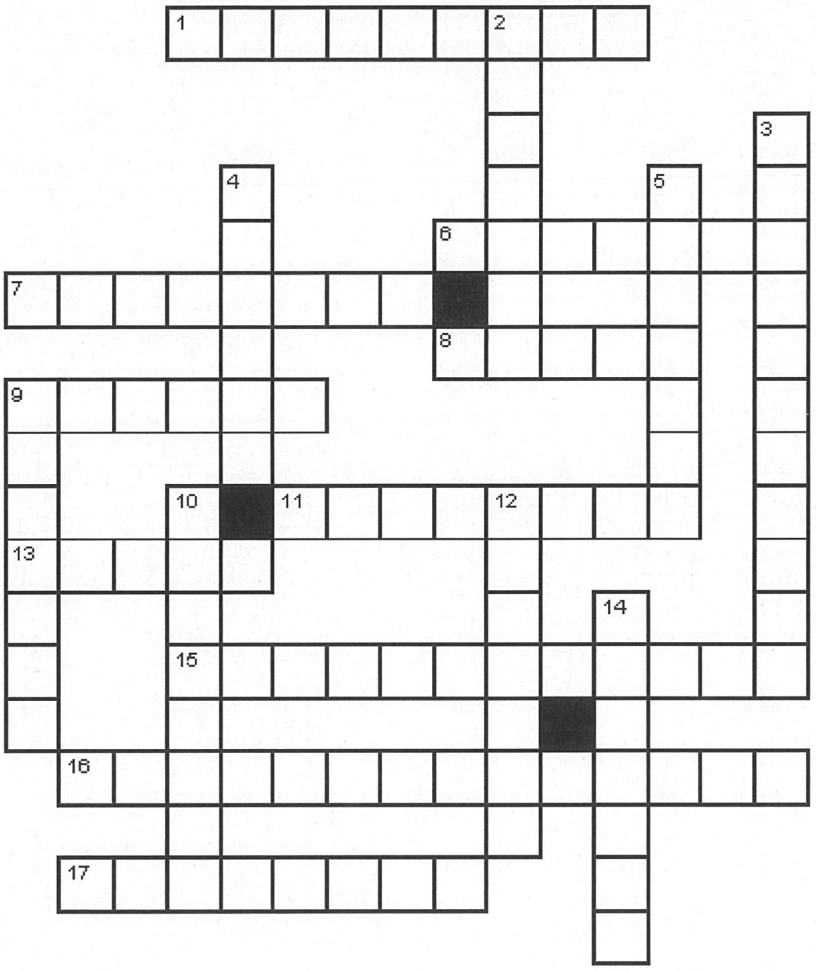
Discuss the effect on the reaction rate of using powdered marble with hydrochloric acid compared with using marble chips. In your answer, you should:

- compare the rates of reaction
- explain the differences in the reaction rate by discussing how crushing the marble chips affects the number of particle collisions.

Comparison of rates of reaction:
The reaction rate will be faster with the powdered marble than when the chips were used. More gas will be produced each minute. The reaction itself will be completed in a shorter period of time.
Explanation of effect:
There are more reactant particles immediately available to react because the surface area of the powder is greater than that of the chip. There is greater exposure of the marble particles so there are more available for the acid particles / hydrogen ions / H^+ ions to collide with.
This means there will be more (effective) collisions per second / more frequent collisions between the acid particles and the ions in the calcium carbonate powder, leading to an increase in the rate of the reaction and the reaction will be completed sooner.

Atomic Structure

www.science-teachers.com/physical.htm



Across

1 Isotope of hydrogen with one neutron. (9)

6 When two atoms of different elements combine chemically, what does it produce? (7)

7 The lightest element. (8)

8 Elements that lend electrons in chemical reactions. (5)

9 A nuclear reaction in which the nucleus of two atoms combine to form one nucleus. (6)

11 Helium, neon, argon, or krypton. (5,3)

13 Where electrons reside in the atom. (5)

15 The most common isotope of carbon. (6,6)

16 The isotope of carbon that is used for dating things in archeology. (6,8)

17 Elements that borrow electrons in chemical reactions. (8)

Down

2 An atom of an element with a different number of neutrons in the nucleus. (7)

3 Unstable. (11)

4 Positively charged particle in the nucleus. (6)

5 The center of an atom. (7)

9 A nuclear reaction in which an atom's nucleus splits to form two new atoms. (7)

10 Negatively charged particle. (8)

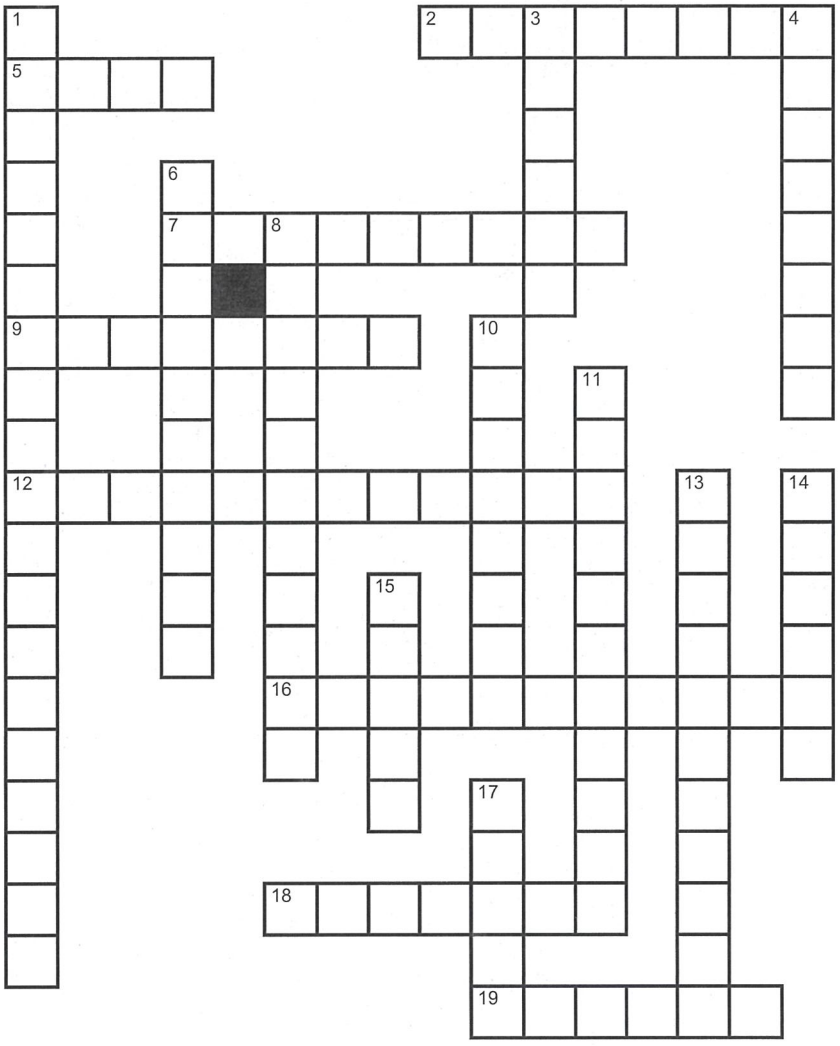
12 Isotope of hydrogen with two neutrons. (7)

14 Particle with no charge. (7)



Atomic Valence

www.science-teachers.com/physical.htm



Down

1 The group of metals with a valence of positive two. (8,5,6)

3 Atoms that lend electrons. (6)

4 Ionic bonds usually _____ in water. (8)

6 A group of gases that have a valence of zero. (5,5)

8 The valence of chlorine. (8,3)

10 A bond where electrons are shared instead of lent and borrowed. (8)

11 The valence of sodium. (8,3)

13 The valence of magnesium. (8,3)

14 nonmetals _____ electrons when they form compounds. (6)

15 Number of electrons in most stable outer shells. (5)

17 A bond where atoms are lent or and borrowed. (5)

Across

2 What two atoms produce when they combine. (8)

5 Metals _____ electrons when they form compounds. (4)

7 Atoms that borrow electrons. (9)

9 A gas with a valence from -3 to +5. (8)

12 The group of metals with a valence of positive one. (6,6)

16 The valence of oxygen. (8,3)

18 The ability of an atom to borrow or lend electrons. (7)

19 An atom with four electrons in its outer shell that forms covalent bonds. (6)

