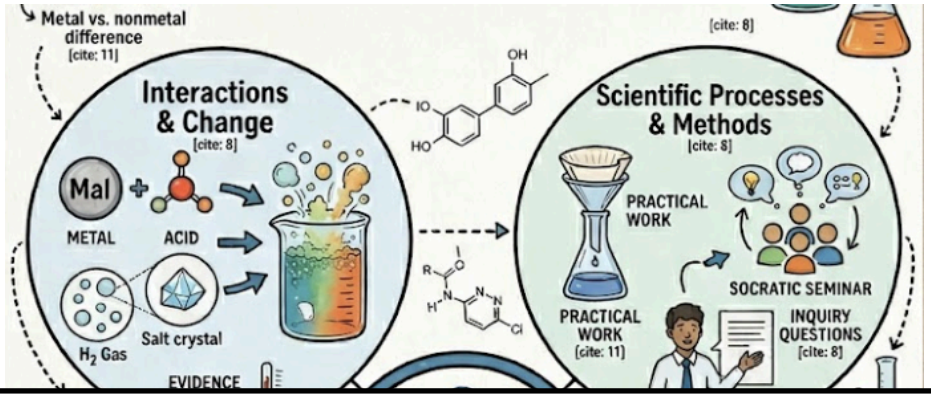
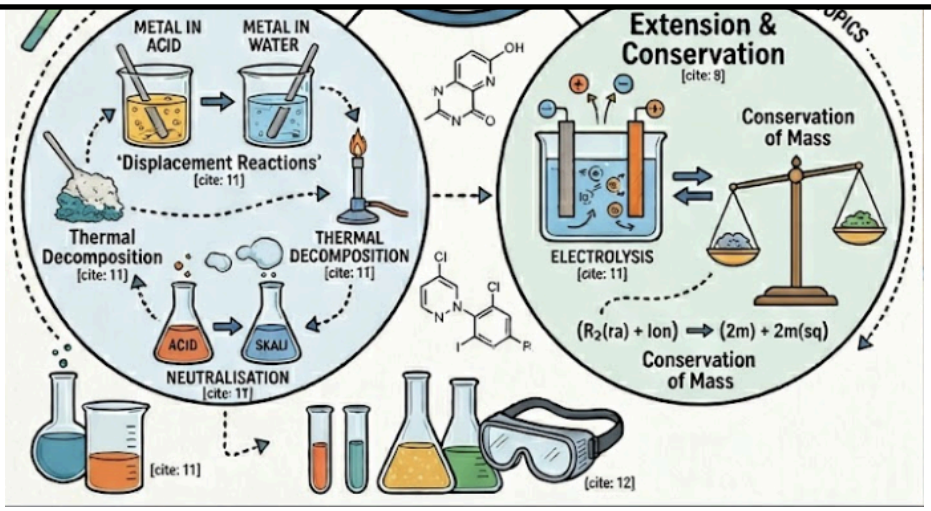
Middle Years Programme

Name:	Class:



Reactivity

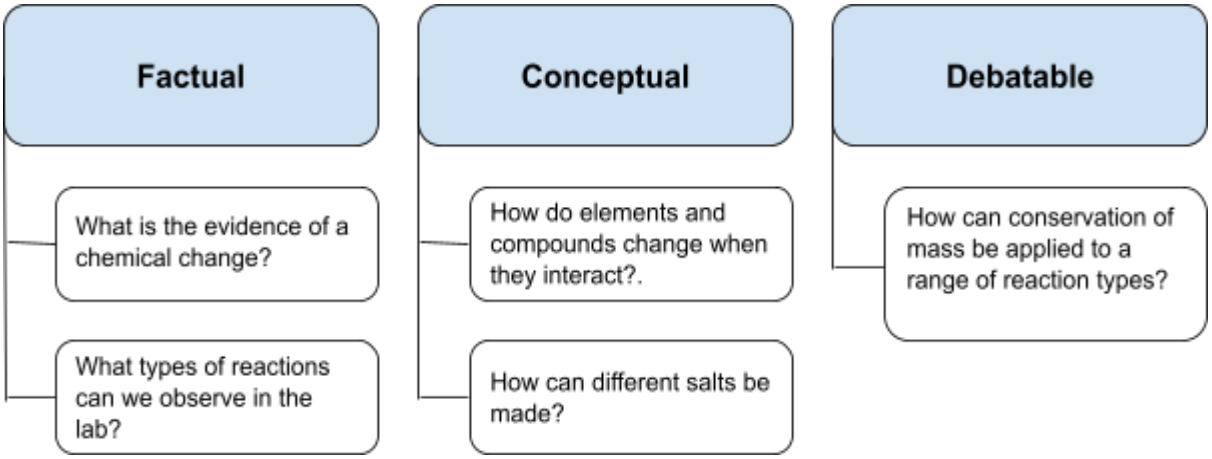


Lesson No.	Content	Lesson No.	Content
1	Acids, Bases & Indicators	8	Making Salts
2	Neutralisation	9	Displacement
3	Periodic Table	10	Precipitation Reactions
4	Word and Symbol Equations	11	Thermal Decomposition
5	Rocket Investigation	12	Electrolysis
6	Metals in Water	13	Revision
7	Metals in Acid	14	Criteria A Assessment

(2026-2027)

Statement of Inquiry: When substances interact, there is evidence that they change as a result of scientific processes

In this unit, we will consider these questions:



These concepts will be covered…

Key concept: Change

Related concepts: Interaction, Evidence

Global Concept: Scientific and technological innovations

This unit will give the opportunity to improve in these skills…

- Communication skills
- Critical-thinking skills

Assessment opportunities in this unit include…

Criterion A: Knowing and Understanding

The Periodic Table of the Elements

1	2											3	4	5	6	7	0
							1 **H** hydrogen 1										4 **He** helium 2
7 **Li** lithium 3	9 **Be** beryllium 4											11 **B** boron 5	12 **C** carbon 6	14 **N** nitrogen 7	16 **O** oxygen 8	19 **F** fluorine 9	20 **Ne** neon 10
23 **Na** sodium 11	24 **Mg** magnesium 12											27 **Al** aluminium 13	28 **Si** silicon 14	31 **P** phosphorus 15	32 **S** sulfur 16	35.5 **Cl** chlorine 17	40 **Ar** argon 18
39 **K** potassium 19	40 **Ca** calcium 20	45 **Sc** scandium 21	48 **Ti** titanium 22	51 **V** vanadium 23	52 **Cr** chromium 24	55 **Mn** manganese 25	56 **Fe** iron 26	59 **Co** cobalt 27	59 **Ni** nickel 28	63.5 **Cu** copper 29	65 **Zn** zinc 30	70 **Ga** gallium 31	73 **Ge** germanium 32	75 **As** arsenic 33	79 **Se** selenium 34	80 **Br** bromine 35	84 **Kr** krypton 36
85 **Rb** rubidium 37	88 **Sr** strontium 38	89 **Y** yttrium 39	91 **Zr** zirconium 40	93 **Nb** niobium 41	96 **Mo** molybdenum 42	[98] **Tc** technetium 43	101 **Ru** ruthenium 44	103 **Rh** rhodium 45	106 **Pd** palladium 46	108 **Ag** silver 47	112 **Cd** cadmium 48	115 **In** indium 49	119 **Sn** tin 50	122 **Sb** antimony 51	128 **Te** tellurium 52	127 **I** iodine 53	131 **Xe** xenon 54
133 **Cs** caesium 55	137 **Ba** barium 56	139 **La*** lanthanum 57	178 **Hf** hafnium 72	181 **Ta** tantalum 73	184 **W** tungsten 74	186 **Re** rhenium 75	190 **Os** osmium 76	192 **Ir** iridium 77	195 **Pt** platinum 78	197 **Au** gold 79	201 **Hg** mercury 80	204 **Tl** thallium 81	207 **Pb** lead 82	209 **Bi** bismuth 83	[209] **Po** polonium 84	[210] **At** astatine 85	[222] **Rn** radon 86
[223] **Fr** francium 87	[226] **Ra** radium 88	[227] **Ac*** actinium 89	[261] **Rf** rutherfordium 104	[262] **Db** dubnium 105	[266] **Sg** seaborgium 106	[264] **Bh** bohrium 107	[277] **Hs** hassium 108	[268] **Mt** meitnerium 109	[271] **Ds** darmstadtium 110	[272] **Rg** roentgenium 111	Elements with atomic numbers 112–116 have been reported but not fully authenticated						

Key

relative atomic mass
atomic symbol
name
atomic (proton) number

**** The lanthanoids (atomic numbers 58–71) and the actinoids (atomic numbers 90–103) have been omitted.***

The relative atomic masses of copper and chlorine have not been rounded to the nearest whole number.

Acids and Bases Introduction

Acids

Most people are familiar with acids and some of the things that acids do, such as reacting with metals and causing burns if they come in contact with the skin.

Find out where these acids are found and write your answers in this table.

Acids	Places where found
acetic acid (ethanoic acid)	
formic acid (methanoic acid)	
citric acid	
oxalic acid	
hydrochloric acid	
tartaric acid	
lactic acid	

You may have been surprised to see hydrochloric acid in that list. It is used by the body to digest food. It is of course very dilute. Even the 'dilute acid' in the laboratory is much more concentrated.

In the **laboratory**, the main acids used are:

Acid	Chemical formula	
hydrochloric acid	HCl	These are used a lot
nitric acid	HNO_3	
sulfuric acid	H_2SO_4	
phosphoric acid	H_3PO_4	These are sometimes used
carbonic acid	H_2CO_3	
nitrous acid	HNO_2	
sulfurous acid	H_2S0_3	

Bases

You may not be so familiar with the group of chemicals called ***BASES***. Bases are the chemical opposites of acid. They are oxides or hydroxides of metals. Some of the bases normally found in the laboratory are shown in the table below.

Bases	Chemical formula	solubility
copper(II) oxide	CuO	These bases are *insoluble* in water
iron(II) oxide	FeO	
zinc oxide	ZnO	
sodium hydroxide	NaOH	These bases are *soluble* in water
potassium hydroxide	KOH	
calcium hydroxide	$Ca(OH)_2$	

The bases that dissolve in water are given a special name. They are called ***ALKALIS***. Sodium hydroxide, potassium hydroxide, and calcium hydroxide are all *ALKALIS*. One other alkali which is a little unusual is ammonium hydroxide, NH_4OH. It does not contain a metal like the other bases but is a solution of ammonia gas (NH_3) in water.

pH Indicators

Aim:

To describe the use of litmus, universal indicator & phenolphthalein to identify acids & alkalis

Background Scientific Information:

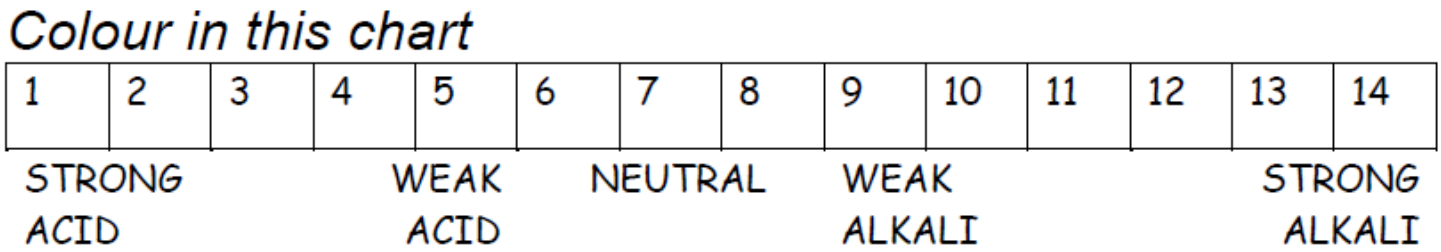
The presence of acids or alkalis may be shown using ***INDICATORS.*** An indicator changes from one colour when mixed with an acid, to another colour when mixed with an alkali.

e.g. litmus, methyl orange and phenolphthalein

pH and the strength of acids and alkalis

Different acids have different strengths, e.g. sulphuric acid is a strong acid and citric acid is a weak acid. The same applies to alkalis. Some are strong, some are weak. Sometimes it is useful to know the strength of acids or alkalis. Unfortunately, indicators such as litmus, methyl orange and phenolphthalein do not tell us which acids and alkalis are strong and which are weak. However, there is another indicator called Universal Indicator that can be used to tell the difference between strong and weak acids and alkalis.

Universal Indicator gives a different colour depending on the strength of the acid or alkali. The colour can be compared with a chart from which you can read a number known as the pH number.



Method:

1. Quarter fill three test tubes with distilled water.
2. Add a few drops of universal indicator to this first test tube and record the colour in the table below.
3. Repeat using the phenolphthalein indicator.
4. Line up one small piece of red and one small piece of blue litmus paper on a white tile.
6. Using a glass rod, take a drip of distilled water from the third test tube and place this onto both pieces of litmus paper. Record the colour of both pieces of paper in the table. Rinse the glass rod each time.

7. Repeat the experiment by quarter filling three new test tubes with the other substances listed in the table below. Only test one substance at a time.

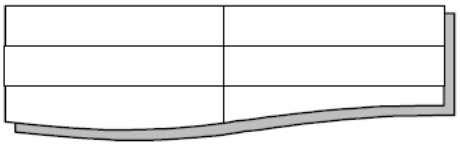
Results:

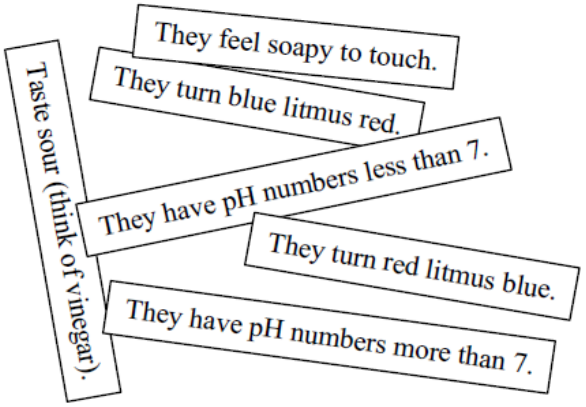
Substance to be tested	Colour with universal indicator (UI) solution	Colour with phenolphth-alein solution	Colour of red litmus paper after adding substance	Colour of blue litmus paper after adding substance	pH	Type of substance
hydrochloric acid (teacher demo)						
distilled water						
sodium hydroxide						
salt solution						
lemon juice						
vinegar						
washing powder in solution						

Acids, Alkalis and Indicators - EXTENSION

1. The sentences on the right are to do with acids and alkalis. Three describe acids, and the other three describe alkalis.

   Make a table with the headings shown below, then copy the sentences into the correct columns. You will need four lines in your book.





2. Acids and alkalis often have one of these hazard symbols on the bottle.

   Copy the symbols into your book. Find out what each one means. Write down what they mean next to the symbols in your book.

3. For each of these substances, write down whether they are:

   strongly acidic, **weakly acidic**, **neutral**, **weakly alkaline**, or **strongly alkaline**.

   a) grapefruit juice, pH 3.0
   b) blood, pH 7.4
   c) beer, pH 5.0
   d) rain, pH 6.2
   e) sea water, pH 8.5
   f) saliva, pH 7.0

4. Universal indicator paper has the following range of colours:

colour	red	orange	yellow	green	blue	purple
pH	0 – 4	5	6	7	8 – 10	11 – 14

   An experiment to find the pH of some substances gave these results:

substance	**colour of universal indicator paper**
orange juice	red
egg white	blue
oven cleaner	purple
milk	yellow

   For **each** substance, write down the **name** of the substance, its **pH**, and what the pH **means**.

5. Copy the table below into your book. Complete your table to show the colour that each indicator turns (if it does) in acidic, neutral and alkaline solutions.

	blue litmus paper	red litmus paper	universal indicator
acidic			
neutral			
alkaline			

6. Write a brief description of an experiment you have done to find out whether different substances are acidic, neutral or alkaline. You can do a diagram to help your answer if you want to.

Space for notes about acids, alkalis and indicators

Neutralisation

Aim

Recall that neutralisation reactions produce heat (thermal energy) (are exothermic). Describe how to use the temperature rise to determine the point of neutralisation of an acid and an alkali. Draw a line graph of experimental results with straight lines of best fit. Make a conclusion by explaining what your results show.

Introduction

When an **acid** reacts with an **alkali** a **neutralisation** reaction occurs:

acid + alkali → salt + water

Suggest, using previous knowledge, how you could find the volume of acid needed to exactly neutralise 20cm^3 of an alkali.

.....

.....

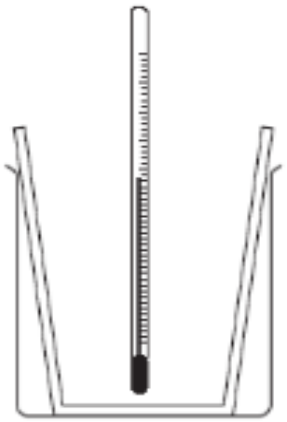
.....

Neutralisation reactions **produce heat** and the temperature rises during the reaction. The reactions are said to be **exothermic**. This heat can also be used to determine the volume of acid required for neutralisation.

What to do:

1. Obtain a polystyrene cup with a lid and sit it in a 250cm^3 beaker to give it stability.
2. Use a 25cm^3 measuring cylinder to carefully measure out 20cm^3 of sodium hydroxide solution and pour this into the polystyrene cup.
3. Record the temperature of the alkali.
4. Using a 10cm^3 measuring cylinder carefully measure out 5cm^3 of hydrochloric acid solution. Pour this into the sodium hydroxide solution and stir.
5. Record the new temperature.
6. Repeat steps 4 & 5 until you have added a total of 40cm^3 of hydrochloric acid.

You need to measure out the 5cm^3 portions of acid and add them *as quickly as possible* to obtain the most accurate temperature change.



Materials required

Polystyrene cups + lids
250cm^3 beakers
Thermometers
25cm^3 and 10cm^3 measuring cylinders
Glass rod
2 teat pipettes
1M hydrochloric acid
1M sodium hydroxide

Safety:

Sodium hydroxide is corrosive
Hydrochloric acid is an irritant
Wear safety goggles

9C 2a

Results:

Volume of sodium hydroxide used =

Volume of acid added (cm^3)	Temperature of solution (°C)
0	
5	
10	
15	
20	
25	
30	
35	
40	

Analysis of your results:

1) Why was a polystyrene cup used in the experiment rather than a glass beaker?

.....

.....

.....

2) Plot a graph of volume of acid (x-axis) vs temperature of solution (y-axis) Draw **TWO** best fit straight lines through the points, starting from both ends of the graph, meeting at a peak. The point where the lines cross on the graph indicates the maximum temperature reached in the experiment.

3) What was the maximum temperature in your experiment (***from the graph***)?

.....

4) What volume of hydrochloric acid exactly neutralised the $20cm^3$ of sodium hydroxide solution? How can you tell?

.....

.....

.....

5) What was the reacting ratio of volume of sodium hydroxide: volume of hydrochloric acid?

.....

6) Why did the temperature start to fall after neutralisation?

.....

.....

.....

7) Write a word equation for the reaction.

.....

8) The chemical equation for this reaction is:

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

This equation shows a ratio of **1** HCl reacting with **1** NaOH. Does this agree with what you obtained in the experiment? Explain.

.....

.....

.....

9) Suggest 3 reasons that the results of this experiment are not totally accurate, and suggest ways to improve the accuracy.

(i).....

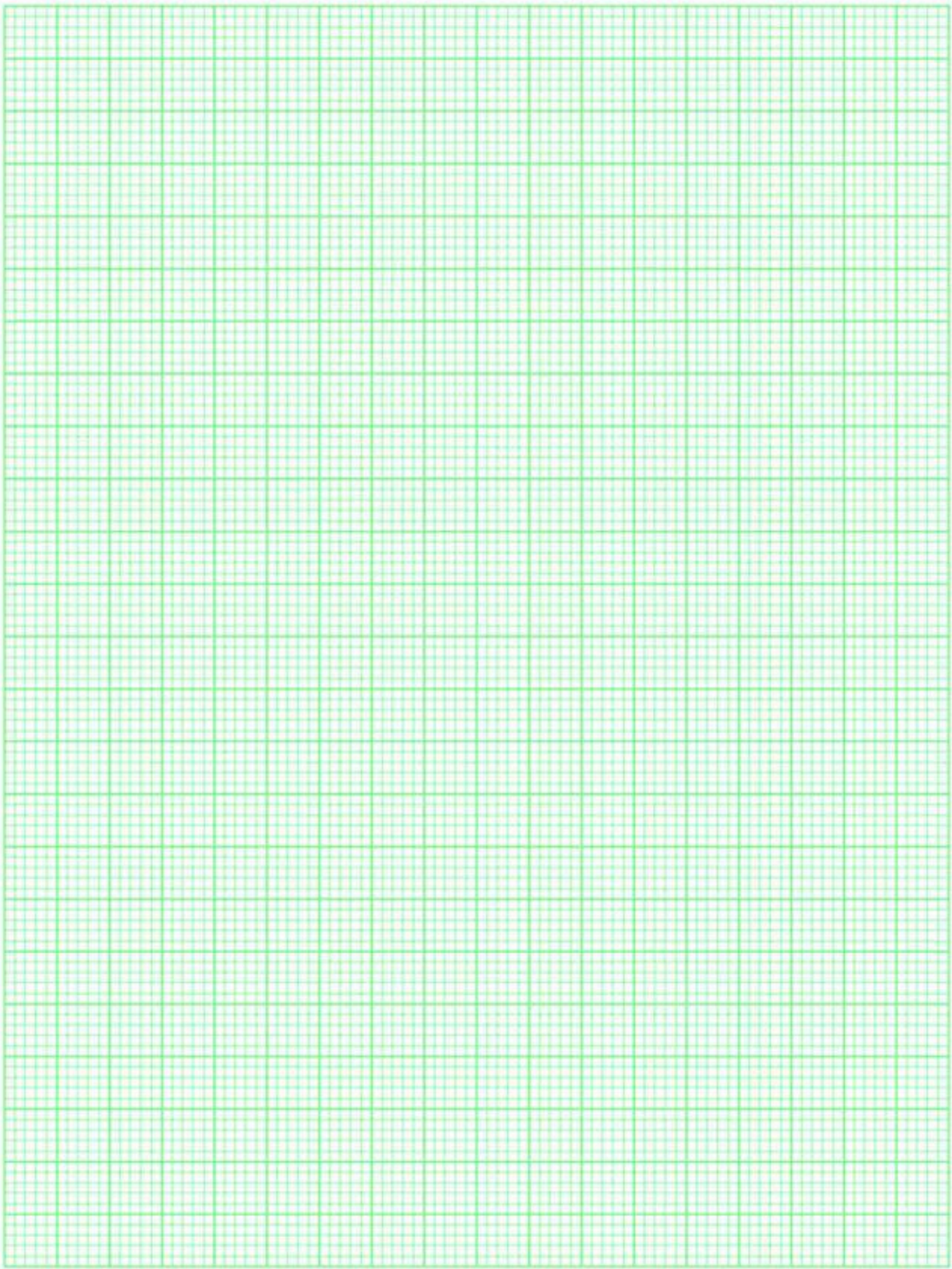
.....

(ii).....

.....

(iii).....

.....

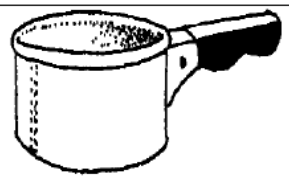
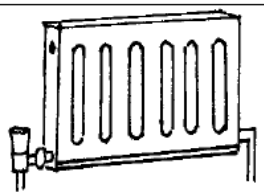
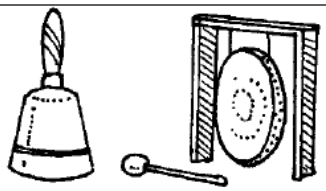
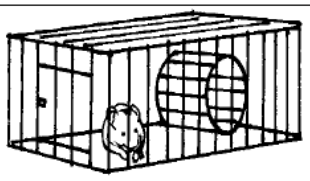
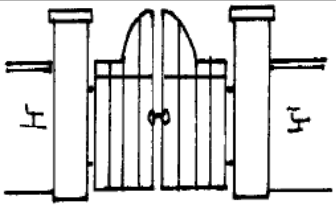
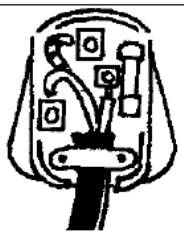


Properties of Metal and Non Metal Elements

Your task is to fill this table to compare the properties of metals and non-metals. You might use the internet. (*This is a revision of work you did in Year 8.)*

Property	Metal	Non-metal
Are they usually **solids, liquids or gases** at room temperature?		
Do they usually **have high or low melting points**?		
Do they usually **conduct electricity**?		
Do they usually **conduct heat?** (i.e. **conductor** or **insulator**)		
Are they usually **flexible** or **brittle**?		
Can they usually be shaped by hitting them with a hammer? This property is called **malleability**.		
Sonorous - do they make a **sound** if you hit them?		
Are they usually **magnetic**?		
Are their **oxides** usually **acids or bases**? (Remember an alkali is a soluble base.)		

Metals in the Home Card Activity

	this hamster is kept in its cage by thin metal bars	strong
	copper, steel and aluminium are used for saucepans	malleable – can be bent into different shapes
	ladders are often made from aluminium	shiny
	the pins and cables in this plug are metal	strong but lightweight
	iron is used to make garden gates	good conductor of heat
	jewellery is made from different metals	ductile – can be stretched into thin wires
	bells and gongs are made of metal	good conductor of electricity
	radiators are made of metal	sonorous – they ‘ring’ when hit

Marketing Metals - Making and Presenting Task Sheet

Aim: Formulate a link between uses of metals and their properties. Suggest why particular metals are used for certain purposes. Present information clearly and logically

We use metals for so many things but why is that?

For example, why do we use metals to make saucepans or church bells?

Why are car bodies made of so much metal?

Imagine you have just discovered a metal; the world has never seen any metals before.

Your Task:

Design an advertising poster which will tell everyone exactly what metals are and what they can be used for.

- ❏ Include the properties all metals have.
- ❏ Also include properties only some metals have, giving specific examples.
- ❏ Link each property to a possible use, giving examples of where they could be used (obviously they already are, but just pretend!).
- ❏ Give reasons OR explanations OR use detailed scientific knowledge for why metals would be good for the uses you suggest.

The detail you give will depend on the level you are working at:

- *'reasons' .....**novice** level*
- *'explanations' .....**confident** level*
- *'detailed scientific knowledge'.....**expert** level*

Use the 'ECN' Learning Ladder on the next page to help you do your best.

Use your own words throughout the project and ensure any external sources of information are referenced accurately.

'ECN' LEARNING LADDER

Assessment level	The types of things you can do:
Expert	• Design a detailed poster, drawing on detailed scientific knowledge and understanding. • Explain at least seven properties of metals. • Link these properties to uses of metals, using some particle diagrams to explain why they are suitable. • Compare the suitability of metals for uses, considering more than one property. • Use a range of scientific words, symbols and units accurately.
Confident	• Design a poster, drawing on scientific knowledge and understanding. • Explain at least five properties of metals. • Link these properties to uses of metals. • Explain why some metals with the same properties may be better than others at given jobs. • Use a range of appropriate scientific words, symbols and units.
Novice	• Design a simple poster, drawing on some scientific knowledge and understanding. • Describe at least three properties of metals. • State roles that metals are suitable for, giving a reason. • State why some metals are not suitable for certain uses. • Use some appropriate scientific words, symbols and units.

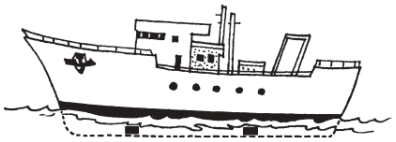
Space for notes/diagrams about metals

9C 3e

Metals in Action Card Activity

Look at each of the **'Fact cards**'. Each of the '**Reason cards**' matches one Fact card.

Fact 1:
Ships made of iron sometimes have blocks of magnesium attached to the hull.



Fact 2:
Iron can be galvanised by coating it with zinc. This can protect the iron and stop it rusting.

Fact 3:
Steel cans are sometimes coated with tin. Dented cans can be dangerous because rust can get into the food.

Fact 4:
Although aluminium is more common in the ground than iron, in Victorian times aluminium was a very expensive metal.

Fact 5:
Ancient gold jewellery is often in very good condition when it is discovered.

Fact 6:
The bronze age came before the iron age.

Reason A
Zinc is a more reactive metal than iron. The zinc will react first so that the iron is protected.

Reason B
Tin is less reactive than iron, so rust will not affect the metal can in normal conditions. When the can is dented, the iron can be exposed, and rust can get into the food.

Reason C
Gold is an unreactive metal. Even after thousands of years it doesn't react with air or water.

Reason D
Aluminium is a reactive metal and it is very difficult to extract it from its compounds without modern technology.

Reason E
Magnesium is a reactive metal. The magnesium block reacts with the water before the iron. When the block has all reacted, it can be replaced before the hull of the ship gets damaged.

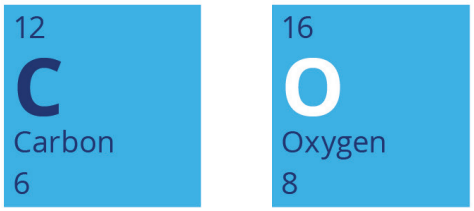
Reason F
Bronze is mostly made of copper. Copper is an unreactive metal. It is possible to make bronze by heating some types of rock in a fire. Iron ore has to be heated to a much higher temperature to make iron.

Writing Chemical Formulae

Carbon dioxide is a compound made from one atom of carbon and two atoms of oxygen.

The chemical symbol for carbon is **C.**

The chemical symbol for oxygen is **O.**



So the formula for carbon dioxide is **CO_2**.

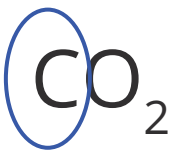
The number **2** is written **subscript**.

This means it is smaller and written below the line.

The number always comes **after** the element symbol it refers to.

It tells us how many atoms of that element there are in the compound.

If there are no numbers after an element symbol, we know there is only one atom of that element in the compound.



Write the formula for each compound. You can find the symbols for each element on the periodic table.

Compound	Number of Atoms	Formula
carbon dioxide	1 atom of carbon 2 atoms of oxygen	CO_2
silver bromide	1 atom of silver 1 atom of bromine	
water	2 atoms of hydrogen 1 atom of oxygen	
copper (II) chloride	1 atom of copper 2 atoms of chlorine	
ammonia	1 atom of nitrogen 3 atoms of hydrogen	
iron (III) oxide	2 atoms of iron 3 atoms of oxygen	
benzene	6 atoms of carbon 6 atoms of hydrogen	
zinc carbonate	1 atom of zinc 1 atom of carbon 3 atoms of oxygen	
calcium sulfate	1 atom of calcium 1 atom of sulfur 4 atoms of oxygen	
potassium nitrate	1 atom of potassium 1 atom of nitrogen 3 atoms of oxygen	
sodium sulfate	2 atoms of sodium 1 atom of sulfur 4 atoms of oxygen	
zinc thiosulfate	1 atom of zinc 2 atoms of sulfur 3 atoms of oxygen	
guanine	5 atoms of carbon 5 atoms of hydrogen 5 atoms of nitrogen 1 atom of oxygen	

Writing Equations

Description	If a metal reacts with oxygen, the product is a metal oxide.
General equation	
Word equation	
Chemical equation	

Description	If a metal reacts with water the products are a metal hydroxide and hydrogen.
General equation	
Word equation	
Chemical equation	

Description	If a metal reacts with an acid the products are a salt and hydrogen.
General equation	
Word equation	
Chemical equation	

Description	When a metal oxide reacts with an acid the products are a salt and water.
General equation	
Word equation	
Chemical equation	

Description	When a metal carbonate reacts with an acid, there are three products: a salt, water and carbon dioxide.
General equation	
Word equation	
Chemical equation	

Balancing Chemical Equations

This sheet shows you the steps to follow when you want to write a balanced symbol equation for a chemical reaction. Here is a worked example

Question: What is the balanced equation for the reaction of methane with oxygen?

Answer:

Step 1 **Write down the equation in words**

To do this, you need to know the names of the reactants and products

methane + oxygen → carbon dioxide + water

Step 2 **Write down the formulae of the reactants and products**

You can look up the formulae in a table of data.

$CH_4 + O_2 \rightarrow CO_2 + H_2O$ We cannot change the formulae to balance the equation

Step 3 **Check to see if the equation needs balancing**

Count the atoms on both sides of the equation.

Left hand side	**Right hand side**	
1 carbon atom	1 carbon atom	
4* hydrogen atoms	2* hydrogen atoms	***Not balanced** the numbers of hydrogen and oxygen atoms do not match
2* oxygen atoms	1* oxygen atom	

If the equation is not balanced (as in this example), go to step 4. If it is already balanced go to step 5.

Step 4 **Balance the equation**

You must not change any of the formulae to balance the equation. You balance the equation by writing numbers in front of the formulae. These numbers refer to the whole formula.

a. Each methane molecule has only one carbon atom so we get one molecule of carbon dioxide
b. 4 hydrogen atoms are enough to make 2 water molecules
c. There are 4 oxygen atoms on the right, so we need 2 oxygen molecules on the left

$CH_4 + 2O_2 \rightarrow CO_2 + 2H_2O$

Left hand side	**Right hand side**
1 carbon atom	1 carbon atom
4 hydrogen atoms	4 hydrogen atoms
4 oxygen atoms	4 oxygen atoms

Balanced! - we now have the same numbers of each atom on both sides of the equation.

Step 5 **Add state symbols**

These normally show the states of the reactants and products at room temperature

$CH_4(g) + 2O_2(g) \rightarrow CO_2(g) + 2H_2O(l)$

We use (g) for a gas, (s) for a solid, (l) for a liquid and (aq) for a solution of something dissolved in water.

Balancing Chemical Equations

What to do: Balance the following equations by putting large numbers in front of the formulae. Remember that you can never change any of the formulae.

1. $Na + Cl_2 \rightarrow NaCl$
2. $Al + O_2 \rightarrow Al_2O_3$
3. $KBr + Cl_2 \rightarrow KCl + Br_2$
4. $CH_4 + O_2 \rightarrow CO_2 + H_2O$
5. $NH_3 + Cl_2 \rightarrow N_2 + HCl$
6. $H_2S + O_2 \rightarrow H_2O + S$
7. $PbO + NH_3 \rightarrow Pb + N_2 + H_2O$
8. $CaO + K \rightarrow K_2O + Ca$
9. $H_2O_2 \rightarrow H_2O + O_2$
10. $Zn + Fe_2O_3 \rightarrow ZnO + Fe$
11. $Na + H_2SO_4 \rightarrow Na_2SO_4 + H_2$
12. $KClO_3 \rightarrow KCl + O_2$
13. $NH_3 + O_2 \rightarrow N_2 + H_2O$
14. $Fe + H_2O \rightarrow Fe_3O_4 + H_2$
15. $FeCl_3 + NH_4OH \rightarrow Fe(OH)_3 + NH_4Cl$

Extension:

16. $Pb(NO_3)_2 \rightarrow PbO + NO_2 + O_2$
17. $FeS_2 + O_2 \rightarrow Fe_2O_3 + SO_2$

Rockets Investigation

Introduction:

The combustion reaction of hydrogen and oxygen is used to produce the explosive energy needed to power spaceships. The reaction is also being engineered to serve as a source of continuous energy for fuel cells in electric vehicles. In this investigation, you will generate microscale quantities of hydrogen and oxygen and test their explosive nature in mixtures of various proportions. The goal is to find the most "powerful" gas mixture and use it to launch a rocket across the room.

Q1. Give the word equation for these two gases reacting to make water:

Hydrogen, the most abundant element in the universe, is a colourless, odourless gas. It is combustible, which means that it readily burns. Hydrogen gas is conveniently generated in the lab by the reaction of zinc metal with hydrochloric acid.

Q2. Balance the chemical equation that we will use to generate hydrogen:

hydrochloric acid + zinc → zinc chloride + hydrogen

____HCl + ____Zn → ____$ZnCl_2$ + ____H_2

Q3. What is the chemical test for hydrogen gas?

Oxygen, the most abundant element on Earth, is also a colourless, odourless gas. Oxygen gas supports combustion which means it must be present for materials to burn. Small quantities of oxygen gas are conveniently generated in the lab by the decomposition of hydrogen peroxide using a manganese oxide catalyst.

Q4. Balance the chemical equation that we will be used to generate oxygen:

hydrogen peroxide → oxygen + water

____H_2O_2 → ____O_2 + ____H_2O

Q5. What is the chemical test for oxygen gas?

Materials:

To prepare hydrogen gas:
Hydrochloric acid (about 15 cm^3 of 2 M acid)
Zinc metal (about 4 g provided in test tube)
One hole bung to fit test tube

To prepare oxygen gas:
Hydrogen peroxide H_2O_2 (about 15 cm^3 of 10 vol solution)
Manganese oxide catalyst (<0.01 g provided in test tube)
One hole bung to fit test tube

The rockets:
Test tube rack
3x calibrated pipette bulbs
Lots of paper towels

For launch:
Ignition switch (one set up in corridor)
Tape measure in corridor

Safety:
Hydrochloric acid is corrosive.
Hydrogen peroxide is an irritant.

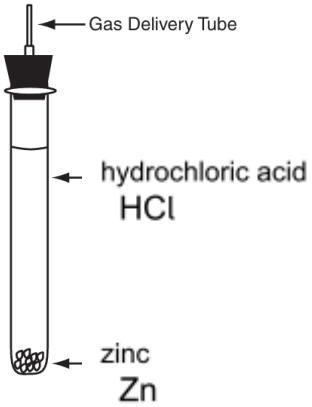
Wear goggles at all times!

Also, keep out of range of the rockets when firing!

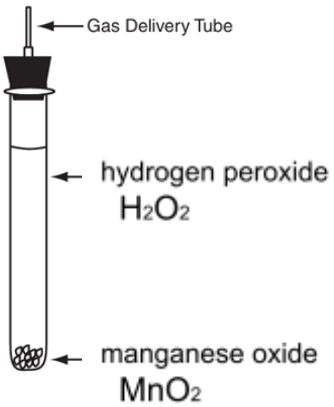
Method PART 1:
Make your hydrogen and oxygen gas generators

a) Add hydrochloric acid to the zinc so that the tube is about ¾ full (see diagram below).
b) Stopper the test tube with the one-hole bung.
c) Add hydrogen peroxide to the manganese oxide so the test tube is approximately ¾ full.
d) Stopper this test tube with another one-hole bung.

To generate hydrogen gas:



To generate oxygen gas:



Method PART 2:

Fill and test rockets with pure oxygen and pure hydrogen.

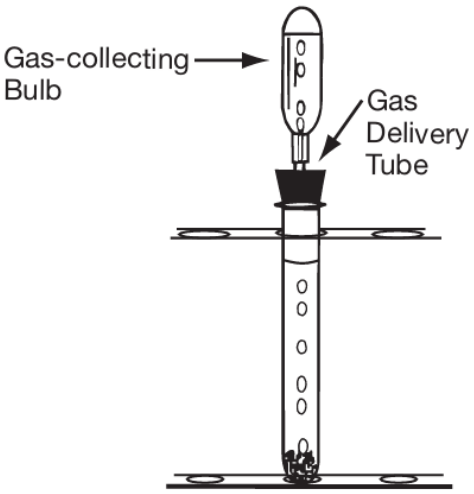
e) Completely fill a pipette bulb with water. Then place the bulb over the gas delivery tube to collect hydrogen gas by the downward displacement of water.

f) As the bubbles enter the pipette bulb, the water will flow out of the bulb and down the sides of the test tube onto the paper towels.

g) Once full of hydrogen gas, remove the pipette bulb and quickly seal the hole with your finger.

h) Take a second rocket, but this time fill it completely with oxygen gas only. Seal the hole as before.

i) Quickly open the hole of the hydrogen rocket and hold a lit split near the opening. Note your observations in the table below.



j) Repeat with the oxygen rocket, but this time introduce a glowing splint. You may need to squeeze the gas gently over the glowing splint. Record your observations.

Pure gas	Observations
hydrogen (H_2)	
oxygen (H_2)	

Prediction:

Q6. Using your observations, make a prediction for what ratio of gases you think will be best to propel a rocket the furthest. See the table on the next page with the ratios you will be using.

Predicted best ratio: ___O_2 : ___H_2

Reason why:

Method PART 3:

Fill the rockets with different ratios of gases and test.

k) Collect a rocket and fill it with water again.
l) This time only fill the rocket with ⅛ oxygen. Always fill with oxygen first.
m) Quickly remove it and place it onto the hydrogen gas generator and displace the rest of the water.
n) When not collecting gas, ensure your finger is *always covering the hole* to seal your mixture of gases inside the rocket.
o) At the launch site quickly place the pipette bulb over the spark generator and press launch!
p) Measure the distance that the rocket travelled (in cm) and record it in the table below.
q) Start again, but this time fill the rocket with the other ratios in the table below recording your data as you go.
r) If you have time, repeat the whole experiment and calculate an average.

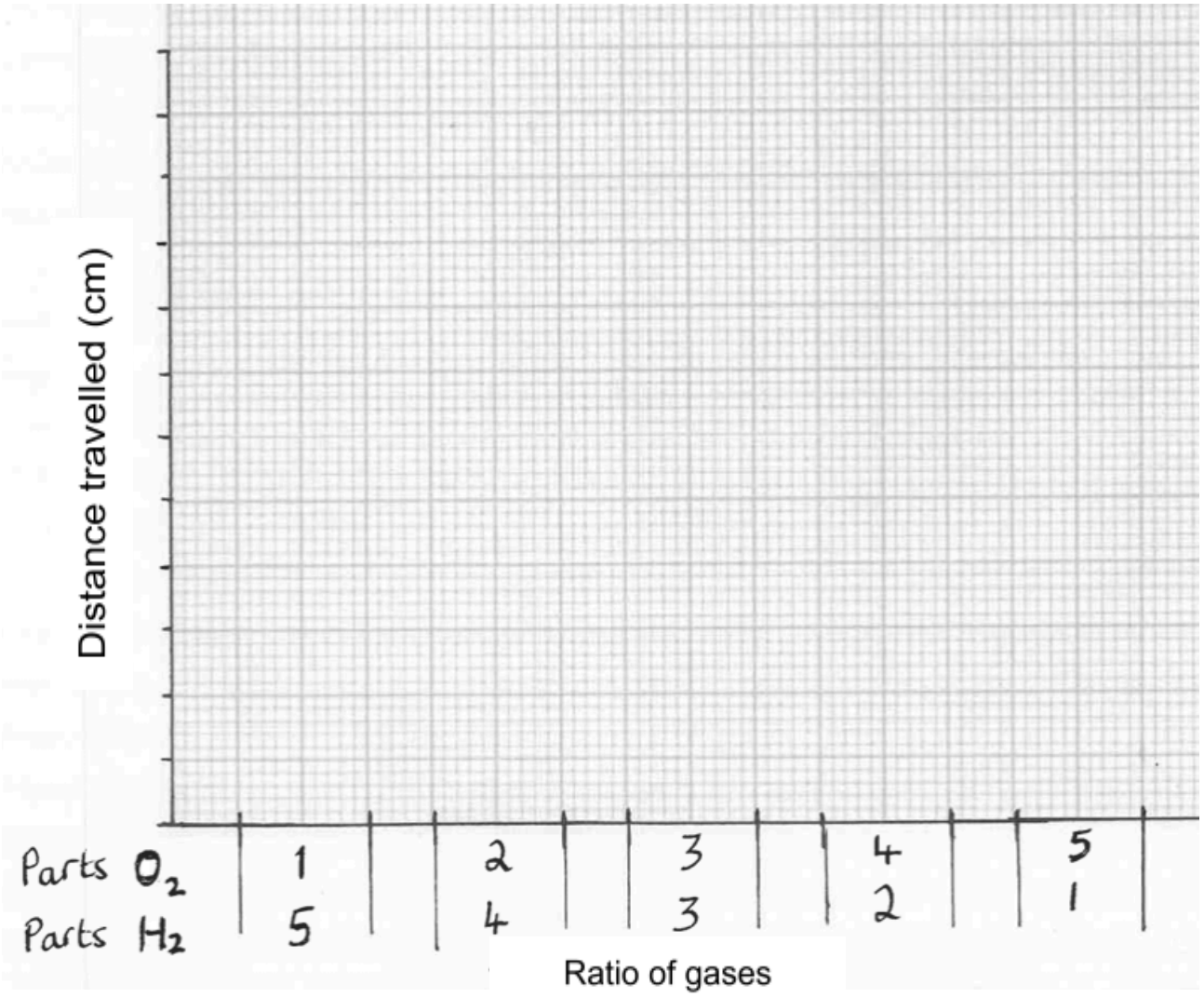
Note: If the reaction in one of the gas generators slows down so much that it is no longer useful, fill the second gas generating tube with liquid (either HCl or H_2O_2, as appropriate) and use it instead.

Results:

Oxygen to hydrogen ratio O_2 : H_2	Distance travelled by rocket (cm)			
	Trial 1	Trial 2	Trial 3	Average
1 : 5				
2 : 4				
3 : 3				
4 : 2				
5 : 1				

Also record your **qualitative observations**. For example, which ratio made the loudest bang? Were there any flames? Did the rocket bounce funny or sometimes not work at all?

Q7. Draw a bar graph to show the average distance travelled for each ratio of gas



Conclusion:

Q7. Write a balanced chemical equation for the combustion reaction of hydrogen and oxygen. You may want to refer to the word equation in question 1.

Q8. Use the balanced chemical equation above to explain which rocket travelled the furthest distance.

Evaluation:

Q9. What parts of your experiment worked well?

Q10. What aspects of your experiment lacked accuracy? What could you do to improve the accuracy?

Q11. What aspects of your experiment lacked precision? What could you do to improve the precision?

Extension:

Carry out some research about the fuels used in real space rockets. Are there any similarities to what you have done today? What are the main differences in terms of the chemical reaction taking place between your ‘rocket’ and real spaceships?

Metals and Water

Metal	Observations when put in water
magnesium	
zinc	
lead	
iron	
copper	

Note that most metals show no reaction with water. Or the reaction is so slow, it is not noticeable. We will leave these metals in water until the next lesson and look again.

More Reactive metals: Fill in your observations during/after demonstrations.

	Calcium	Lithium	Sodium	Potassium
Symbol				
Metal or Non-metal?				
Appearance				
More or less dense than water				
Method of storage				

9C 6a

	Calcium	Lithium	Sodium	Potassium
Reaction with water				
Products of reaction with water				

EQUATIONS

Complete the following word and chemical equations for some of the reactions you observed:

sodium + water → ……. + ……..…..

…..Na + …..H_2O → …..NaOH + …..H_2

potassium + water → ……. + ……..…..

…..K + …..H_2O → …..KOH + …..H_2

calcium + water → ……. + ……..…..

…..Ca + …..H_2O → …..$Ca(OH)_2$ + …..H_2

Metals Reactions

Choose your answers from the words below. Each answer is used only once.

calcium copper iron lead magnesium potassium sodium

1. Give the name of:

a two metals which float on water and react very quickly to form alkalis

b a metal which burns with a bright white flame and reacts slowly with cold water

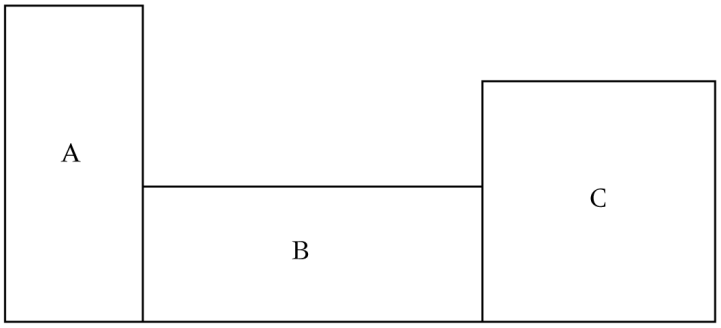
c a metal which goes rusty if you leave it in water

d a metal which reacts quickly with water and makes the water go white

e a metal which is still used for piping because it does not react with water

f a metal which used to be used for piping but is no longer used because of the risk of poisoning the water supply.

2. Look at the sketch of the Periodic Table.



Which section of the table includes:

a unreactive metals and non-metals

b the most reactive metals

c metals that are less reactive.

3. Two of the metals in the list below react with water, giving off a gas and producing metal hydroxides. The other two metals do not react.

sodium **lead** **copper** **calcium**

a Which two metals do *not* react?

b Write word equations for the reactions of the other two metals with water.

4. Carlton wrote in his exercise book:

> The metals that react best with oxygen are the same as the ones which react best with water. If you put them in order of reactivity, the order is exactly the same. All the metals which burn also react with water.

Do you agree with Carlton or not? Explain your answer.

Metals and Steam

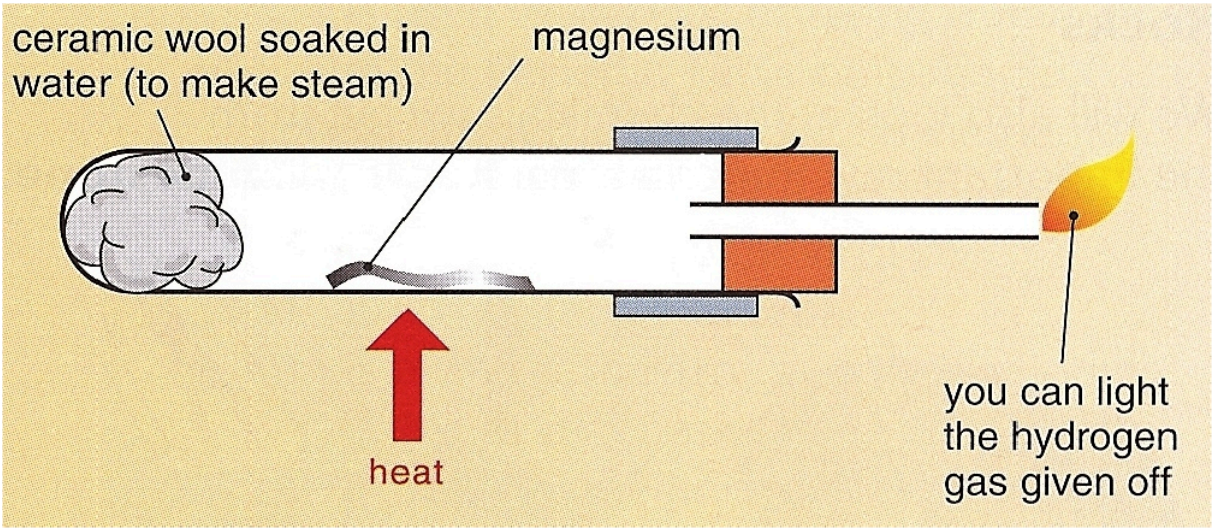
Some metals do not react with cold water but will react with **steam**. Suggest why

……

……

……

Your teacher will demonstrate **magnesium** and **steam**. Describe your observations.



Observations:

……

……

……

……

……

Complete the following **word** and **chemical equation** for the reaction of steam and magnesium

magnesium + steam → …… + ……..…..

…..Mg + …..H_2O → …..$Mg(OH)_2$ + …..H_2

9Fa/3 Reactions with water

aluminium

Al

No reaction with cold or hot water. Will react with steam to produce aluminium oxide and hydrogen.

magnesium

Mg

Very slow reaction with cold water. Slow reaction with hot water. Reacts readily with steam to form magnesium oxide and hydrogen.

calcium

Ca

Reacts rapidly with cold water. Hydrogen gas is given off. The water turns milky white.

potassium

K

Violent reaction. Potassium floats on the surface of the water, melts and then catches fire. Burns with a lilac coloured flame. Hydrogen gas given off.

copper

Cu

No reaction with cold or hot water. No reaction with steam.

silver

Ag

No reaction with cold or hot water. No reaction with steam.

gold

Au

No reaction with cold or hot water. No reaction with steam.

sodium

Na

Rapid reaction. Sodium floats on water, and moves around rapidly. Heat from the reaction melts the sodium. Hydrogen gas given off.

iron

Fe

Iron will rust slowly in cold water.

zinc

Zn

No reaction with cold or hot water. Will react slowly with steam to produce zinc oxide and hydrogen.

9Fb/4 Reactions with oxygen

aluminium

Al

No reaction when in block form unless heated very strongly indeed. Burns readily in powder form.

magnesium

Mg

Magnesium ribbon burns brightly when heated in a flame. Magnesium powder burns very rapidly with a white flash.

calcium

Ca

Calcium pieces burn strongly if heated in a flame for several minutes.

potassium

K

Melts very easily and then catches fire. Burns very rapidly with a lilac coloured flame.

copper

Cu

Metal glows red when heated in a strong flame but does not burn. There is a black coating on the metal at the end.

silver

Ag

No reaction in a flame. Silver will melt if it is heated to a high temperature, but it will not burn. Will react very slowly with the air to form silver oxide.

gold

Au

No reaction. Gold will melt if it is heated to a high temperature, but it will not burn. It does not oxidise in the air.

sodium

Na

Melts easily and then sets on fire. Burns rapidly with a yellow/orange flame.

iron

Fe

No reaction in block form. Fine wire or filings will sparkle when put in a flame. Iron will rust slowly in moist air.

zinc

Zn

No reaction when in block form. Burns in powder form.

Reaction of Metals and Acids Practical

Aim: Rank metals in order of reactivity based on their reactions with acid. Construct word equations and simple balanced equations for metal + acid reactions.

Planning

1. What factors should you keep the same to make it a fair test?

   .

   .

   .

2. Why is it difficult in this case to make the test completely fair?

Materials required:

- Calcium metal
- Copper pieces
- Magnesium ribbon
- Iron nails
- Zinc pieces
- Dilute hydrochloric acid
- Test tube rack
- 5 test tubes
- Wooden splint
- Lighter
- Goggles

Safety:

Do not touch the pieces of calcium. Your teacher will handle the calcium using forceps.

Wear eye protection

What to do:

Your teacher will add a piece of calcium to a test tube about 1/3 full with dilute hydrochloric acid. Note the results.

1. Fill a different test tube about 1/3 full with dilute hydrochloric acid.
2. Add a piece of one of the metals shown in the table below.
3. If any gas is given off, test it with a lighted splint.
4. Feel the tube to see if it is warm.
5. Look to see if the metal has reacted in the acid.
6. Record your results in the table.
7. Repeat the test with other metals.

Results :

Metal	Did you get bubbles?	Did the gas burn with a pop?	Did the metal react?	Did the tube get warm?

Analysis of your results :

How many metals reacted? _____

How many did not react? _____

What is the name of the gas that is given off ? _____

List the metals in order of reactivity, from the highest to the lowest.

1 _____

2 _____

3 _____

4 _____

5 _____

Write word equations for the reactions that have taken place.

More challenging:

Write balanced equations for each of the word equations you gave above.

The formula for hydrochloric acid is HCl, Hydrogen gas is H_2 and magnesium chloride is $MgCl_2$. All the other salts have a similar formula to magnesium chloride.

Metals and Acids Formulae and Equations

1 The symbol equation for the reaction of zinc with sulfuric acid is:

$$Zn + H_2SO_4 \rightarrow ZnSO_4 + H_2$$

a How many atoms are there in a molecule of hydrogen gas?

b Name one compound in this equation that does not contain a metal.

c What is the name of the compound with the formula $ZnSO_4$?

d This is a *balanced* equation. Explain the meaning of 'balanced' in terms of numbers of atoms.

e Write a similar balanced symbol equation for the reaction of magnesium with sulphuric acid.

2 The formula of zinc chloride is $ZnCl_2$. Here is an equation which shows the formulae of all the substances that take part in the reaction:

$$Zn + HCl \rightarrow ZnCl_2 + H_2$$

a Write the formulae for:

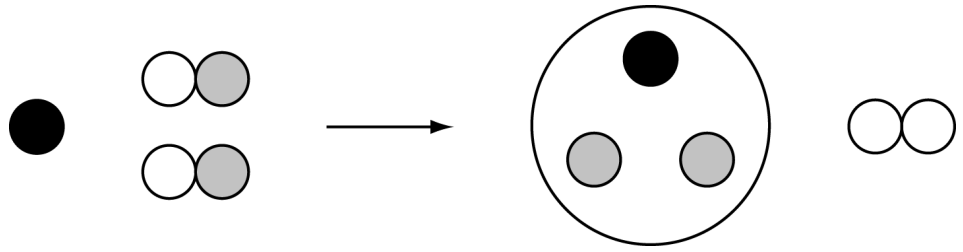
- the two reactants
- the two products.

b The equation above is not fully correct. It is not balanced. Explain why it is wrong.

The balanced equation is written like this:

$$Zn + 2HCl \rightarrow ZnCl_2 + H_2$$

c This diagram illustrates the equation.



In the diagram, which symbol represents:

i an atom of zinc

ii an atom of hydrogen

iii a molecule of hydrogen?

d Kevin wrote that the correct symbol equation should be

$$Zn + HCl \rightarrow ZnCl + H$$

Kevin's equation is balanced, but it is not correct. Explain why Kevin's equation is not correct.

3 Balance the following chemical reactions:

$$\ldots.Mg + \ldots.H_2SO_4 \rightarrow \ldots.MgSO_4 + \ldots.H_2$$

$$\ldots.Mg + \ldots.HCl \rightarrow \ldots.MgCl_2 + \ldots.H_2$$

$$\ldots.Zn + \ldots.HCl \rightarrow \ldots.ZnCl_2 + \ldots.H_2$$

$$\ldots.Fe + \ldots.H_2SO_4 \rightarrow \ldots.FeSO_4 + \ldots.H_2$$

$$\ldots.Zn + \ldots.HNO_3 \rightarrow \ldots.Zn(NO_3)_2 + \ldots.H_2$$

9C 7c

Metals and Acids Review and Application

1. When metals react with acids, a gas may be given off.

a Name the gas_____

b How do we test for this gas? _____

2. Complete the word equations for these reactions. Here is an example:

calcium + hydrochloric acid → calcium chloride + hydrogen

a calcium + nitric acid → calcium nitrate + _____

b _____ + hydrochloric acid → zinc chloride + hydrogen

c magnesium + _____ acid → magnesium chloride + hydrogen

d _____ + sulphuric acid → iron sulphate + _____

3. Put these formulae next to the correct acid in the table below.

H_2SO_4 HCl HNO_3

Acid	**Chemical formula**
nitric	
sulphuric	
hydrochloric	

4. You have got some sulfuric acid that you need to store. You could store it in a metal can, a glass jar or a plastic bottle.

Suggest advantages and disadvantages for each type of container, and say which one you think would be the best to choose.

Advantages of a metal can _____

_____

Advantages of a glass jar _____

_____

Advantages of a plastic bottle _____

_____

Disadvantages of a metal can _____

_____

Disadvantages of a glass jar _____

_____

Disadvantages of a plastic bottle _____

_____

Which would you choose? _____

Why? _____

Title: Making Salts

Salts are made when acids react with various substances such as alkalis, metals or alkaline solutions.

The name of the salt will depend upon the acid and the other substance in the reaction.

Here are some examples:

- sulfuric acid + copper oxide → copper sulfate
- hydrochloric acid + magnesium → magnesium chloride
- sulfuric acid + copper oxide → copper sulfate
- nitric acid + zinc oxide → zinc nitrate

Acid	Substance	Salt Formed
Hydrochloric	Copper Oxide	
Hydrochloric	Calcium Carbonate	
sulfuric Acid	Magnesium Oxide	
sulfuric Acid	Zinc	
Nitric Acid	Magnesium	
Nitric Acid	Sodium Hydrogen Carbonate	

Conclusion:

1. When a substance reacts with hydrochloric acid a _____ is formed.
2. When a substance reacts with sulfuric acid a _____ is formed.
3. When a substance reacts with nitric acid a _____ is formed.
4. The other products in the reactions are _____, _____ and _____ depending on the substance added to the acid.

.

Title: Making Copper Sulfate Crystals

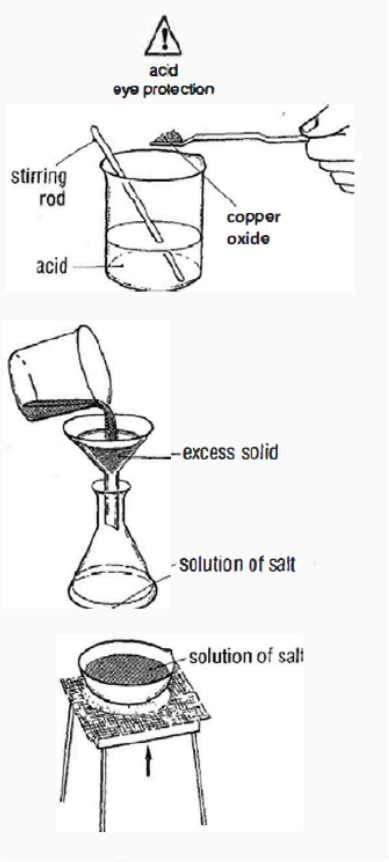
Aim: To produce pure, dry crystals of copper sulfate by reacting a base (copper oxide) and sulfuric acid

Materials Required
Dilute (0.5M) sulfuric acid
Copper oxide
Filter paper, filter funnel
50cm^3 measuring cylinder
250cm^3 beaker
Glass rod and spatula
250cm^3 conical flask
Evaporating basin
Tripod, gauze, bunsen
Fireproof mat

Safety.
Wear safety goggles.

Be careful when heating the acid using the bunsen.

Heat the acid for just 1 minute on a safety flame.



Methods

1. Put 50cm^3 *of dilute sulfuric acid* in a 250cm^3 beaker using a measuring cylinder.
2. Very carefully heat the acid using a Bunsen for 1 minute.
3. Turn off the Bunsen burner.
4. Add the copper oxide base to the acid *one spatula measure at a time,* until no more reacts. **Stir** the mixture with a glass rod.
5. **Filter** the mixture. Collect the liquid (**filtrate**) in a conical flask.
6. Put the liquid in an evaporating dish. You should only fill this up to ⅔ full. Carefully **evaporate** the filtrate to *half its original volume* OR until crystals are seen forming at the edge of the solution (Heat gently to stop the solution from spitting). Keep adding any more solution until you have a saturated solution.
7. Leave the basin to *cool*. The *crystals* of salt should form slowly. This may take a few days and is best left on the window sill in the lab. Please label your evaporating basin.
8. After the crystals have formed, **decant** the excess solution and **blot** the crystals **dry** on a paper towel.

Considering Your Results

Pictures of the different stages of preparation are shown. Draw **diagrams** of each stage - use a pencil & ruler and draw in 2D.

Describe the colour, shape and size of the crystals. Are they transparent and clear or dull and opaque? This will tell you how pure the salt crystals are.

Extension: How is the size of the crystals related to the speed of evaporation?

9C 8b

Questions on Acid Base Salt Preparation

Copper sulfate crystals were made by adding **excess base** to an **acid.**
Bases are **metal oxide** solids (e.g. copper oxide, CuO)

Q1:
I) Name and give the *formula* of the **acid** used to make **copper sulfate** crystals.

name:……*formula*:……

ii) Give the name and formula of the **base** used to make these **salt** crystals.

name:……*formula*:……

Complete the general equation that describes this reaction.

ACID + BASE → +

Write a **word** and **chemical equation** for this reaction

……

……...

During this reaction, the acid becomes neutral. How could this be tested?

When an acid is made neutral, what type of reaction is this called?

Why was **excess** copper oxide used in this reaction?

How was the excess copper oxide removed?

Why was the solution only partially evaporated?

Describe how **dry** crystals are obtained from the cooled solution.

9C 8c

Alkalis are soluble bases.
Alkalis are soluble **metal hydroxide** solutions. (e.g.sodium hydroxide NaOH).
Alkalis react in the same way as **bases**.

j) *Complete the general equation that describes a reaction between an acid and an alkali.*

ACID + ALKALI → +

k) Are alkali's solids or solutions?

Are alkali metal oxides or metal hydroxides?

Complete this equation about how an alkali and an acid react.

Hydrochloric acid + sodium hydroxide →

HCl + NaOH →

The acid is made into a neutral substance during this reaction. If the salt were tested with U.I paper, what colour should it be?

Q2. Give the word equations and symbol equations for the following acid base reactions.
(you will need these formula **$ZnSO_4$** and **KNO_3)**

a)i) Sulfuric acid + Zinc oxide

a)ii) H_2SO_4 + ZnO

b)i) Nitric acid + potassium hydroxide.

b)ii) HNO_3 + KOH

EXTENSION:

The crystals of copper sulfate contain **water of crystallisation**.
This is water which is *chemically joined* to the crystals. The crystals are said to be **hydrated.**
If **hydrated** *copper sulfate* crystals are heated they give off steam and **anhydrous** *copper sulfate* is formed.

$CuSO_4 . 5H_2O_{(s)} \rightarrow CuSO_{4\,(s)} + 5H_2O_{(l)}$

Write the formula for **hydrated** copper sulfate. …….

Write the formula for **anhydrous** copper sulfate. ……..

9C 8d

Space for notes/diagrams about salt preparation

9C 9a

Displacement Reactions

Aim: Deduce the order of reactivity of several metals from results of displacement reactions. Construct word equations for displacement reactions.

Information

A **displacement reaction** is one where a **more reactive metal** will displace a **less reactive metal** from its compounds

Planning

a *Choose a colour, and underline the four elements on the results table overleaf.*

b *Choose a different colour, and underline the four compounds.*

c *Fill in the key by your table*

Materials required:

- Copper foil
- Magnesium ribbon
- Iron nails
- Zinc foil

Solutions of:

- Copper sulfate
- Magnesium sulfate
- Iron(III)sulfate
- Zinc sulfate
- Spotting tile

Safety:

Wear eye protection

What to do:

1 Fill 3 wells on a spotting tile (dimple tile) with copper sulfate solution.

2 Add 1 piece of zinc to one, an iron nail to the second and 1 piece of magnesium to the third.

3 Leave the solutions for several minutes. Check to see if there is any reaction. Look for:

- colour changes on the surface of the metal
- colour changes in the solution
- bubbles of gas given off

4 Write your results in the table. Please write the ORIGINAL colour of each metal and each solution above the name for each substance.

5 Repeat the experiment with the other solutions. You may take a photo of your results.

Results :

	copper sulfate	**zinc sulfate**	**Iron sulfate**	**magnesium sulfate**
copper				
zinc				
iron				
magnesium				

Key  elements  compounds

Order of reactivity of metals:

1 _____

2 _____

3 _____

4_____

Analysis

1. How does the list of metals compare with the list of compounds?

2. Here is a word equation for the reaction of lead with copper sulfate:

lead + copper sulfate → copper + lead sulfate

Write word equations ***for the reactions that took place*** in your experiments

Reactivity Series of Metals

Aim: Recall the reactivity series of metals : *potassium, sodium, lithium, calcium, magnesium, aluminium, zinc, iron, (hydrogen),copper, silver and gold.*

Remembering the Reactivity Series

Find a way of remembering the Reactivity Series. Some ideas are given below:

1. Look for Patterns – colour all the Group 1 metals in red, group 2 metals in green, group 3 metals in yellow and transition metals in blue:

Potassium	K
Sodium	Na
Lithium	Li
Calcium	Ca
Magnesium	Mg
Aluminium	Al
Zinc	Zn
Iron	Fe
(Hydrogen)	(H) .....hydrogen is not a metal but sometimes reacts like one
Copper	Cu
Silver	Ag
Gold	Au

2. Make up a rhyme (or mnemonic). A suggestion is given below:

Potassium	Peter
Sodium	Smith
Lithium	Loves
Calcium	Catching
Magnesium	Monkeys
Aluminium	And
Zinc	Zebras
Iron	If
(Hydrogen)	His
Copper	Catch
Silver	Smells
Gold	Good

See if you can do better! Try making a rhyme of your own.
Share rhymes and vote for the best one – adopt it as a class mnemonic!

Displacement Equations and Applications

1. Complete the following word equations and then use the formula given below to write balanced equations for these reactions. An example is done for you.

$CuSO_4$ $FeCl_2$ CuO MgO $ZnCl_2$ $MgSO_4$

e.g.

magnesium + copper sulfate → magnesium sulfate + copper

Mg + $CuSO_4$ → $MgSO_4$ + Cu

a) zinc + iron chloride →

b) magnesium + copper oxide →

2. Explain what happens in a **displacement** reaction? ……

……..

3. Use the Reactivity Series to help you to decide which of the pairs below will react.

IF THEY DO REACT then complete the word equation, otherwise write ‘no reaction’

zinc + copper oxide →

iron + magnesium oxide →

magnesium + sulfuric acid →

copper + silver nitrate →

copper + magnesium chloride →

4. You have 3 unknown metals A, B and C. You know that C displaces B from its oxide when heated. However, there is no reaction when C is heated with the oxide of A.

   Rank the 3 metals in order of reactivity (most reactive first). Explain how you reached your decision.

Precipitation Reactions

A precipitation reaction occurs with lead nitrate solution and potassium iodide solution.

What is a precipitation reaction?

The reaction between lead nitrate and potassium iodide is also a displacement reaction. Write the word equation for this reaction.

Now balance the chemical equation for this reaction.

$$\_\_\_Pb(NO_3)_2 + \_\_\_KI \rightarrow \_\_\_KNO_3 + \_\_\_PbI_2$$

Practical

1. Add the two solutions together in a test tube. (Do this *slowly* and how your teacher demonstrated the first experiment.)
2. Filter your mixture to obtain the insoluble salt.
3. Write a word and chemical equation.
4. Wash your salt with distilled water to remove other chemicals.
5. Once the filtering is complete, unfold your filter paper and allow the salt to dry.

Draw labelled apparatus of how you obtained your salt via filtration

Extension:

Sodium chloride (common table salt) has some well known uses such as flavouring and preserving food. However, there are many other salts with many different uses. Research some different salts and give their uses in the table below

Name of salt	Use

Precipitation Reaction Equations

You do **not** need to know any of the following reactions off by heart. However, you should be able to do the following:

1) Read the word equation
2) Balance the chemical equation (if it is already balanced, say so)
3) Use the information to highlight the precipitate.

sodium hydroxide + silver nitrate → sodium nitrate + silver hydroxide

$$\_\_NaOH + \_\_AgNO_3 \rightarrow \_\_NaNO_3 + \_\_AgOH$$

The precipitate of silver hydroxide is brown.

sodium hydroxide + copper sulfate → sodium sulfate + copper hydroxide

$$\_\_NaOH + CuSO_4 \rightarrow Na_2SO_4 + Cu(OH)_2$$

A blue gelatinous precipitate of copper hydroxide is produced.

potassium iodide + mercury nitrate → mercury iodide + potassium nitrate

$$\_\_KI + \_\_Hg(NO_3)_2 \rightarrow \_\_HgI_2 + \_\_KNO_3$$

A bright orange precipitate of mercury iodide is produced.

potassium iodide + silver nitrate potassium nitrate + silver iodide

$$\_\_KI + \_\_AgNO_3 \rightarrow \_\_KNO_3 + \_\_AgI$$

A yellow white precipitate of silver iodide, AgI is produced.

sodium chloride + silver nitrate sodium nitrate + silver chloride

$$\_\_NaCl + \_\_AgNO_3 \rightarrow \_\_NaNO_3 + \_\_AgCl$$

A creamy silver chloride precipitate is formed.

mercury nitrate + potassium fluoride → mercury fluoride + potassium nitrate

$$\_\_Hg(NO_3)_2 + \_\_KF \rightarrow \_\_HgF_2 + \_\_KNO_3$$

An orange brown precipitate of mercury fluoride, HgF_3 is produced.

copper sulfate + potassium iodide → copper iodide + potassium sulfate

$$\_\_CuSO_4 + \_\_KI \rightarrow \_\_CuI_2 + \_\_K_2SO_4$$

An olive green precipitate of copper iodide is produced.

Thermal decomposition of metal carbonates

INTRODUCTION:

Some metal carbonates undergo thermal decomposition (the breakdown of a compound when it is heated). One such example is copper carbonate. In this practical, you are going to observe what happens when copper carbonate decomposes.

PROCEDURE:

1. Set up the apparatus as demonstrated to you by your teacher. Draw a diagram of it here →

2. Add a small pile of copper carbonate to the boiling tube.

3. Heat the metal carbonate strongly; try not to move any of the apparatus.

4. As soon as you start heating, hold a test tube of limewater in position and once cloudy, remove the test tube, **but do NOT stop heating**.

5. Carefully observe the carbonate to see if you can see any changes in appearance.

Experiment set up

6. Check there is no more liquid in the delivery tube. Only once the delivery tube is empty, turn off the heat.

QUESTIONS:

a) Give the word equation for the thermal decomposition of copper carbonate.

_____

b) Give the balanced chemical equation for the thermal decomposition of copper carbonate ($CuCO_3$) to make copper oxide (CuO) and carbon dioxide.

_____

c) What colour change did copper carbonate show when it decomposed?

_____

d) How do you know what gas was made?

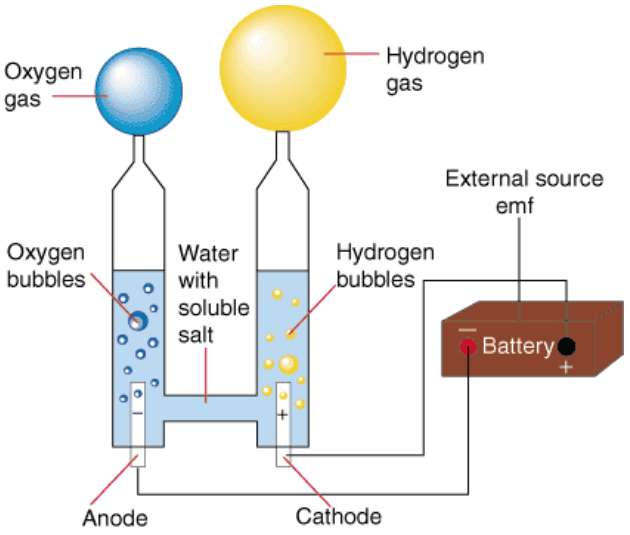
_____

e) Limestone is mainly made up of calcium carbonate. This metal carbonate also decomposes when heated: write a word equation for this reaction.

_____

Introduction to Electrolysis

Your teacher will demonstrate the electrolysis of water using the Hoffman voltameter:



Write a word and balanced chemical equation for the reaction that takes place when water is electrolysed

Word equation: _____

Chemical equation: _____

What gas is produced at the positive electrode (anode)? _____

What gas is produced at the negative electrode (cathode)? _____

What is electrolysis? _____

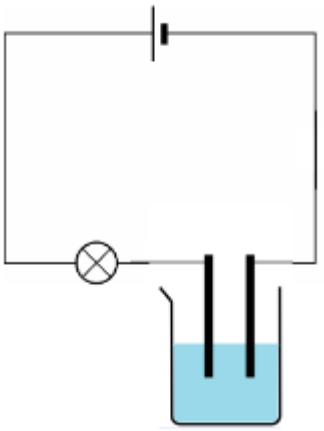
_____

Fill in this table with the tests for gases:

Gas	Chemical Test	Positive Result
Oxygen (O_2)		
hydrogen (H_2)		
chlorine (Cl_2)		

Electrolysis of copper chloride solution

Instructions for Practical:



1. Build a circuit and check that it is working (the bulb should light when you touch the electrodes together). Once it is working, turn the power off.
2. Fill a small beaker with *about* 50 cm^3 of copper chloride ($CuCl_2$) solution and set up the experiment as shown on the right
3. Insert the electrodes into the solution and turn on the power for 2-3 minutes. Observe.
4. Hold some damp UI paper above the electrode that is bubbling to test for chlorine.
5. Turn the power off and pull out the electrodes. Note down what you can see at each electrode.

Results:

Observations at the positive electrode (anode)	
Observations at the negative electrode (cathode)	

Conclusion:

Write a word and chemical equation for the electrolysis of copper chloride ($CuCl_2$) solution

Word equation: _____

Chemical equation: _____

Give some uses for electrolysis: _____

_____

_____

Electrolysis of Aqueous Solutions

A student carried out an investigation into the electrolysis of sodium chloride.

The student placed solid sodium chloride into a beaker and inserted two graphite electrodes connected to a power supply. When the power supply was switched on, nothing appeared to happen.

1. Why did this experiment **not** work?

   Tick **one** box.

   Electrolysis is slow and does not start straight away. ☐

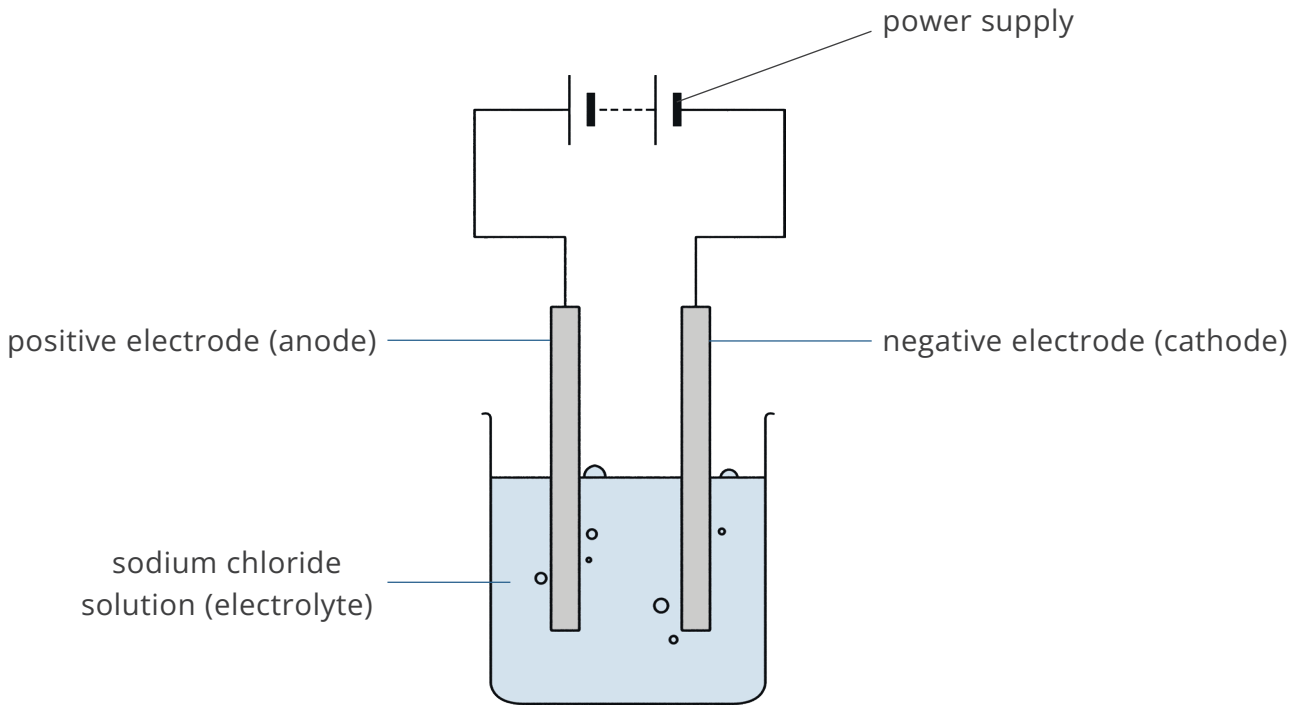
   Solid sodium chloride does not conduct electricity. ☐

   The voltage of the power supply was too high. ☐

The student then dissolved the sodium chloride in water.

Figure 1 shows the apparatus used in the electrolysis of sodium chloride solution, NaCl(aq).

Figure 1



2. The electrodes are made of graphite. Why is graphite a suitable material for the electrodes?

   Tick **two** boxes.

   Graphite has a high melting point. ☐

   Graphite is a good conductor of electricity. ☐

   Graphite is slippery. ☐

   Graphite is unreactive. ☐

The student observed that bubbles of gas were produced at both the positive and the negative electrodes.

The gas produced at the negative electrode is hydrogen.

3. Why are hydrogen ions present in sodium chloride solution, NaCl(aq)?

   Tick **one** box.

   Chloride ions are turned into hydrogen ions during electrolysis. ☐

   Hydrogen from the air dissolves in the sodium chloride solution. ☐

   Water molecules are split into hydrogen ions and hydroxide ions. ☐

4. Explain why hydrogen gas is produced at the negative electrode and **not** sodium metal.

The students carried out another investigation to test the following hypothesis.

'In the electrolysis of salt solutions, oxygen is always produced at the positive electrode unless a halogen is present.'

5. Complete the table below to predict the name of the product that will form at each electrode during the electrolysis of the salt solutions named.

Salt Solution	Product Formed at the Positive Electrode (Anode)	Product Formed at the Negative Electrode (Cathode)
copper sulfate		
silver nitrate		
zinc chloride		

Summary Sheets - Acids, Bases and Indicators

Acids and alkalis

I..... are coloured dyes which often come from plants such as red cabbage and beetroot.

Acids make indicators change colour. **Litmus** is an indicator which turns r..... in acids. Common acids include v..... and l..... j.....

Alkalis have a different effect on indicators to acids. Litmus turns b..... in alkalis.

The strengths of acids and alkalis can be measured on the **pH scale**, which runs from 1 to 14. pH numbers **1 to 6.9** are acids, **7** is neutral, and **7.1 to 14** are alkalis. You can find out the pH number using a **u..... i.....**, or by using a **pH meter**.

Strong acid			Weak acid			neutral	Weak alkali			Strong alkali			
1	2	3	4	5	6	7	8	9	10	11	12	13	14

stomach Acid, vinegar, skin, pure water, indigestion powders, washing powder, oven cleaner

lemon Juice, fizzy drinks, milk, blood, toothpaste

Metals and acids

Many metals react with acids. Some unreactive metals will only react very slowly with strong acids, some will not react at all. Some metals are more reactive and explode when added to acid.

When a metal reacts with an acid, **h.....** gas is given off. The reaction also produces a compound called a **salt**.

There are three main types of **salt**:

Chlorides are made when h..... acid is used.
Sulfates are made when s..... acid is used.
Nitrates are made when n..... acid is used.

We can test for **hydrogen** by putting a **b..... s.....** into a test tube of gas. If hydrogen is present, it will explode with a **squeaky 'pop'**.

KEY WORDS: red, vinegar, indicators, universal indicator, lemon juice, blue, hydrogen, burning splint, hydrochloric, nitric, sulfuric,

The general equation is:

acid + metal → salt + hydrogen

For example:

hydrochloric acid + z..... → zinc chloride + h.....

Bases
Bases are compounds which react with acids. All **metal oxides**, **metal hydroxides and metal carbonates** are bases. Bases which dissolve in water are called **alkalis** (e.g. sodium hydroxide).

Metal oxides and hydroxides and acids
A metal oxide or a metal hydroxide reacts with an acid to form water and a salt. This reaction is called **n.....**.

The general equation is:

acid + metal oxide → salt + water

For example:

sulfuric acid + c..... oxide → copper s..... + water

We can check to see if neutralisation has occurred using universal indicator. The pH of the solution gets closer to neutral (pH7).

Metal carbonates and acids
A metal carbonate will also neutralise an acid. This time the products are a salt, carbon dioxide and water.

The general equation is:

acid + metal carbonate → salt + carbon dioxide + water

For example:

sulfuric acid + copper carbonate → copper sulfate + c..... d..... + water

We can test for **carbon dioxide** using **l.....**. Limewater goes milky if carbon dioxide is bubbled through it.

Some rocks, like l..... and m....., contain calcium carbonate. The rock fizzes when an acid is added and some of the rock is worn away. The rock is **weathered**.

KEY WORDS: neutralisation, copper, sulfate, zinc, limewater, hydrogen, carbon dioxide, limestone, marble

9C 13a

Preparation of soluble salts

Dry crystals of **soluble salts** can be prepared by reacting an acid with a metal, metal oxide or metal carbonate:

1. Measure out 25cm^3 of acid using a ....
2. Add excess solid to the acid and stir
3. ..... off the excess solid
4. Pour the filtrate into an ..... basin
5. Heat to partially ..... the solution
6. Leave the solution to c..... and c.....
7. Decant the excess solution and blot the crystals dry on a paper towel

Preparation of insoluble salts via precipitation reactions

1. Add the two solutions together in a ....
2. ..... the mixture to obtain the insoluble salt.
3. ..... the salt with ..... water to remove other chemicals.
4. Allow the salt to dry and .....

KEY WORDS:
You can use these words, once, more than once or not at all.

measuring cylinder **test tube** **filter** **distilled** **evaporate**

wash **crystallise** **cool** **evaporating**

Acids & Salts Revision Questions

1. Give an example of:
a) a strong acid …… b) a weak acid ……..……
c) a strong base……..…….. d) a weak base ……..…

2. Complete the last column of the table to state whether the following substances are strongly acidic; weakly acidic; neutral; weakly basic or strongly basic. The first one has been done for you:

Substance	pH	Description
hydrochloric acid	1.0	strong acid
gastric juice	1.2	
ammonia	11.0	
egg	7.8	
Rain water	6.5	
apples	3.0	
milk	6.8	
tears	7.4	
oven cleaner	13.8	
human saliva	6.4	
human blood	7.4	

3. In this topic you made different salts. Salts are made when an acid is **neutralised** by a base or when an acid reacts with a metal or a carbonate. Complete the following by filling in tile blank spaces and by naming the compounds.

Sulfuric acid (formula H_2SO_4) forms a salt called ……

Hydrochloric acid (formula HCl) forms salts called ……..

…….(formula HNO_3) forms salts called nitrates

4. Look at the reactivity series on the right.

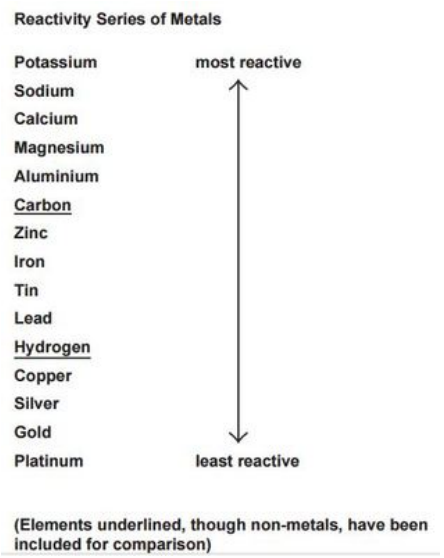
Metals above hydrogen in the reactivity series react with acids.

Complete the following word equations by writing the names of the substances in the appropriate place.

zinc + *sulfuric acid* → ……..……+ ……

magnesium + *hydrochloric acid* → ……..…..+ ……

iron + *sulfuric acid* → ……+ ……..…



5. Bases react with acids as follows:

Complete the following word equations:

a) *copper oxide* + *sulfuric acid* → .... + ……

b) *magnesium oxide* + *nitric acid* → .... + ……..

c) *iron oxide* + *hydrochloric acid* → .... + ……..

6. Metal carbonates react with acids as follows:

Complete the following word equations:

copper carbonate + *hydrochloric acid* → ……...+ ……+ ……..

calcium carbonate + *hydrochloric acid* → ……+ ……...+ ……...

zinc carbonate + *sulfuric acid* → ……...+ ……..…..+ ……

7. Alkalis are soluble bases and these react with acids in a similar way to bases:

Complete the following word equation:

sodium hydroxide + *hydrochloric acid* → .... + ….……

8. Hydrochloric acid is a strong acid.

(a) Winston used universal indicator solution to find the pH of some hydrochloric acid.

(i) Suggest the **colour** of the universal indicator in the hydrochloric acid. …….

(ii) Suggest the **pH** of the hydrochloric acid. …….

9. (a) Neutral litmus paper is purple in neutral solutions, red in acids & blue in alkalis. Use this information to answer the questions.

(i) A piece of neutral litmus paper turned red in some grapefruit juice. What does this show about the grapefruit juice?

.....

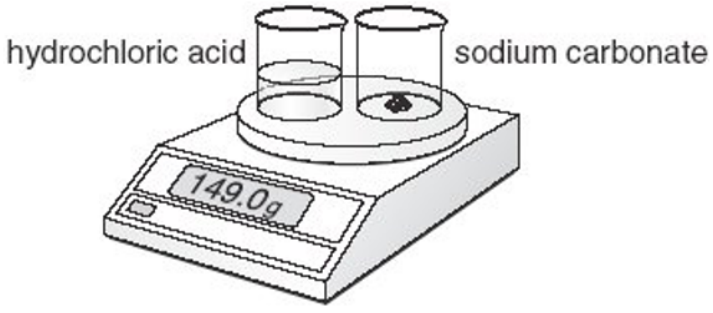
(ii) Gwen added drops of sodium hydroxide solution to the grapefruit juice. The litmus paper soon turned blue. What does the blue colour show about the sodium hydroxide solution?

.....

(b) What name is given to the reaction between an acid and an alkali? Circle the correct answer

distillation neutralisation precipitation separation

10. In an experiment, Molly put two beakers on a balance. One contained 20 cm^3 of hydrochloric acid. The other contained 5 g of sodium carbonate. She poured the acid onto the sodium carbonate. They reacted.



(a) Complete the word equation with the names of the **three** products.

sodium carbonate + hydrochloric acid → ..... + ... + ...

(b) Balance the chemical equation:

$$\text{.....}Na_2CO_3 + \text{.....}HCl \rightarrow \text{.....}NaCl + \text{.....}CO_2 + \text{.....}H_2O$$

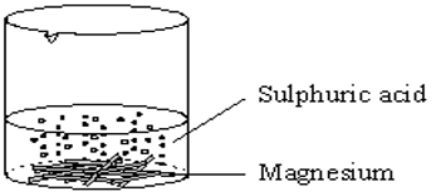
(c) The total mass at the start was 149.0 g. When the reaction stopped, the reading on the balance was 147.0 g. Why was there a loss of mass in this reaction?

.....

(d) When the reaction stopped, Molly tested the contents of the beaker with universal indicator paper. The sodium carbonate had neutralised the acid. What is the colour of universal indicator paper in a neutral solution?

.....

11. A student tried to make some magnesium sulfate ($MgSO_4$). Excess magnesium was added to dilute sulfuric acid (H_2SO_4). During this reaction fizzing was observed due to the production of a gas called hydrogen (H_2).



(i) Is the equation for this reaction naturally balanced, or do numbers need to be added?

$$\text{.....}Mg + \text{.....}H_2SO_4 \rightarrow \text{.....}MgSO_4 + \text{.....}H_2$$

(ii) At the end of the reaction the solution remaining was filtered.
Why was the solution filtered?

.....

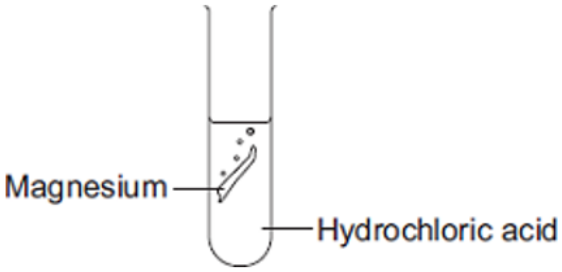
(iii) The filtered solution was left in a warm place. Explain why the filtered solution was left in a warm place.

.....

……

9C 13b

12. A student investigated the reaction between magnesium and hydrochloric acid.



(a) Give **two** observations the student could make during the reaction.

1 .....

2 .....

(b) Write a word equation for this reaction

……

(c) The student investigated how the rate of this reaction changed when the concentration of hydrochloric acid was changed.

Write a plan the student could use.

In your plan you should:

- describe how you would carry out the investigation and make it a fair test (make it clear which variables you change, measure and control)
- describe the measurements you would make (ie give the method)

.....

.....

.....

.....

.....

.....

.....

.....

Quick Quiz: Types of Reaction

1 The gas in the air that reacts with metals most easily is:
A argon. **B** carbon dioxide. **C** nitrogen. **D** oxygen.

2 A metal that does not react with the air is:
A calcium. **B** gold. **C** iron. **D** magnesium.

3 The gas which is given off when metals react with water is:
A carbon dioxide. **B** hydrogen. **C** oxygen. **D** nitrogen.

4 Sodium reacts with water to form:
A sodium chloride.
B sodium oxide.
C sodium hydroxide.
D sodium carbonate.

5. The gas which is given off when metals react with acids is:
A carbon dioxide. **B** hydrogen. **C** oxygen. **D** nitrogen.

6. When magnesium reacts with sulfuric acid, it forms:
A magnesium oxide.
B magnesium chloride.
C magnesium sulfate.
D magnesium carbonate.

7 Choose the correct statement to complete this word equation:

zinc + sulfuric acid →

A zinc + sulfur + acid
B zinc hydrate + sulfur
C zinc sulfate + hydrogen
D zinc hydroxide + hydrogen

8. Iron is more reactive than copper. If a piece of iron is put into copper sulfate solution, what would you see?
A Brown copper would appear on the iron.
B Blue copper would appear on the iron.
C Nothing would happen.
D the iron would dissolve completely.

9 Zinc is more reactive than tin. It will displace tin from a compound. Choose the correct statement to complete this word equation:

zinc + tin sulfate →

A zinc + tin sulfate
B zinc + zinc sulfate
C tin + zinc sulfate
D tin + zinc chloride

10 Copper is more reactive than silver. Iron is more reactive than copper. This means that:
A copper will react with iron nitrate solution.
B silver will react with iron nitrate solution.
C iron will react with silver nitrate solution.
D silver will react with copper nitrate solution.

11 Zinc reacts with copper sulfate solution and silver nitrate solution. This means that zinc:
A is more reactive than copper and silver.
B is less reactive than copper and silver.
C is less reactive than copper but more reactive than silver.
D is less reactive than silver but more reactive than copper.

12 Which of these materials is used to make most car bodies?
A plastic **B** aluminium **C** copper **D** steel

13 Some window frames are made of aluminium. It is a good metal to use because:
A it conducts electricity.
B it conducts heat.
C it does not melt easily.
D it does not react very quickly with air or water.

14 Magnesium would react more slowly with acid if you:
A added more acid.
B added more water.
C heated the acid.
D used a more concentrated acid.

15 Which of these statements is true?
A Many reactive metals have been known since ancient times.
B Magnesium was discovered before iron.
C Reactive metals can be extracted by heating their compounds with charcoal.
D Most reactive metals were discovered after the invention of the electric battery.

Quick Quiz: Acids & Bases

1 When some acid is put onto a piece of metal:
- **A** there is always a reaction which burns a hole in the metal.
- **B** there is never a reaction.
- **C** some metals will react with the acid and produce bubbles of gas.
- **D** there is always a reaction, which produces a powder.

2 Which of the following is the correct way to test for hydrogen gas?
- **A** Bubble the gas through limewater.
- **B** Bubble the gas through universal indicator solution.
- **C** Put a glowing splint into a tube of the gas (the splint will burn brightly).
- **D** Put a burning splint into a tube of the gas (the gas will explode with a squeaky pop).

3 If an acid reacts with a metal, the products are:
- **A** a salt and water.
- **B** a salt and hydrogen gas.
- **C** only hydrogen gas.
- **D** a salt, water and carbon dioxide.

4 Which of the following is **not** needed to make a prediction about the products of a reaction between a metal and an acid?
- **A** general information about the reactions between metals and acids
- **B** information about the properties of the metal
- **C** the name of the metal used
- **D** the name of the acid used

5 When some acid is put onto a piece of rock:
- **A** it always reacts and gives off a gas.
- **B** it reacts if the rock contains a carbonate.
- **C** it always reacts explosively and shatters the rock.
- **D** it won't react.

6 The best test for carbon dioxide uses:
- **A** universal indicator solution.
- **B** a burning splint.
- **C** litmus paper
- **D** limewater.

7 When an acid reacts with a metal carbonate, the products are:
- **A** the metal and carbon dioxide.
- **B** a salt and water.
- **C** carbon dioxide, water and a salt.
- **D** the metal, a salt and water.

4 Which of these is **not** a sign that a reaction has taken place?

A The substance catches fire.
B The substance has changed from a solid to a liquid.
C A gas is given off.
D There is an explosion.

8 A neutral solution is made when:

A two acids are added together.
B an acid and an alkali are added together.
C water is added to an acid.
D water is added to an alkali.

9 When an acid and an alkali react together:

A a salt and water are both produced.
B only a salt is produced.
C a metal is formed.
D a gas is given off.

10 Which of these word equations is correct?

A copper oxide + hydrochloric acid → copper sulfate + water
B copper oxide + hydrochloric acid → copper chloride + carbon dioxide + water
C copper oxide + hydrochloric acid → copper chloride + hydrogen
D copper oxide + hydrochloric acid → copper chloride + water

11 Which of these is **not** a salt?

A magnesium sulfate
B iron sulfide
C tin chloride
D zinc nitrate

12 Which of the following is **not** responsible for making rainwater acidic?

A lead dioxide
B carbon dioxide
C sulfur dioxide
D nitrogen dioxide

13 Which of the following is one of the main causes of acid rain?

A weathering of rocks
B photosynthesis in plants
C power stations burning fossil fuels
D farmers putting peat on their soil

Year 9 Types of Reaction Checklist

Reactivity	Green	Amber	Red
I can arrange metals into an order of reactivity, based on their reactions with water and steam.			
I can describe the reactions between some metals and water (eg alkali metals).			
I can describe the reaction between magnesium and steam.			
I can write word and simple balanced symbol equations (from a given formula), for metals reacting with water or steam.			
I can rank metals in order of reactivity based on their reactions with acid and oxygen.			
I can write word equations for metal + oxygen or metal + acid reactions.			
I can write simple balanced equations for metals reacting with oxygen or acid from a given formula.			
I can explain what is meant by a fair test.			
I can define displacement.			
I know that a more reactive metal will displace a less reactive metal from its compounds.			
I can work out the order of reactivity of several metals from results of displacement reactions.			
I can write word equations for displacement reactions.			
I can write simple balanced equations for displacement reactions (when given formulas).			
I can give some uses of common metals (Fe, Cu, Ag, Au) and explain why they are used in this way.			
I can describe the causes, effects and ways to reduce acid rain.			
I know the names and formulas of some common			

acids, bases & salts.			
I can describe the use of universal indicator to identify strong and weak acids and alkalis.			
I can describe how to produce dry crystals of a salt (copper sulphate) by reacting an insoluble metal oxide (copper oxide) with acid (sulphuric acid).			
I can explain the reasons for each step in the method to produce the above salt. For example, heat the acid gently to dissolve more base, filter to remove excess copper oxide.			
I can write word equations and simple balanced equations (when given formula), for metal oxides or alkalis reacting with acids.			
I know that an alkali is a soluble base.			
I know that neutralisation reactions produce heat (are exothermic).			
I can describe how to use the temperature rise to determine the point of neutralisation of an acid and an alkali (by plotting my results on a graph).			

Keywords:

You should be able to use these in a sentence:

Solute, Acid, Base, Alkali, Indicator, Litmus, Universal Indicator, Phenolphthalein, Salts, Weathered, Metal Carbonate, Metal Oxide, Neutralisation, Soluble, Insoluble, Electrolysis, Precipitate, Combustion, Displacement, Reactivity, pH, Thermal Decomposition.