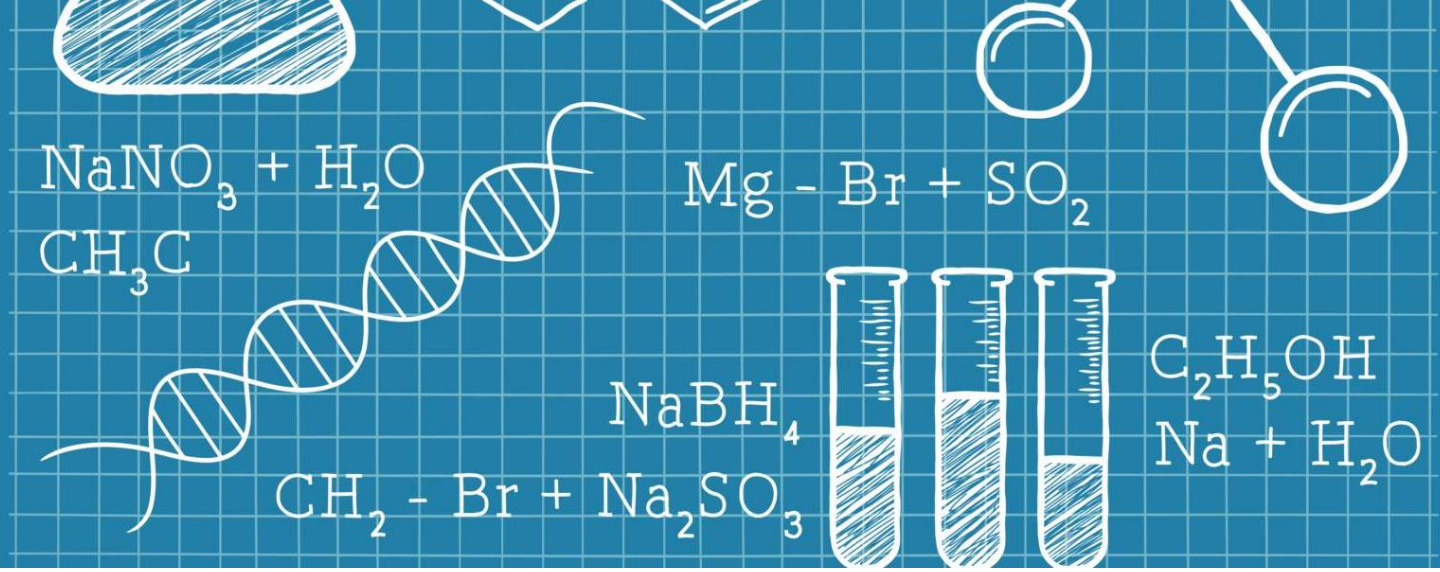
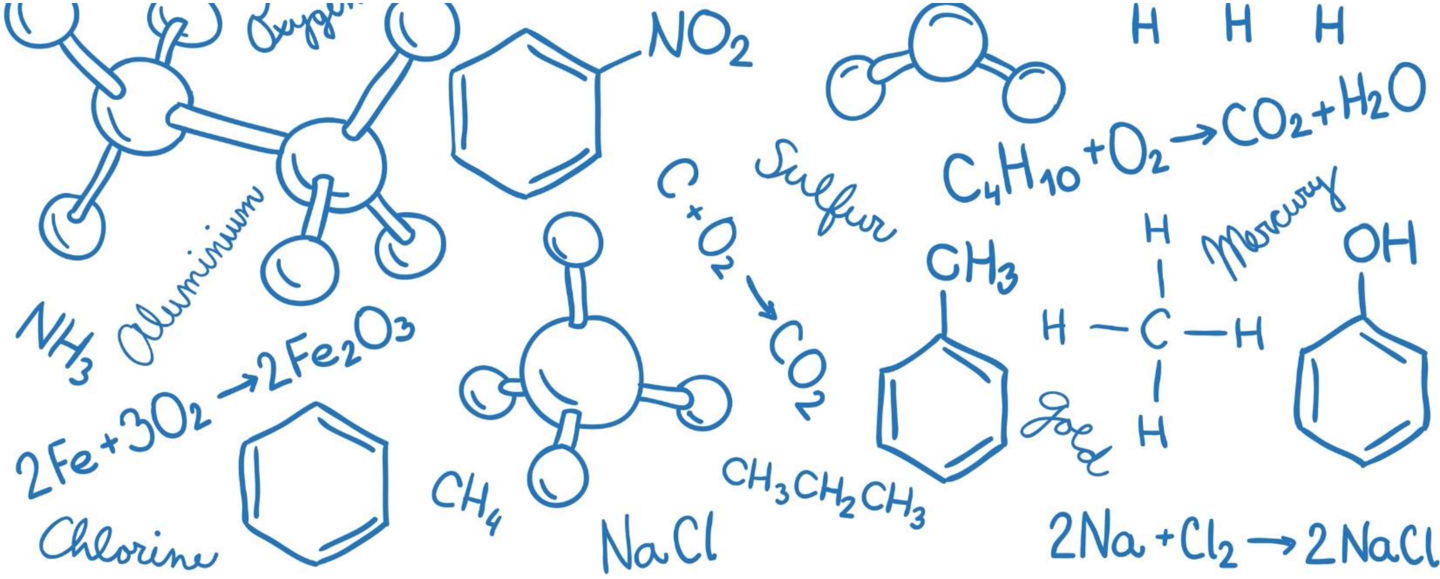
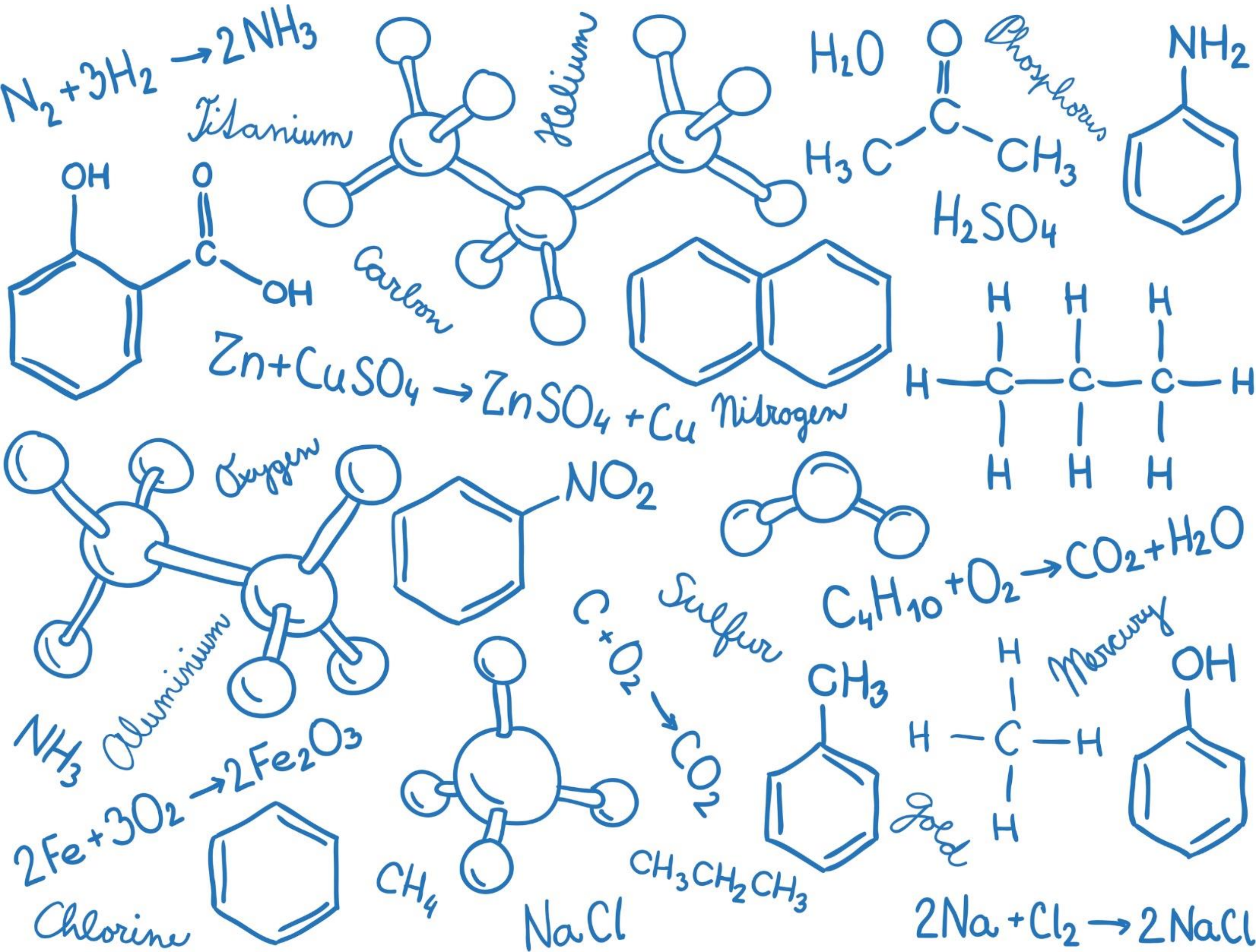


Year 8 Chemistry Unit 5

Class:
Name:



Atomic structure



L1: Elements, Mixtures and Compounds

Atoms and molecules

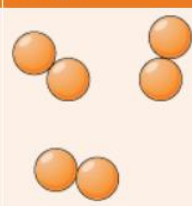
Remember that an **element** is one type of atom, like carbon, gold or chlorine. We will look at three ways that atoms can exist.

1. Single atoms

The atoms of some elements do not join up with other atoms. They stay as **single atoms**. The element helium is like this. Helium atoms do not join up with each other or any other element and it is a gas.

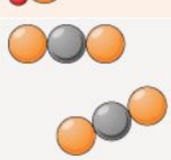
2. Molecules of elements

When atoms of the same element join together we get a molecule of that element.

Molecule name	Image
Oxygen	
Hydrogen	

3. Compounds

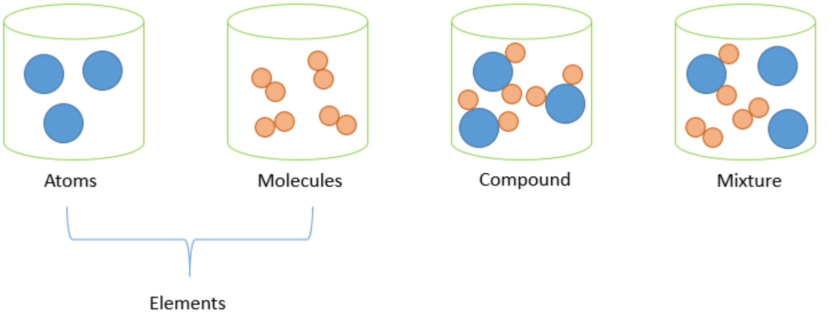
A compound is made when atoms of different elements join together by chemical bonds. This means that compounds will always exist as molecules, not separate atoms. The diagrams show some molecules of common compounds.

Compound name	Image
Water molecule	
Carbon dioxide molecule	

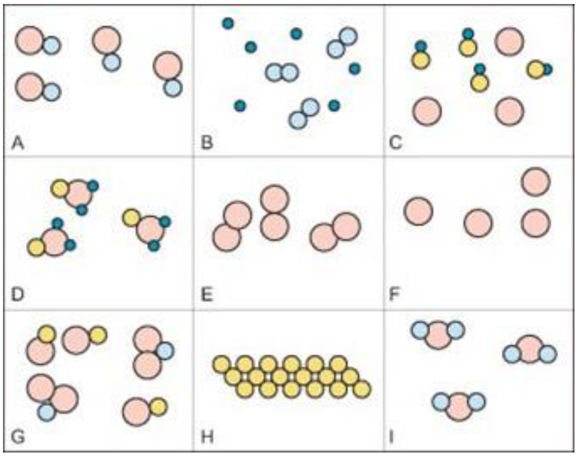
What is a mixture?

A **mixture** is made from different substances that are **not chemically joined**.

In summary:



Test yourself



Task: Write the correct letters below.

1. 1 type of element: ______________________________
2. 1 type of compound: ____________________________
3. Mixture of elements: ____________________________
4. Mixture of compounds: __________________________
5. Mixture of elements and compounds: ________________

Challenge:

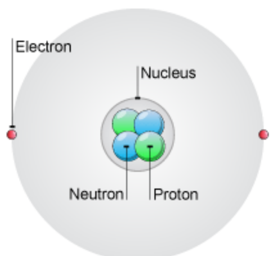
1. Which letter is showing molecules of elements?
2. Which letters are showing gases?
3. Which letter is showing a solid?
4. Which letter could be showing water (H_2O)

L2 & L3: Structure of the atom, atomic mass and atomic number

Atomic structure

All substances are made from tiny particles called **atoms**. An atom has a small central nucleus made up of smaller sub-atomic particles called **protons and neutrons**. The nucleus is surrounded by even smaller sub-atomic particles called **electrons**

Protons and electrons have an electrical charge. Protons are positive, electrons are negative. Neutrons are neutral.



Subatomic particle	Mass	Charge
Proton	1	+1
Neutron	1	0
Electron	Negligible	-1

The number of electrons in an atom is **equal to** the number of protons in its nucleus. This means <u>atoms have no overall electrical charge</u>.

Atomic number and atomic mass

The **atomic number** of an atom is the number of protons it contains.

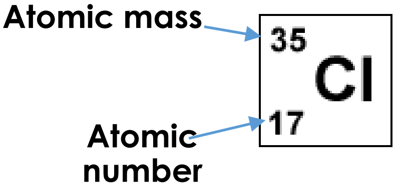
The atoms of different elements have different numbers of protons. For example, all oxygen atoms have 8 protons and all sodium atoms have 11 protons.

The **atomic mass** (or mass number) of an atom is the total number of protons and neutrons it contains.

Challenge: Calculating the number of subatomic particles in each atom using the atomic number and the atomic mass.

The symbol on the right tells you that chlorine has 17 protons. This is because the atomic number is 17.

In an atom, the number of protons is equal to the number of electrons, so chlorine contains 17 electrons.



To work out the number of neutrons, you subtract (take away) the atomic number from the mass number.

35 – 17 = 18

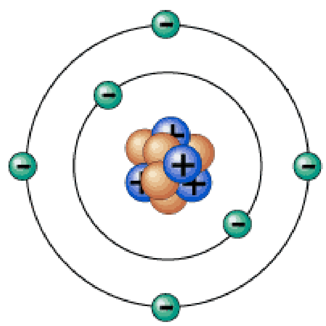
So, chlorine has 18 neutrons!

Test yourself

Task 1: Look → Cover → Write → Check

Information	1st try	2nd try
The atomic number is the number of protons an atom contains.	The atomic number is the number of…	
The atomic mass is the total number of protons and neutrons an atom contains.	The atomic mass is the total number of…	
In an atom, the number of protons is the same as the number of electrons	In an atom…	

Task 2: Label the protons, neutrons and electrons in the diagram below.



Task 3: Complete the table below.

Properties of Protons, Neutrons, and Electrons

	Electron	Proton	Neutron
Charge			0
Relative mass		1	

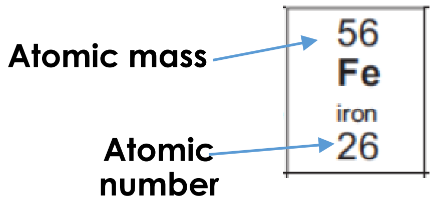
Challenge: Sodium has an atomic number of 11 and a mass number of 23.

1. How many protons does it have?
2. How many electrons does it have?
3. How many neutrons does it have?

L4: Calculating the number of each subatomic particle and learning about isotopes

Calculating the number of subatomic particles

The symbol on the right tells you that iron has 26 protons. This is because the atomic number is 26.



In an atom, the number of protons is equal to the number of electrons, so iron contains 26 electrons.

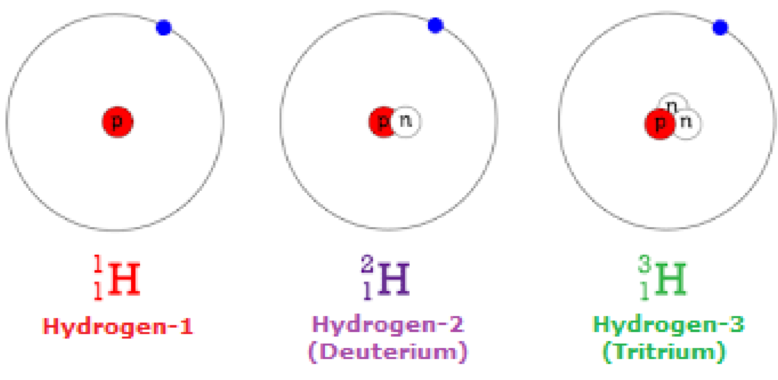
To work out the number of neutrons, you subtract (take away) the atomic number from the mass number.

56 – 26 = 30

So, iron has 30 neutrons!

Isotopes

Isotopes are the atoms of an element with different numbers of neutrons but **the same** number of protons. This means that they have the same atomic number (proton number) but a different atomic mass.



Hydrogen-1	Hydrogen-2	Hydrogen-3
1 proton	**1 proton**	**1 proton**
0 neutrons	**1 neutron**	**2 neutrons**
1 electron	**1 electron**	**1 electron**

Test yourself

Task 1: Fill in the missing words. The key words are provided below:

The smallest particle of an element is called an ____________. The ____________ is in the centre of an atom. Electrons have a __________________ charge and protons have a ___________________ charge. The atomic number is the number of ___________________ in an atom. The Atomic mass is the total number of ________________ and _______________ inside an atom.

For an isotope, the atoms have the ________________ number of protons but __________________ number of neutrons.

Same **Protons** **Negative** **Atom** **Protons** **Different** **Nucleus** **Neutrons** **Positive**

Task 2: The picture on the right shows an oxygen atom. Oxygen has an atomic number of 8 and an atomic mass of 16.

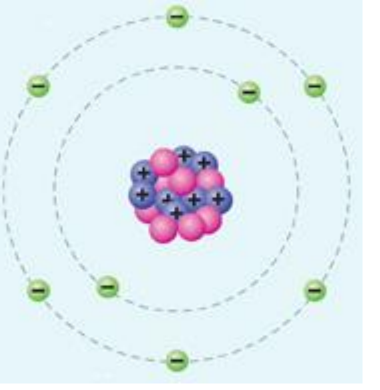
Using the picture and the information to help you, answer the following questions.

An oxygen atom contains ________ protons.

An oxygen atom contains ________ electrons

An oxygen atom contains ________ neutrons.

16
O
oxygen
8



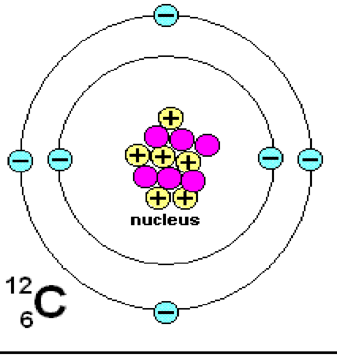
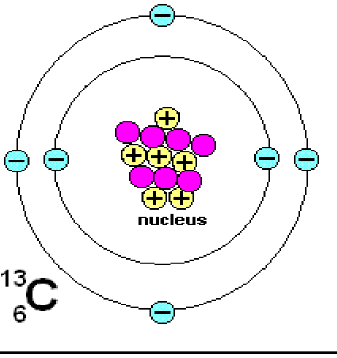
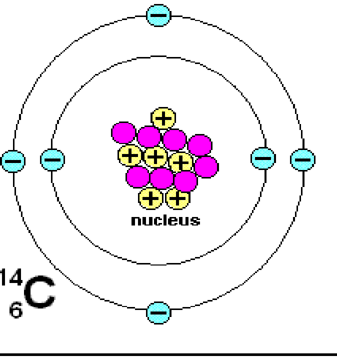
Task 3: Complete the table using the pictures to help you. **Remember**, the top number shows atomic mass and the bottom number shows the atomic number.

12	23	14	31	4	40
C	**Na**	**N**	**P**	**He**	**Ca**
carbon	sodium	nitrogen	phosphorus	helium	calcium
6	11	7	15	2	20

The first row has been done to help you!

Name	**Symbol**	**Protons**	**Neutrons**	**Electrons**
Sodium	***Na***	***11***	***23 – 11 = 12***	***11***
	P			
				6
			7	
			20	
		2	2	2

Task 4: The table below shows isotopes of carbon. Each carbon atom has an atomic number of 6 but different atomic masses. State the number of electrons, protons and neutrons in each isotope of carbon.

		
Carbon-12 No. of protons = No. of electrons = No. of neutrons =	Carbon-13 No. of protons = No. of electrons = No. of neutrons =	Carbon-14 No. of protons = No. of electrons = No. of neutrons =

L5: Electronic arrangements of elements in the periodic table

Electronic structure

The electrons in an atom occupy **energy levels**. These are also called **shells**. Each electron in an atom is found in a particular energy level.

The lowest energy level (innermost shell) fills with electrons first. Each energy level can only hold a certain number of electrons before it becomes full.

The table below shows the maximum number of electrons that fit on each shell.

Energy level or shell	Maximum number of electrons
first	2
second	8
third	8

Writing an electronic structure

The electronic structure of an atom is written using numbers to represent the electrons in each energy level. For example, sodium contains 11 electrons so the electronic structure will be written as 2,8,1. This shows that there are:

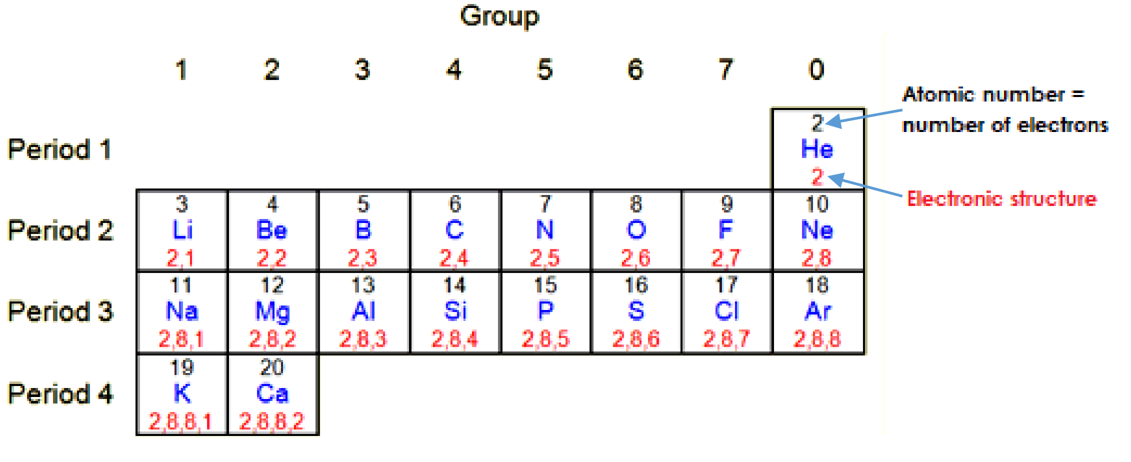
2 electrons in the first energy level

8 electrons in the second energy level

1 electron in the third energy level.

You can work out the electronic structure of an atom from its atomic number (proton number). This is because the number of protons in an atom equals the number of electrons in an atom.

The diagram below shows the first 20 elements and their electronic structures. You will need to be able to write the electronic structure of any of the first 20 elements (hydrogen to calcium)

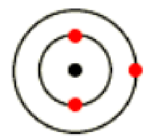
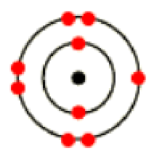
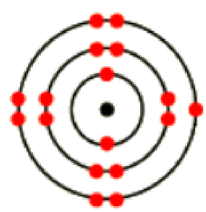
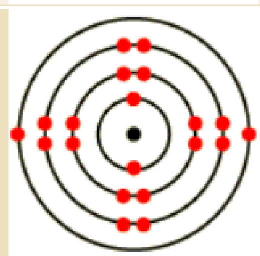


Electronic structure diagrams

You need to be able to draw the electronic structure of any of the first twenty elements (hydrogen to calcium). In these drawings:

- the nucleus is shown as a black spot
- each energy level is shown as a circle around the nucleus
- each electron is shown by a dot or a cross.

The electronic structure of some elements

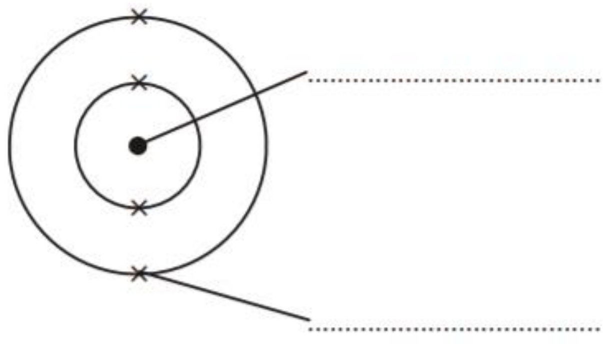
Element	Symbol	Electronic structure (written)	Electronic structure (drawn)
lithium	Li	2,1	
fluorine	F	2,7	
chlorine	Cl	2,8,7	
calcium	Ca	2,8,8,2	

Test yourself

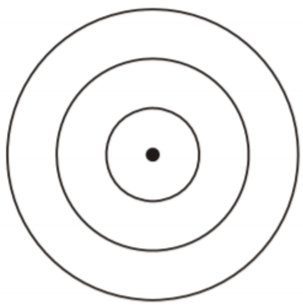
Task 1. Answer the following questions.

1. The diagram represents an atom of beryllium. Use words from the box to label the diagram.

electron
Ion
isotope
molecule
nucleus



2. Use crosses (*x*) to complete the diagram to show the electronic structure of a magnesium atom. The atomic (proton) number of magnesium is 12.



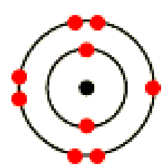
Task 2. Match the elements to the correct atoms! One element is not shown.

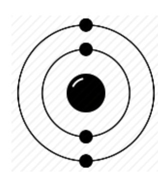
23
Na
sodium
11

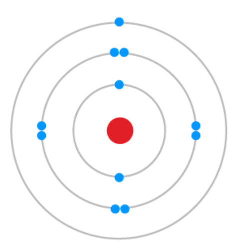
12
C
carbon
6

19
F
fluorine
9

9
Be
beryllium
4





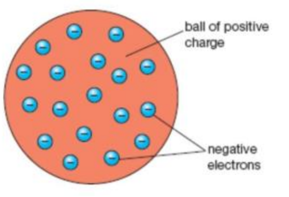


L6: Discoveries leading to the current atomic model

Ideas about atoms have changed over time. Scientists developed new **atomic models** as they gathered new experimental evidence.

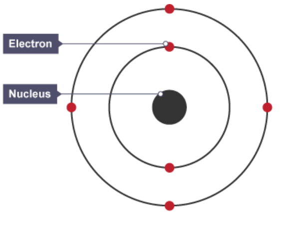
John Dalton published his ideas about atoms in 1803. He thought that all matter was made of tiny particles called **atoms**, which he imagined as tiny spheres that could not be divided.

Nearly 100 years later, **J J Thomson** carried out experiments and discovered the **electron**. This led him to suggest the **plum pudding model** of the atom. In this model, the atom is a ball of positive charge with negative electrons embedded in it - like currants in a Christmas pudding.



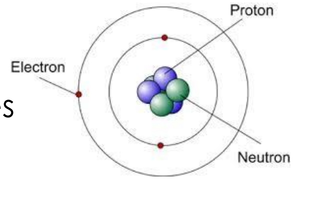
In 1909 **Ernest Rutherford** designed an experiment to test the plum pudding model. The evidence from his experiment suggested a new model for the atom, called the **nuclear model**. In the nuclear model:

- the mass of an atom is concentrated at its centre, the **nucleus**
- the nucleus is positively charged



Niels Bohr adapted Rutherford's nuclear model. Bohr did calculations that led him to suggest that electrons orbit the nucleus in shells. The shells are at certain distances from the nucleus.

Further experiments led to the idea that the nucleus contained small particles, called **protons**. Each proton has a small amount of positive charge.



In 1932 **James Chadwick** found evidence for the existence of particles in the nucleus with mass but no charge. These particles are called **neutrons**. This led to another development of the atomic model, which is still used today.

Test yourself

Task 1: Fill in the gaps using the key words below.

The discovery of the electron led to the ___________ _____________ model of the atom. Before the discovery of the electron atoms were thought to be tiny spheres that could not be divided.

Rutherford and Marsden's alpha particle scattering experiments led to the plum pudding model being replaced by the ________________ model.

___________adapted the nuclear model by suggesting that _____________ orbit the _____________ in shells. The theoretical calculations of Bohr agreed with experimental observations.

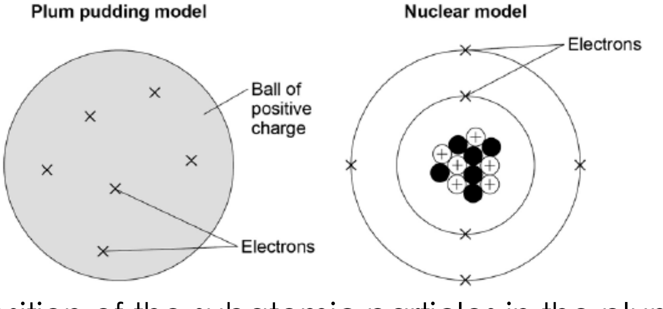
Later experiments led to the idea that the positive charge of any nucleus could be subdivided into a whole number of smaller particles, each particle having the same amount of positive charge. The name _______________ was given to these particles. In 1932 the experimental work of ______________ provided the evidence to show the existence of _______________within the nucleus.

Electrons **Neutrons** **Proton** **Chadwick** **Nuclear** **Bohr**

Plum pudding **Nucleus**

Challenge:

The diagram shows the plum pudding model of an atom of carbon and the current nuclear model of an atom of carbon.



Compare the position of the subatomic particles in the plum pudding model with the nuclear model. (4 marks)

____

____

____

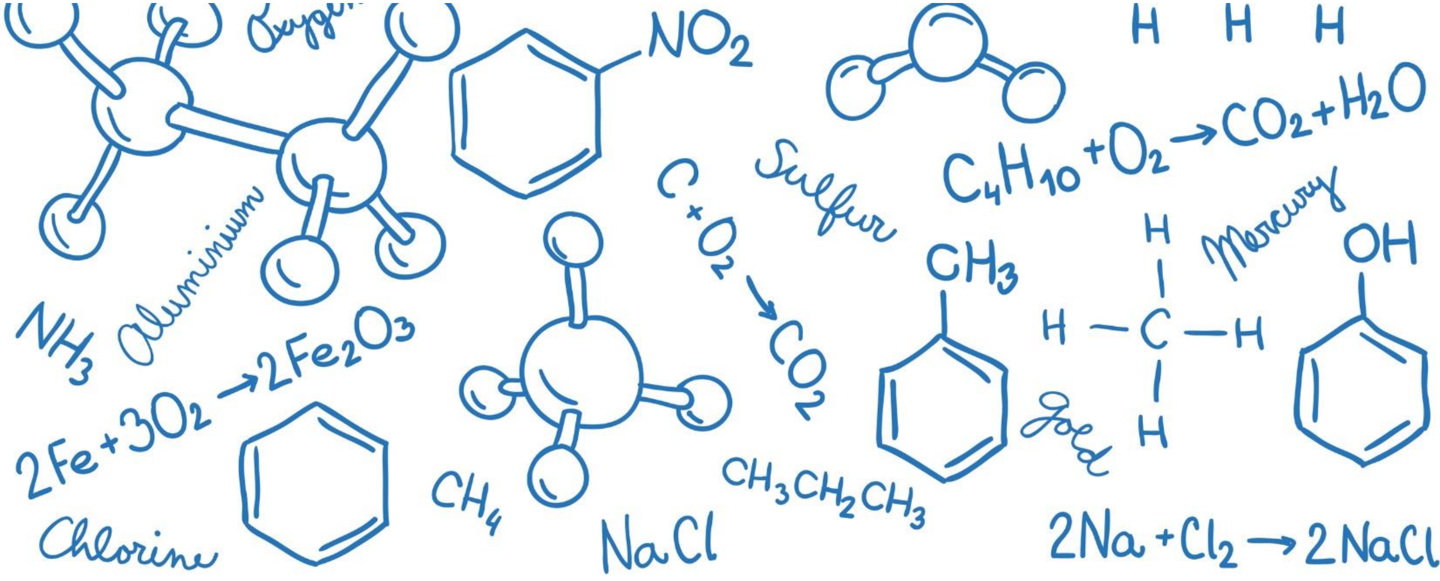
____

____

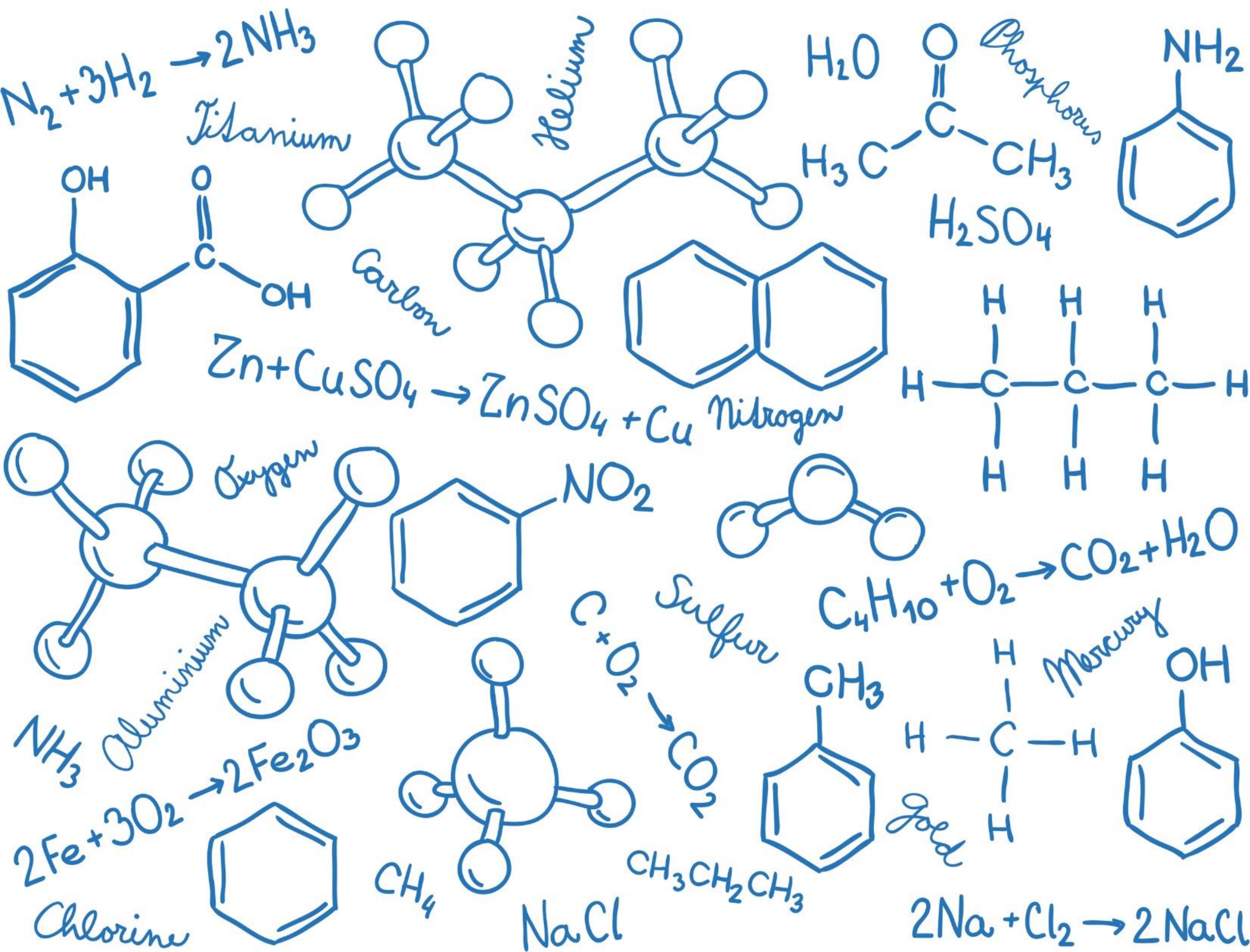
____

____

____



Periodic table



L1: Mendeleev and the periodic table

The periodic table

All the different elements are arranged in a chart called the **periodic table**.

There were many scientists who noticed that some elements had similar properties and tried to arrange them in order. However, a pattern could not be found for all the elements.

A Russian chemist called **Dimitri Mendeleev** arranged the elements in an order that we would now recognise.

He realised that the physical and chemical properties of elements were related to their atomic mass in a 'periodic' way, and arranged them so that groups of elements with similar properties fell into vertical columns in his table.

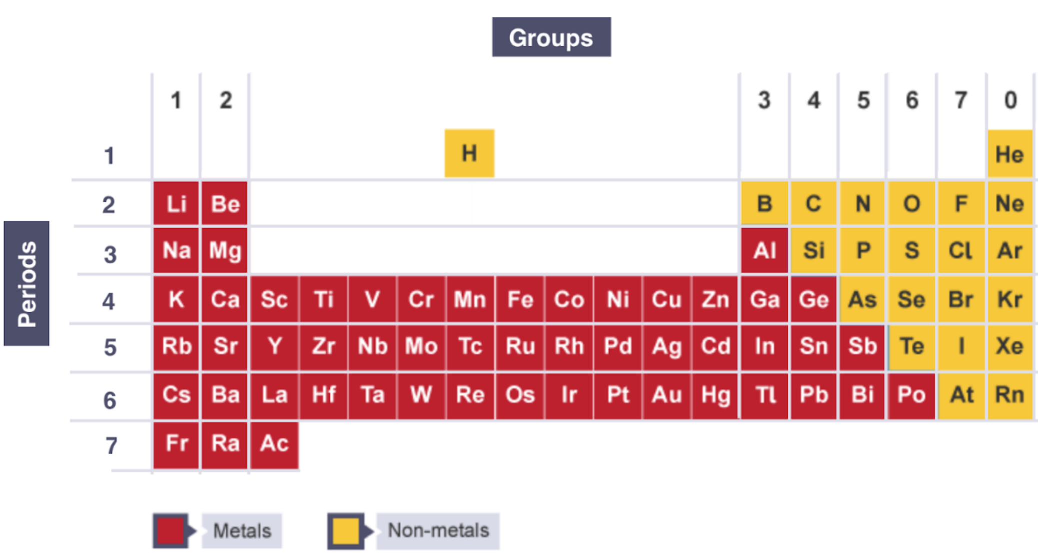
Gaps and predictions

Sometimes this method of arranging elements meant **there were gaps** in his horizontal rows or 'periods'. But instead of seeing this as a problem, Mendeleev thought it simply meant that the elements in the gap had not been discovered yet!

He was also able to work out the atomic mass of the missing elements, and so **predict their properties** and when they *were* discovered, Mendeleev turned out to be right. This is why his periodic table became widely accepted.

So, **Mendeleev** produced one of the first practical periodic tables in the 19th century. The modern periodic table is based closely on the ideas he used:

- the elements are arranged in order of increasing **atomic number**
- the horizontal rows are called **periods**
- the vertical columns are called **groups**
- elements in the same group are similar to each other



The groups of the periodic table

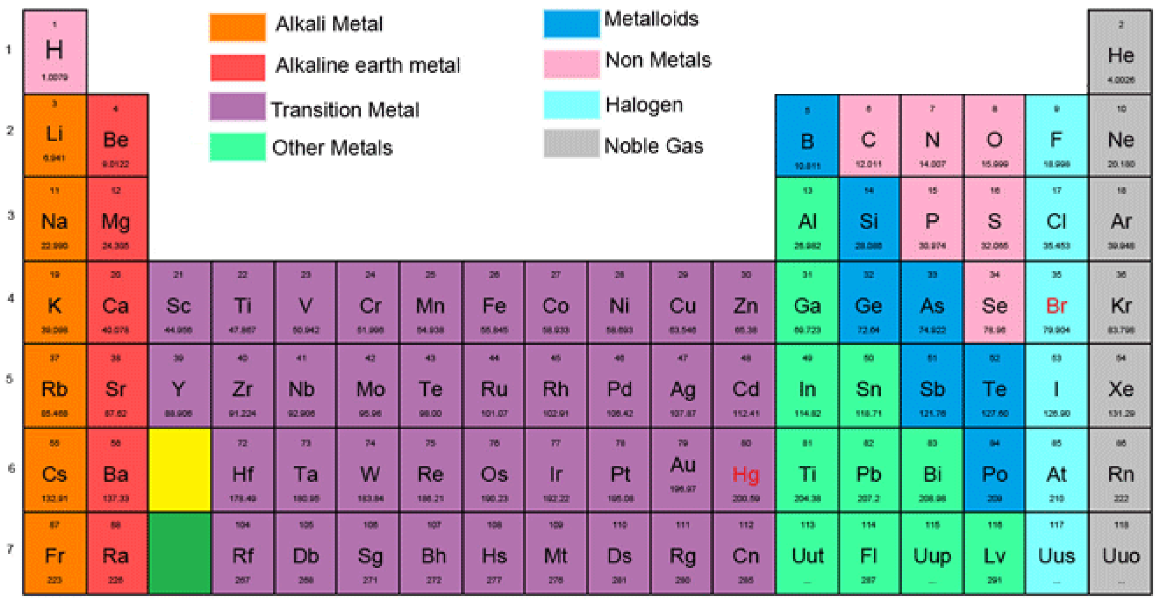
The groups on the periodic table also have names. The main ones you need to know are listed below.

Group 1 = Alkali metals (orange)

Group 2 = Alkaline earth metals (Dark pink)

Group 7 = Halogens (Turquoise)

Group 0 = Noble gases (Grey)



<u>Test yourself</u>

Task 1: Complete the paragraph below using the key words.

Mendeleev created one of the first versions of the _______________ table. Using information about elements that had already been discovered, he was able to ________________ properties of elements that had not yet been _______________. This included things such as their melting point, _____________ and appearance.

Discovered **Periodic** **Mass** **Predict**

Task 2: Use the periodic table above and on the previous page to answer the following questions.

1. How many groups are there in the periodic table?
2. How many elements are there in group 1?
3. How many elements are there in the transition metals?
4. Which group is Cl (chlorine) in?
5. Which groups is Na (sodium) in?
6. Which group is Ne (Neon) in?
7. Which of these elements is the odd one out? Li Na Mg K Rb Cs

L2: Properties of metals and non-metals

Metals

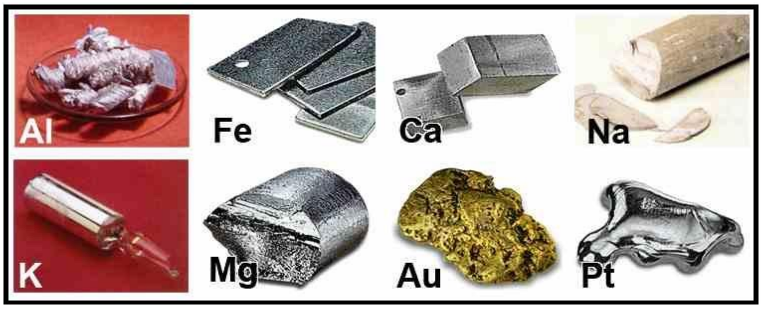
Iron, magnesium and gold are examples of metal elements. Metals have properties in common. They are:

- **shiny**, especially when they are freshly cut
- good **conductors** of heat and electricity
- **malleable** (they can be bent and shaped without breaking)

Most metals also have other properties in common. They are:

- solid at room temperature (except mercury).
- **hard** and **strong**
- they have a high **density**
- they are **sonorous** (make a ringing sound when hit)

Only three metals are **magnetic**. They are nickel, iron and cobalt.



Non-metals

Oxygen, carbon, sulphur and chlorine are examples of non-metal elements. Non-metals have properties in common. They are:

- **dull** (not shiny)
- **poor conductors** of heat and electricity (they are **insulators**)
- weak and **brittle** (they easily break or shatter when solid)

Most non-metals also have these properties:

- they have a **low density** (they feel light for their size)
- They are NOT **sonorous** (they do not make a ringing sound when hit)

Eleven non-metals are gases at room temperature, including oxygen and chlorine.

One non-metal, bromine, is a liquid at room temperature.

The other non-metals are solids at room temperature, including carbon and sulfur.

Test yourself

Task 1: Look → Say → Cover → Write → Check

Look	Say	Cover	Write	Check	Write	Check
example	✓	✓	*exampel*	×	*example*	✓
Shiny						
Conductor						
Malleable						
Sonorous						
Magnetic						
Brittle						
Insulator						
Density						

Task 2: Complete the questions below.

1. *Match the following terms to their definitions*

electrical conductor malleable

sonorous flexible ductile thermal conductor

------------------------------------ Metals do not break – they bend

------------------------------------ Metals can be drawn into wires

------------------------------------ Metals can be hammered into sheets

------------------------------------ Metals ring like a bell when hit - they do not make a dull thud

------------------------------------ All metals conduct electricity

------------------------------------ Metals allow energy to flow through them, causing heating

2. *Which of the following are NOT properties of most metals? Circles your answers*

strong magnetic high melting point

brittle hard

L3: Properties of group 1 metals and how they react

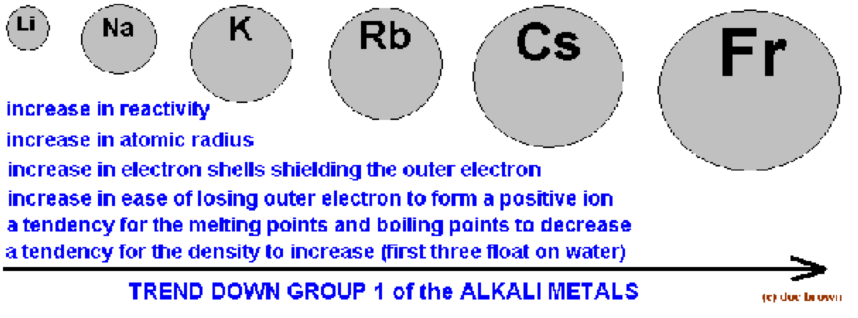
Physical properties of group 1 metals

Group 1 contains **elements** placed in a vertical column on the far left of the **periodic table**. The elements in group 1 are called the **alkali metals**.

The alkali metals share similar **physical properties**. For example, they:

- are **soft** (they can be cut with a knife)
- have relatively low **melting points**
- have **low densities**

The diagram below shows the trend of group 1 metals going down the group.



Chemical properties of group 1 metals

Atoms of **group 1 elements** all have one **electron** in their outer shell. This means that the alkali metals all have similar **chemical properties**.

Reactions with water

The alkali metals react with water to produce a **metal hydroxide** and **hydrogen**. For example, sodium reacts with water:

sodium + water → sodium hydroxide + hydrogen

$2Na(s) + 2H_2O(l) \rightarrow 2NaOH(aq) + H_2(g)$

Sodium hydroxide is an **alkali**. It is a **base** that **dissolves** in water to form an **alkaline solution**. This solution:

- has a **pH** greater than 7
- turns **universal indicator** solution blue or purple

Element	Observation when added to water
Lithium, Li	Fizzes steadily; slowly becomes smaller until it disappears
Sodium, Na	Fizzes rapidly; melts to form a ball; quickly becomes smaller until it disappears
Potassium, K	Burns violently with sparks and a lilac flame; quickly melts to form a ball; disappears rapidly, often with a small explosion

Test yourself

Task 1: What changes would you see if you put the group 1 metals in water?

METAL	SYMBOL	OBSERVATIONS
lithium		1. 2. 3.
sodium		1. 2. 3.
potassium		1. 2. 3.

Task 2: Complete the questions below.

1. What **gas** was produced?
2. What **colour** does the Universal Indicator change after the reaction? ______________________________
3. What does this tell you about the type of **solution** made? ________________________
4. What is **different** about the reaction of **potassium** compared to the other metals? ___________________________

Challenge:

For the reaction of lithium, sodium and potassium with water:

1. Can you write/make a **word equation** for each reaction?

a) ____________ + ____________ → ________________ + ________________

b) ____________ + ____________ → ________________ + ________________

c) ____________ + ____________ → ________________ + ________________

2. Write a symbol equation for each reaction

a) ____________ + ____________ → ________________ + ________________

b) ____________ + ____________ → ________________ + ________________

c) ____________ + ____________ → ________________ + ________________

L4: Properties of halogens and noble gases

Group 7 (halogens)

Group 7 contains **non-metal elements** placed in a vertical column on the right of the **periodic table**. The elements in group 7 are called the **halogens**.

The halogens show trends in their **physical** and **chemical properties**.

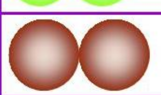
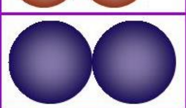
Physical properties of group 7 (halogens)

The halogens exist as simple **molecules**. Each molecule is made up of a pair of halogen **atoms** chemically joined together. In all groups of the periodic table, the further down the group an element is, the higher its **relative molecular mass**.

In group 7, the further down the group an element is, the higher its **melting point** and **boiling point**. This is because, going down group 7:

- the molecules become larger
- the **intermolecular forces** become stronger
- more **energy** is needed to overcome these forces

The table shows the colour and physical **states** of fluorine (yellow), chlorine (pale green), bromine (brown) and iodine (purple-black) at room temperature.

Halogen	Relative size	Melting point (°C)	Boiling point (°C)	State
fluorine		-220	-118	gas
chlorine		-101	-34	gas
bromine		-7	59	liquid
iodine		114	184	solid

Chemical properties of group 7 halogens

Reactions with metals

The halogens react with metals to produce **salts**. For example, chlorine reacts with sodium:

sodium + chlorine → sodium chloride

$2Na(s) + Cl_2(g) \rightarrow 2NaCl(s)$

In group 7, the **reactivity** of the elements decreases down the group.

Reactions with non-metals

The halogens react with non-metals such as hydrogen. When a halogen reacts with hydrogen, the product is a **compound** called a **hydrogen halide**. For example, chlorine reacts with hydrogen:

hydrogen + chlorine → hydrogen chloride

$$H_2(g) + Cl_2(g) \rightarrow 2\,HCl(g)$$

The hydrogen halides are gases at room temperature. They **dissolve** in water to produce **acidic solutions**. Hydrogen chloride dissolves in water to produce hydrochloric acid, $HCl(aq)$.

Group 0 noble (gases)

Noble gases belong to the right-hand column in the periodic table. The noble gases are all chemically unreactive which means they are **inert**.

Physical properties of group 0 (noble gases)

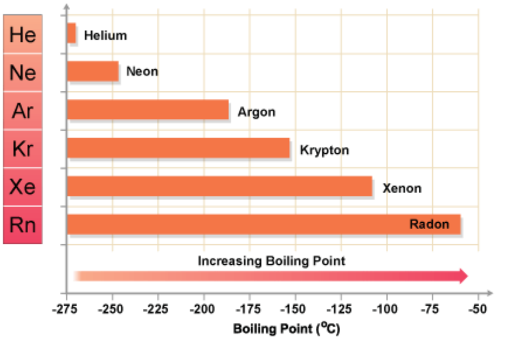
The noble gases have the following properties in common:

- They are **non-metals**
- They are very **unreactive** gases
- They are **colourless**
- They exist as **single** atoms (they are monatomic)

Trends in physical properties

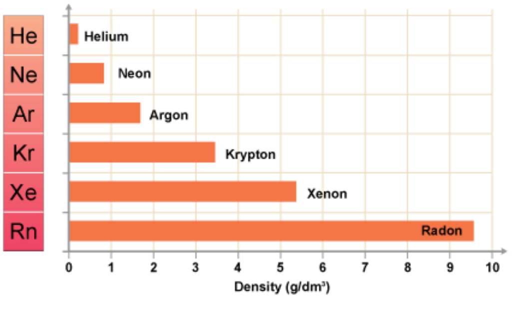
Boiling point

The noble gases all have low boiling points. This is a typical property of non-metals. You can see from the graph (right) that helium, at the top of group 0, has the lowest boiling point in the group. The boiling points then increase as you go down the group.



Density

The density of a substance is a measure of how heavy it is for its size. For example, a small lump of a very dense substance such as gold or lead has a high mass. The particles in gases are spread far apart, so gases have low densities. You can see from the graph (right) that helium, at the top of group 0, has the lowest density in the group. The densities then increase as you go down the group. Radon, at the bottom of the group, is the densest gas known.



Test yourself

Task 1:

This is a periodic table. Colour in:

The Periodic Table

1	2	Groups										3	4	5	6	7	8
									H								He
Li	Be											B	C	N	O	F	Ne
Na	Mg											Al	Si	P	S	Cl	Ar
K	Ca	Sc	Ti	V	Cr	Mn	Fe	Co	Ni	Cu	Zn	Ga	Ge	As	Se	Br	Kr
Rb	Sr	Y	Zr	Nb	Mo	Tc	Ru	Rh	Pd	Ag	Cd	In	Sn	Sb	Te	I	Xe
Cs	Ba	La	Hf	Ta	W	Re	Os	Ir	Pt	Au	Hg	Tl	Pb	Bi	Po	At	Rn

Group 1	red
Group 2	purple
hydrogen	orange
Group 8	yellow
Group 7	green
Group 3 4 5 6	blue
Transition metals	pink

Task 2: Complete the passage using the key words below.

Each group in the periodic table contains elements that have similar ……………………… The atomic number gives the number of ……………………… that an element contains. The lightest element is ……………………… (H) which has an atomic number of one. The atomic number of ……………………… is eight. Sodium (Na) and potassium (K) are two very ……………………… metals. Iron (Fe) and nickel (Ni) are two of the ……………………… metals. The most reactive non-metals are called the ……………………… The ……………………… gases are very unreactive. Magnesium (Mg) and calcium (Ca) are both in group …………………… of the periodic table. Nitrogen (N) and phosphorus (P) are both in group …………………… of the periodic table.

magnetic	**noble**	**two**	**hydrogen**	**reactive**	**five**	**halogens**
properties	**oxygen**	**protons**				

Challenge

The Periodic Table contains groups of elements that have similar chemical properties. The halogens are in Group 7 of the Periodic Table.

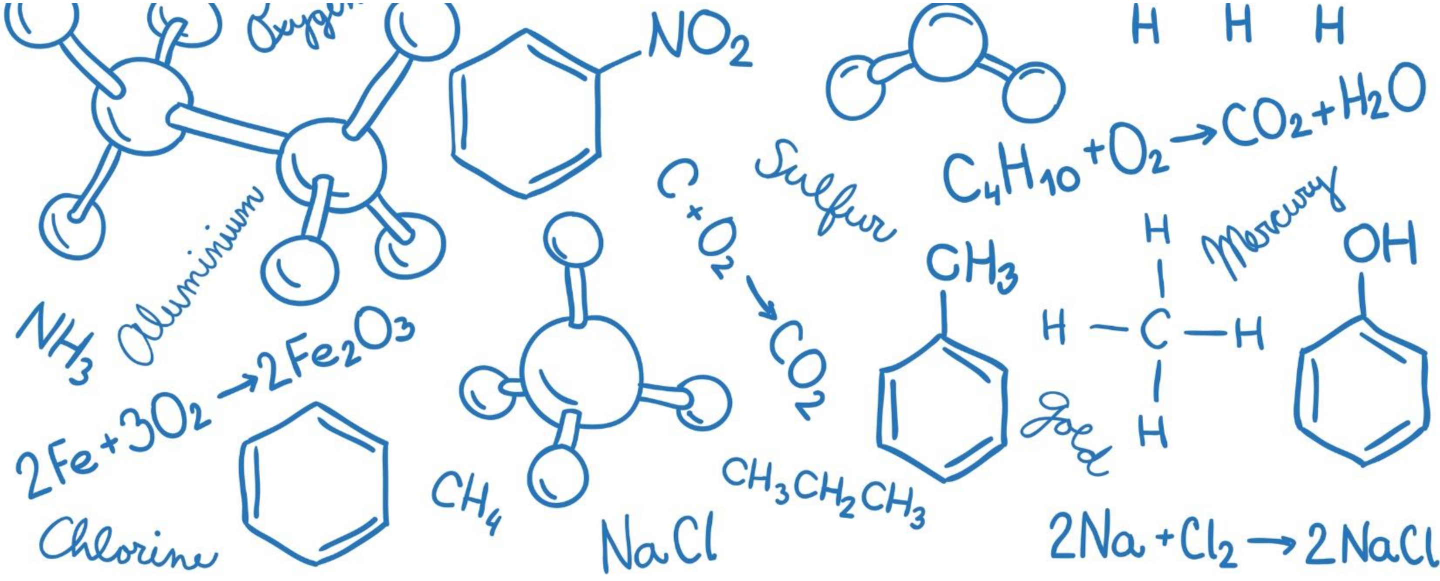
(i) Complete the table. Iodine has been done for you.

Halogen	Colour of vapour
chlorine	
	red-brown
iodine	purple

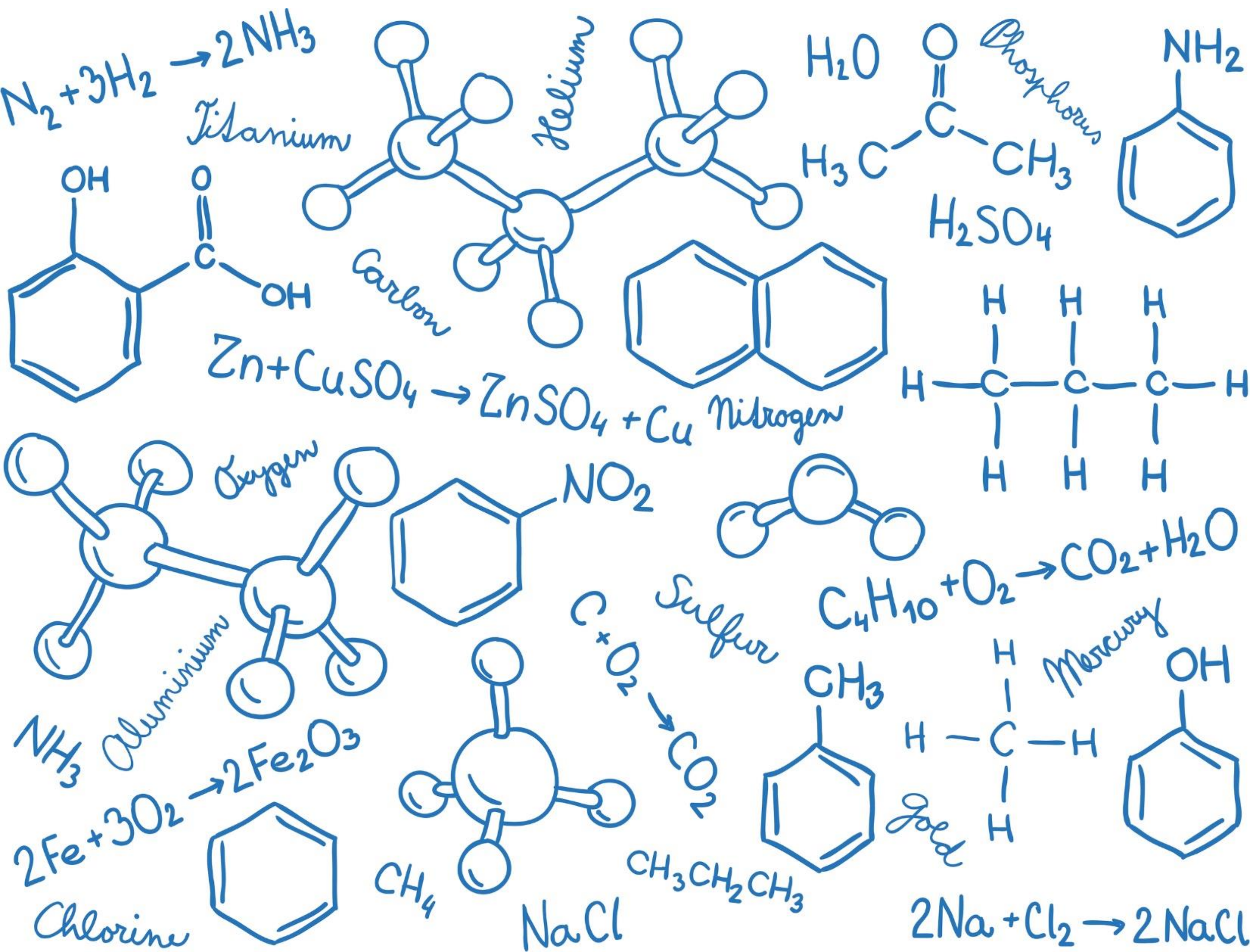
(ii) Why do the halogens have similar chemical properties?

____

____



<u>Chemical reactions</u>



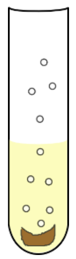
L1 & L2: Introduction to chemical reactions and conservation of mass

Chemical reactions

Atoms are rearranged in a chemical reaction. The substances that:

- react together are called the **reactants**
- are formed in the reaction are called the **products**

The diagram below shows the signs you may see during a chemical reaction.



Gas released (fizzing /bubbles)

An odour

Colour change

Solid formation

Energy change (light, heat etc)

The changes in chemical reactions can be modelled using equations. In general, you write:

reactants → products

Do not write an equals sign instead of an arrow. If there is more than one reactant or product, they are separated by a plus sign.

Word equations

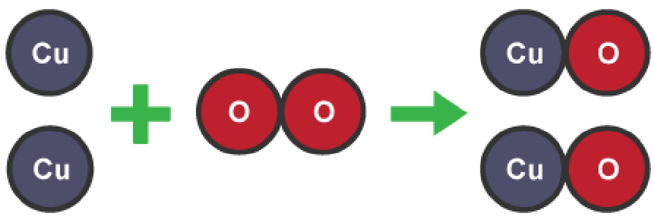
A **word equation** shows the names of each substance involved in a reaction. For example:

copper + oxygen → copper oxide

In this reaction, copper and oxygen are the reactants, and copper oxide is the product.

The law of conservation of mass

No atoms are created or destroyed in a chemical reaction. This means that the total mass of the reactants is the same as the total mass of the products. We say that **mass is conserved** in a chemical reaction.



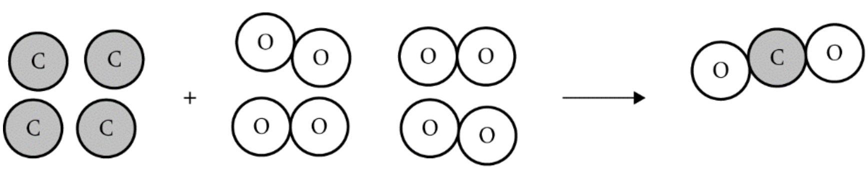
Test yourself

Task 1: Identify whether the following pictures show a physical or chemical change. Mark the chemical reactions with a tick.

Adding acid to alkali 	Fireworks 	Driving a car 
Ice cream melting 	Boiling the kettle 	frying an egg 
Burning a candle 	Melting candle wax 	Dissolving sugar in tea 

Task 2: Complete the questions below.

1. When carbon burns it combines with oxygen to form carbon dioxide. The diagram shows some carbon atoms reacting with some oxygen molecules.



a) Finish the diagram by drawing the correct number of carbon dioxide molecules. One has been done for you.

b) Write 'reactants' and 'products' under the correct sides of the diagram.

c) 12 g of carbon reacted with 32 g of oxygen. What mass of carbon dioxide was formed? Circle the correct answer.

12 g   24 g   32 g   44 g   64 g

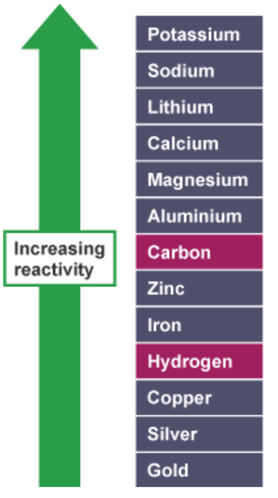
2. Match up the following statements.

If a gas combines with a solid or liquid	appear to decrease in mass
Reactions that release gas	the mass will stay the same
Conservation of mass states that the mass of reactants and products	the mass will appear to increase
If a substance melts,	should be exactly the same
When two liquids react,	the mass of each liquid will add together

L3: The reactivity series

In a reactivity series, the most reactive **element** is placed at the top and the least reactive element at the bottom. A **reactivity series of metals** could include any elements. The diagram on the right shows the reactivity series.

Observations of the way that these elements react with **water** and **acids** enable us to put them into this series.



The tables below show how the elements react with water and dilute acids:

Element	Reaction with dilute acids
Calcium	Very quickly
Magnesium	Quickly
Zinc	More slowly
Iron	More slowly than zinc
Copper	Very slowly
Silver	Barely reacts
Gold	Does not react

Element	Reaction with water
Potassium	Violently
Sodium	Very quickly
Lithium	Quickly
Calcium	More slowly

Metals in water

The word equations and symbol equations for the reaction of group 1 metals with acids is on page 19 (L3: Properties of group 1 metals and how they react)

Metals in acids

The general rule for metals reacting with acids is shown below.

Hydrochloric acid + magnesium → magnesium chloride + hydrogen

"salts"

Nitric acid + iron → iron nitrate + hydrogen

Sulphuric acid + zinc → zinc sulphate + hydrogen

In general, hydrochloric acid makes a chloride, nitric acid makes a nitrate, and sulphuric acid makes a sulphate.

Test yourself

Task 1: Look → Say → Cover → Write → Check

Look	Say	Cover	Write	Check	Write	Check
example	✓	✓	*exampel*	×	*example*	✓
Potassium						
Sodium						
Lithium						
Calcium						
Magnesium						
Aluminium						
Carbon						
Zinc						
Iron						
Hydrogen						
Copper						

Task 2: Answer the following questions

1. The general word equation for the reaction between metal and water is:

2. The general word equation for the reaction between metal and hydrochloric acid is:

3. How can you test for hydrogen?

4. Complete the following word equations:

potassium + water → ………………………………………………… + hydrogen

……………………… + water → lithium hydroxide + ………………………

magnesium + nitric acid → ……………………………………………………… + hydrogen

……………………… + hydrochloric acid → lithium chloride + ………………………

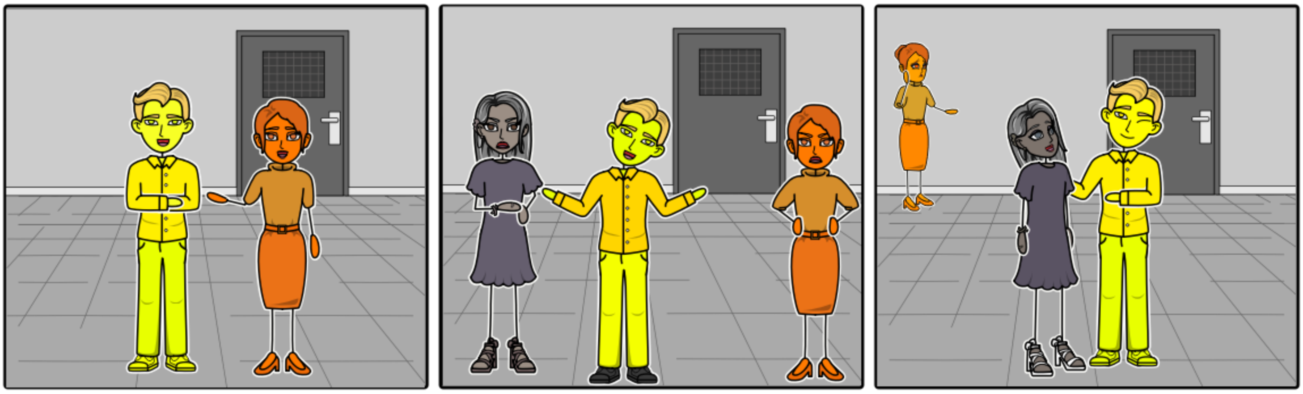
calcium + sulphuric acid → ……………………………………………… + ………………………

L4: Displacement reactions

A more reactive metal will **displace** a less reactive metal from a solution of one of its salts. For example:

magnesium + copper(II) sulphate → copper + magnesium sulphate

$$Mg(s) + CuSO_4(aq) \rightarrow Cu(s) + MgSO_4(aq)$$



Copper and Sulphur (Mr and Mrs Copper Sulfate) are a happy couple out for a walk.

Magnesium comes along and Sulphur is attracted to her because she is more reactive.

Before long, Copper is left on her own as Mr and Mrs Magnesium Sufate become a new happy couple.

Test yourself

Task 1: Work out which metal is more reactive (use the reactivity series on page 27 to help you).

Number	Metal 1	vs.	Metal 2	The most reactive metal wins
1	Lead	vs.	Zinc	Zinc
2	Magnesium	vs.	Hydrogen	
3	Calcium	vs.	Iron	
4	Copper	vs.	Gold	
5	Silver	vs.	Calcium	
6	Potassium	vs.	Carbon	
7	Carbon	vs.	Calcium	
8	Hydrogen	vs.	Carbon	

Task 2: Complete the table. Number 8 and 9 are **challenge** questions.

	Compound	+	Metal		Displacement or No Displacement	Explanation
1	**Magnesium** *Chloride*	+	**Sodium**	→	**Sodium** *Chloride +* ***Magnesium***	Sodium is more reactive Magnesium
2	Potassium Chloride	+	Iron	→	No displacement	Potassium is the most reactive metal
3	Zinc Chloride	+	Iron	→		
4	Aluminium Chloride	+	Calcium	→		
5	Copper Chloride	+	Silver	→		
6	Calcium oxide	+	Zinc	→		
7	Aluminium oxide	+	Zinc	→		
			Challenge			
8	Iron oxide	+	Carbon	→		
9	Gold oxide	+	Hydrogen	→		

L5: The pH scale and neutralisation

Indicators and the pH scale

Solutions can be acidic, alkaline or neutral:

- we get an **acidic** solution when an acid is dissolved in water
- we get an **alkaline** solution when an alkali is dissolved in water
- solutions that are neither acidic nor alkaline are **neutral**

An **indicator** is a substance that changes colour when it is added to acidic or alkaline solutions. Litmus and universal indicator are two indicators that are commonly used in the laboratory.

Litmus paper

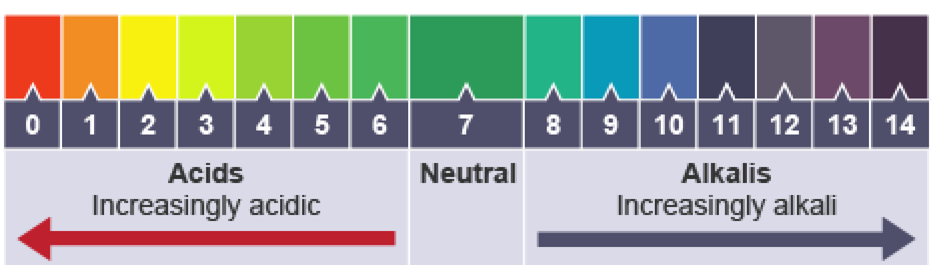
Comes as red litmus paper and blue litmus paper. The table shows the colour changes it can make.

	Red litmus	Blue litmus
Acidic solution	Stays red	Turns red
Neutral solution	Stays red	Stays blue
Alkaline solution	Turns blue	Stays blue

Universal indicator and the pH scale

Universal indicator is supplied as a solution or as **universal indicator paper**. Unlike litmus, universal indicator can show us how strongly acidic or alkaline a solution is, not just that the solution is acidic or alkaline. This is measured using the **pH scale**, which runs from pH 0 to pH 14.

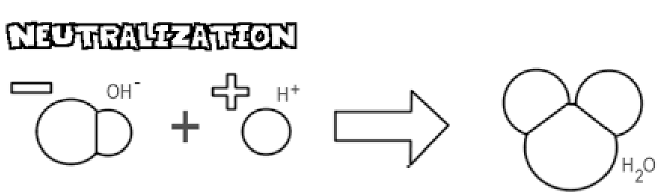
Universal indicator has many different colour changes shown below.



Neutralisation

A chemical reaction happens if you mix together an acid and a base. The reaction is called **neutralisation**. A neutral solution is made if you add just the right amount of acid and base together.

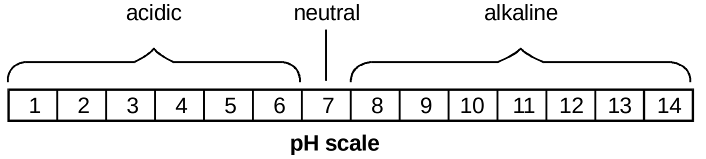
Acids contain H^+ ions and alkalis contains OH^- ions. These can chemically bond to produce water which is neutral!



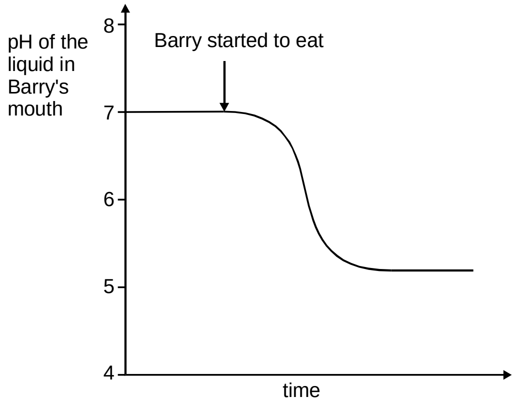
Test yourself

Task: Answer the questions below.

1. The pH scale shown below is used to measure how acidic or alkaline a solution is.



The graph below shows how the pH of the liquid in Barry's mouth changed as he ate a meal.



a) Use the **graph** to give the pH of the liquid in Barry's mouth before he started to eat.

pH ....

b) What does this pH tell you about the liquid in Barry's mouth before he started to eat? Use the **pH scale** above to help you.
Tick the correct box.

It was acidic.	It was alkaline.	It was colourless.	It was neutral.
☐	☐	☐	☐

c) Look at the **graph** above.
What happened to the pH of the liquid in Barry's mouth as he ate the meal?

....

d) Barry chews special chewing gum after each meal. The chewing gum neutralises the liquid in his mouth.
What type of substance neutralises an acid?
Tick the correct box.

an acid	☐	an alkali	☐
an indicator	☐	a solid	☐

L5, L6 & L7: Neutralisation reactions

There are **three** main neutralisation reactions which you need to know.

1. Acid reacting with a **metal oxide**
2. Acid reacting with a **metal hydroxide**
3. Acid reacting with a **metal carbonate**

Metal oxides

Metal oxides act as bases. Here is the general word equation for what happens in their neutralisation reactions with acids:

metal oxide + acid → a salt + water

The salt made depends on the metal oxide and the acid used.

The first part of the salt come from the **metal**.
The second part of the salt comes from the **acid**.

Acid	Salt Formed
hydrochloric acid	- chloride
sulphuric acid	- sulphate
nitric acid	- nitrate

E.g. copper oxide + hydro**chloric** acid → copper **chloride** + water

$$CuO + 2HCl \rightarrow CuCl_2 + H_2O$$

Metal hydroxides

Metal hydroxides act as bases. Some of them dissolve in water, so they form alkaline solutions. Here is the general word equation for what happens in their neutralisation reactions with acids:

metal hydroxide + acid → a salt + water

As with metal oxides, the salt made depends on the metal hydroxide and the acid used.

E.g. sodium hydroxide + sulphuric acid → sodium sulphate + water

$$2NaOH + H_2SO4 \rightarrow Na_2SO4 + 2H_2O$$

Notice that a **salt plus water** are always produced when metal oxides or metal hydroxides react with acids.

Metal carbonates

Most carbonates are usually don't dissolve in water (**insoluble**). They also neutralise acids, making a salt and water, but this time we get **carbon dioxide** gas too.
Here is the general word equation for what happens:

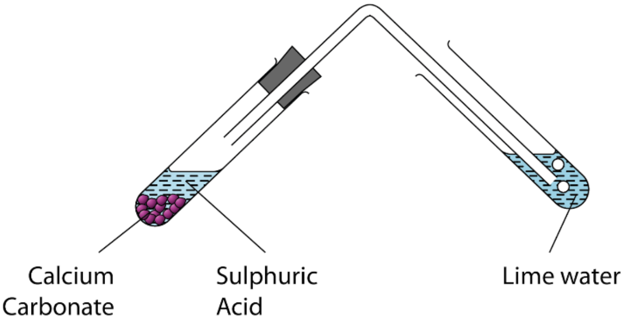
metal carbonate + acid → a salt + water + carbon dioxide

The reaction **fizzes** as bubbles of carbon dioxide are given off. This is easy to remember because we see the word 'carbonate' in the chemical names.

E.g.
copper carbonate + nitric acid → copper nitrate + water + carbon dioxide

$$CuCO_3 + 2HNO_3 \rightarrow Cu(NO_3)_2 + H_2O + CO_2$$

Remember you can test for carbon dioxide using **lime water.**



Test yourself

Task 1: Fill in the table with the salt produced when each of the bases and acids react.

Base	Acid	Salt?
Calcium hydroxide	**Hydrochloric acid**	Calcium chloride
Magnesium oxide	**Nitric acid**	
Calcium carbonate	**Sulphuric acid**	
Aluminium hydroxide	**Nitric acid**	
Potassium hydroxide	**Sulphuric acid**	

Task 2: Match the following:

ACID + ALKALI
Hydrochloric acid + sodium hydroxide
Nitric acid + sodium hydroxide
Sulphuric acid + sodium hydroxide

SALT (+ WATER)
Sodium nitrate + water
Sodium sulphate + water
Sodium chloride + water

Task 3: Write the word equations for the following reactions.

1. Calcium carbonate and hydrochloric acid

2. Sodium hydroxide and hydrochloric acid

3. Copper oxide and sulphuric acid

4. Iron oxide and nitric acid

5. Potassium carbonate and sulphuric acid

6. Magnesium hydroxide and nitric acid

L8: Thermal decomposition

Metal carbonates such as calcium carbonate break down when heated strongly. This is called **thermal decomposition**. Here are the equations for the thermal decomposition of calcium carbonate:

calcium carbonate $\xrightarrow{\text{heat}}$ calcium oxide + carbon dioxide

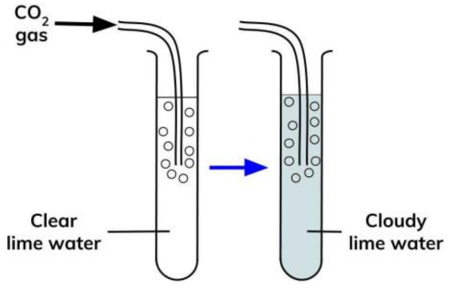
$CaCO_3 \xrightarrow{\text{heat}} CaO + CO_2$

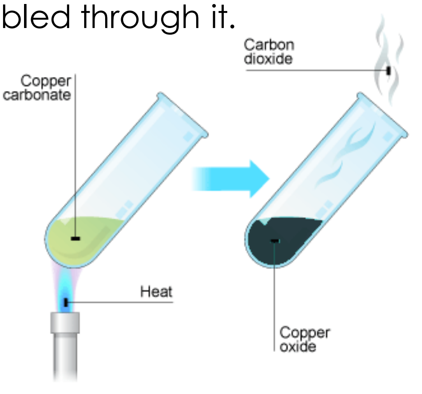
Other metal carbonates decompose in the same way. Here are the equations for the thermal decomposition of copper carbonate:

copper carbonate $\xrightarrow{\text{heat}}$ copper oxide + carbon dioxide

$CuCO_3 \xrightarrow{\text{heat}} CuO + CO_2$

Notice that in both examples the products are a **metal oxide** and **carbon dioxide**. The carbon dioxide gas can be detected using **limewater** which turns cloudy white when carbon dioxide is bubbled through it.





Test yourself

Task:

1. Word equation for thermal decomposition of calcium carbonate

____________ ____________ → ____________ ____________ + ____________ ____________

2. Put these symbols in order to make a symbol equation: CO_2, $CaCO_3$, CaO

__________________ → _______________ + ________________

3. What do the following carbonates decompose to form?

a) Magnesium carbonate →

b) Copper carbonate →

c) Sodium carbonate →

Challenge: Put these symbols in the right order:
MgO, CO_2, $MgCO_3$

________________ → __________________ + __________________

L9: Redox reactions (HT only)

Redox reactions

In terms of oxygen in a chemical reaction:

- **oxidation** is the gain of oxygen
- **reduction** is the loss of oxygen

For example, magnesium reacts with copper(II) oxide:

magnesium + copper(II) oxide → magnesium oxide + copper

In this reaction:
magnesium is **oxidised** to form magnesium oxide
copper(II) oxide is **reduced** to form copper
This is an example of a **redox reaction** because reduction and oxygen happen at the same time.

Oxidation

The following are some more examples of oxidation reactions:

Metals
Metals react with oxygen in the air to produce **metal oxides**. For example, magnesium reacts with oxygen to produce magnesium oxide when it is heated in air:
magnesium + oxygen → magnesium oxide
$2Mg + O_2 \rightarrow 2MgO$

Non-metals
Non-metals react with oxygen in the air to produce **non-metal oxides**. Here are two examples for the non-metals carbon and sulphur.
Carbon reacts with oxygen to form carbon dioxide:
carbon + oxygen → carbon dioxide
$C + O_2 \rightarrow CO_2$
Sulphur burns reacts with oxygen to form sulphur dioxide:
sulphur + oxygen → sulphur dioxide
$S + O_2 \rightarrow SO_2$

Test yourself

Task 1: Complete the following sentences.

1. ______________________ is the loss of oxygen.
2. ______________________ is the gain of oxygen.
3. A __________________ reaction is when both oxidation and reduction are happening at the same time.

Task 2: State which substance is being oxidised and which one is being reduced in the following redox reactions.

1. magnesium + copper(II) oxide → magnesium oxide + copper
Example:

Oxidised: **Magnesium**
Reduced: **Copper oxide**

2. Potassium + iron oxide → potassium oxide + iron

Oxidised:

Reduced:

3. Sodium + zinc oxide → sodium oxide + zinc

Oxidised:

Reduced:

4. Copper oxide + zinc → zinc oxide + copper

Oxidised:

Reduced:

5. Calcium + carbon dioxide → calcium oxide + carbon

Oxidised:

Reduced:

L10: Energy transfer and chemical reactions

Exothermic and endothermic reactions

Exothermic reactions

These are reactions that **transfer energy to the surroundings**. The energy is usually transferred as heat energy, causing the reaction mixture and its surroundings to become **hotter**. The temperature increase can be detected using a **thermometer**.

Some examples of exothermic reactions are:

- burning
- neutralisation reactions between acids and alkalis
- the reaction between water and calcium oxide

Endothermic reactions

These are reactions that **take in energy from the surroundings**. The energy is usually transferred as heat energy, causing the reaction mixture and its surroundings to get **colder**. The temperature decrease can also be detected using a **thermometer**.

Some examples of endothermic reactions are:

- the reaction between ethanoic acid and sodium carbonate
- the *thermal decomposition* of calcium carbonate

	Exothermic	Endothermic
Diagram		
Definition	A reaction that **releases energy to the surroundings**, causing the reaction mixture and its surroundings to become **hotter**	A reaction in which **energy is absorbed from the surroundings**, causing the reaction mixture and its surroundings to become **cooler.**
Examples	Burning/combustion, neutralisation and displacement	Evaporation or melting

Test yourself

Task 1: Complete the sentences using the key words below

When chemical reactions occur, energy is ________________ to or from the surroundings.

An exothermic reaction is one that transfers energy to the surroundings so the temperature of the surroundings ________________. These include combustion, many oxidation reactions and ____________________. Some everyday uses of exothermic reactions are self-heating cans and hand warmers.

An endothermic reaction is one that ______________ in energy from the surroundings so the temperature of the surroundings ____________________.

Endothermic reactions include _________________ ______________________ and the reaction of citric acid and sodium hydrogen carbonate. Some sports injury packs are based on endothermic reactions.

Takes **Increase** **Thermal decomposition** **Neutralisation** **Decrease** **Transferred**

Task 2: Underneath each picture, write down whether it is showing an exothermic or endothermic reaction.

1.

____

2.

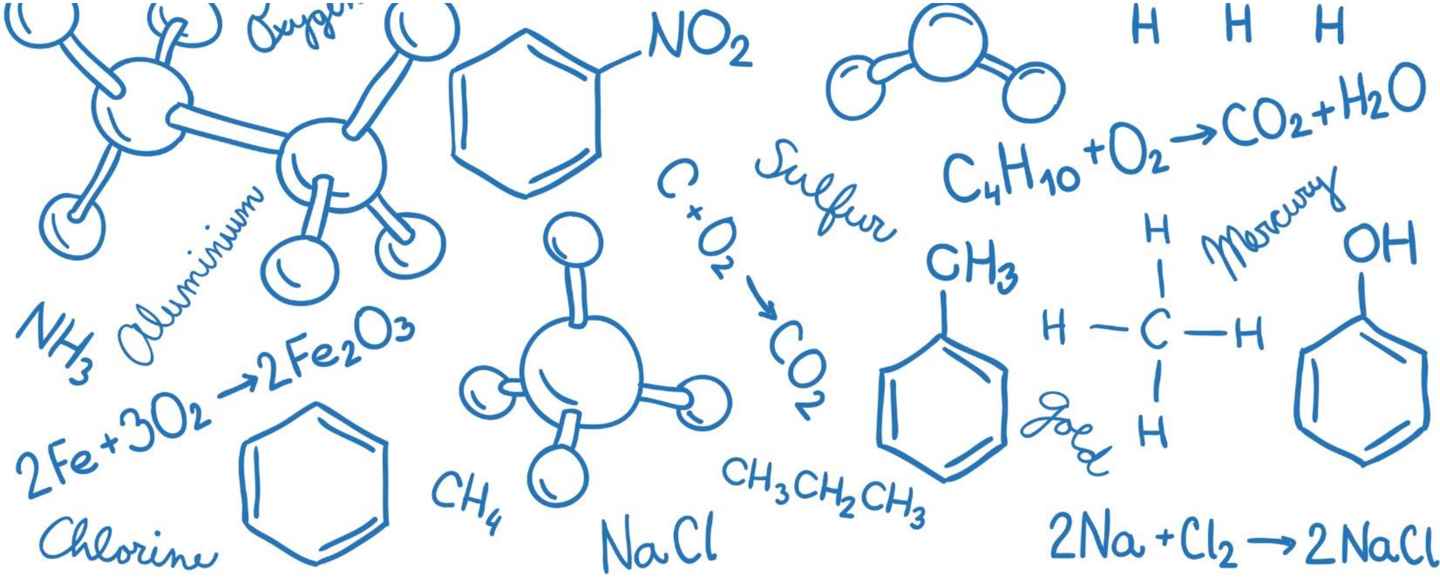
____

3.

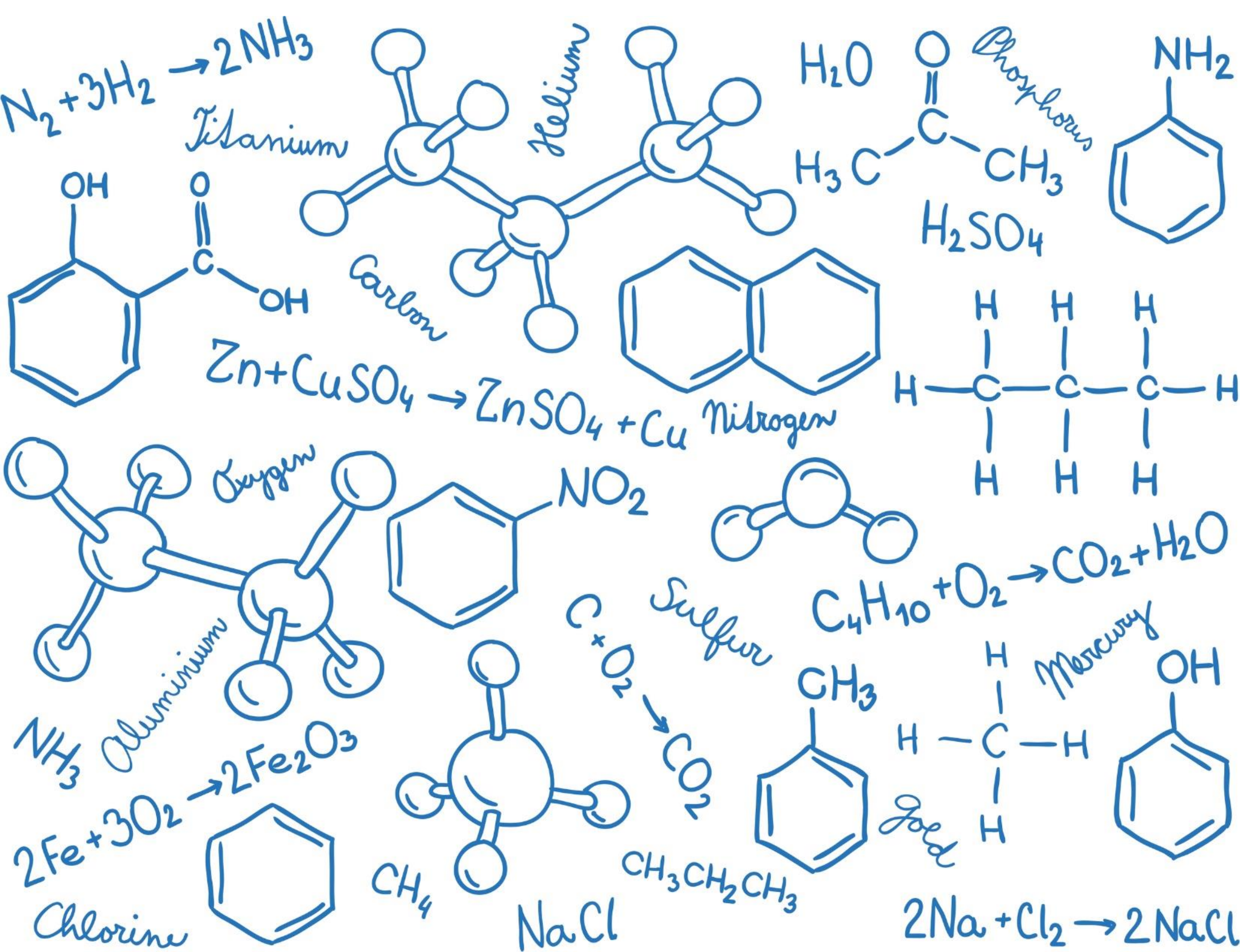
____

4.

____


Oxygen
NO_2
H H H
$C_4H_{10} + O_2 \rightarrow CO_2 + H_2O$
Sulfur
$C + O_2 \rightarrow CO_2$
Aluminium
NH_3
CH_3
Mercury
OH
$2Fe + 3O_2 \rightarrow 2Fe_2O_3$
Gold
CH_4
$CH_3CH_2CH_3$
Chlorine
NaCl
$2Na + Cl_2 \rightarrow 2NaCl$

Answers


$N_2 + 3H_2 \rightarrow 2NH_3$
Titanium
Helium
H_2O
Phosphorus
NH_2
OH
O
H_3C
CH_3
H_2SO_4
OH
Carbon
$Zn + CuSO_4 \rightarrow ZnSO_4 + Cu$
Nitrogen
Oxygen
NO_2
$C_4H_{10} + O_2 \rightarrow CO_2 + H_2O$
Sulfur
$C + O_2 \rightarrow CO_2$
Aluminium
NH_3
CH_3
Mercury
OH
$2Fe + 3O_2 \rightarrow 2Fe_2O_3$
Gold
CH_4
$CH_3CH_2CH_3$
Chlorine
NaCl
$2Na + Cl_2 \rightarrow 2NaCl$

Answers

Atomic structure

L1: Elements, mixtures and compounds

Task:

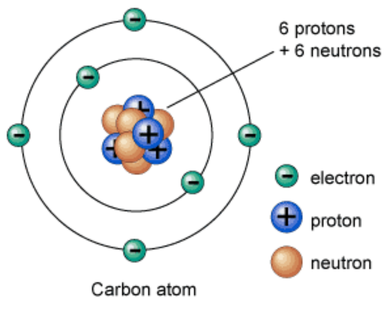
1. 1 elements: **E, F, H**
2. 1 type of Compound: **A, D, I**
3. Mixture of elements: **B**
4. Mixture of compounds: **G**
5. Mixture of elements and compounds: **C**

Challenge:

1. Which letters are showing molecules of elements - **E**
2. Which letters are showing gases **– A, B, C, D, E, F, G, I**
3. Which letter is showing a solid? - **H**
4. Which letter could be showing water (H_2O) - **I**

L2&3: Atomic structure, atomic mass and atomic number

Task 2:



Task 3:

Properties of Protons, Neutrons, and Electrons			
	Electron	Proton	Neutron
Charge	1–	1+	0
Relative mass	Negligible	1	1

Challenge: Sodium has an atomic number of 11 and a mass number of 23.

1. How many protons does it have? **11**
2. How many electrons does it have? **11**
3. How many neutrons does it have? **12**

L4: Calculating the number of each subatomic particle and learning about isotopes

Task 1: Fill in the missing words: **Atom, nucleus, negative, positive, protons, protons and neutrons, same, different.**

Task 2:

An oxygen atom contains **8** protons.

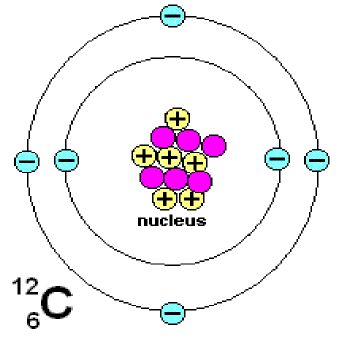
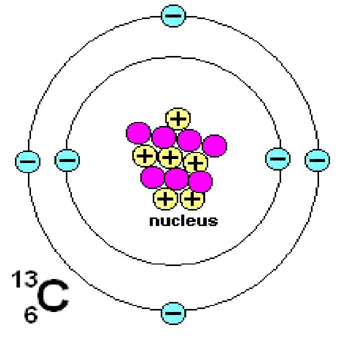
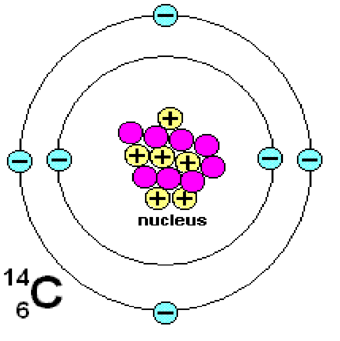
An oxygen atom contains **8** electrons

An oxygen atom contains **8** neutrons.

Task 3:

Name	Symbol	Protons	Neutrons	Electrons
Sodium	***Na***	***11***	***12***	***11***
Phosphorous	P	***15***	***16***	***15***
Carbon	***C***	***6***	***6***	6
Nitrogen	***N***	***7***	7	***7***
Calcium	***Ca***	***20***	20	***20***
Helium	***He***	2	2	2

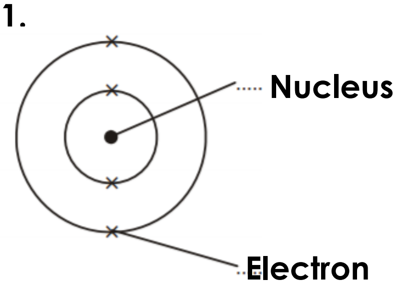
Task 4:

		
Carbon-12 No. of protons = **6** No. of electrons = **6** No. of neutrons = **6**	Carbon-13 No. of protons = **6** No. of electrons = **6** No. of neutrons = **7**	Carbon-14 No. of protons = **6** No. of electrons = **6** No. of neutrons = **8**

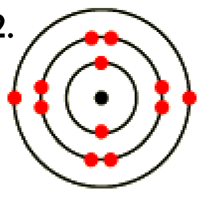
L5: Electronic arrangements of elements in the periodic table

Task 1:

1.

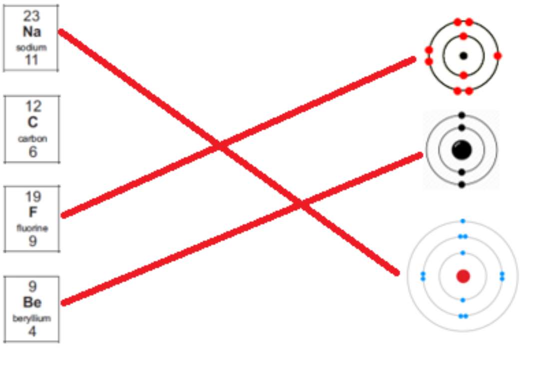


2.



magnesium atom,
Mg 2,8,2

3.



L6: Discoveries leading to the current atomic model

Task 1:

Plum pudding, Nuclear, Bohr, Electrons, Nucleus, Proton, Chadwick, Neutrons.

Challenge:

plum pudding model has a single ball of positive charge and nuclear model has positive charges in the centre / nucleus 1

plum pudding model has electrons in random positions and nuclear model has electrons in fixed position 1

plum pudding model has no nucleus and the nuclear model has a nucleus 1

plum pudding model has no neutrons and the nuclear model has neutrons in the nucleus 1

Periodic table

L1: Mendeleev and the periodic table

Task 1: Periodic, predict, discovered, mass

Task 2:

1) 8 2) 6 3) 38 4) Group 7 5) Group 1 6) Group 0 7) Mg

L2: Properties of metals and non-metals

Task 2

1) Flexible, Ductile, Malleable, Sonorous, electrical conductor, thermal conductor

2) Brittle

L3: Properties of group 1 metals and how they react

Task 1:

METAL	SYMBOL	OBSERVATIONS
lithium	Li	1. Fizzes 2. Moves around on the surface of the water 3. Becomes smaller until it disappears
sodium	Na	1. Fizzes 2. Moves around on the water 3. Melts and turns into a sphere
potassium	K	1. Burns with a lilac flame/sparks 2. Quickly melts and turns into a ball 3. Disappears very quickly

Task 2: Complete the questions below.

1. **Hydrogen**
2. **Blue/purple**
3. **It is an alkali / it is an alkaline solution**
4. **It catches fire**

Challenge

Question 1

a) **Lithium + water → lithium hydroxide + hydrogen**

b) **Sodium + water → sodium hydroxide + hydrogen**

c) **Potassium + water → potassium hydroxide + hydrogen**

Question 2

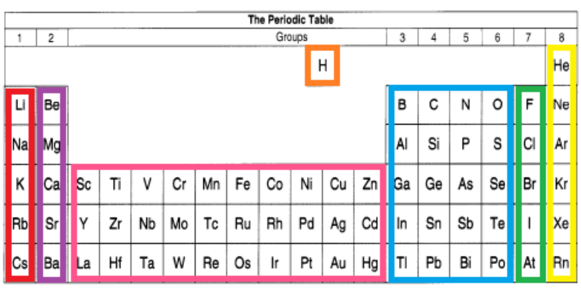
a) **$2\ Li + 2\ H_2O \rightarrow 2\ LiOH + H_2$**

b) **$2\ Na + 2\ H_2O \rightarrow 2\ NaOH + H_2$**

c) **$2\ K + 2\ H_2O \rightarrow 2\ KOH + H_2$**

L4: Properties of halogens and noble gases

Task 1:



Task 2: **properties, protons, hydrogen, oxygen, reactive, magnetic, halogens, noble, two, five.**

Challenge

(i) Chlorine is **green / pale green**.

Bromine is a red-brown colour

(ii) **because they have the same number of electrons in outer shell**

Chemical changes

L1 & L2: Introduction to chemical reactions and conservation of mass

Task 1:

Adding acid to alkali ✓	Fireworks ✓	Driving a car ✓
Ice cream melting x	Boiling the kettle x	frying an egg ✓
Burning a candle ✓	Melting candle wax x	Dissolving sugar in tea x

Task 2:

1a) 3 more carbon dioxide molecules drawn

1b) Carbon + Oxygen → Carbon dioxide

1c) 44g

2.

If a gas combines with a solid or liquid,	appear to decrease in mass
Reactions that release gas	the mass will stay the same
Conservation of mass states that the mass of reactants and products	the mass will appear to increase
If a substance melts,	should be exactly the same
When two liquids react,	the mass of each liquid will add together

L3: The reactivity series

Task 2:

1. **Metal + water → metal hydroxide + hydrogen**
2. **Metal + hydrochloric acid → metal chloride + hydrogen**
3. **The squeaky pop test**
4. Potassium + water → **potassium hydroxide** + hydrogen

   Lithium + water → lithium hydroxide + **hydrogen**

   Magnesium + nitric acid → **magnesium nitrate + hydrogen**

   Lithium + hydrochloric acid → lithium chloride + **hydrogen**

   Calcium + sulphuric acid → **calcium sulphate + hydrogen**

L4: Displacement reactions

Task 1: **Magnesium, Calcium, Copper, Calcium, Potassium, Calcium, Carbon**

Task 2:

	Compound	+	Metal		Displacement or No Displacement	Explanation
3	Zinc Chloride	+	Iron	→	**No displacement**	**Zinc is more reactive Iron**
4	Aluminium Chloride	+	Calcium	→	**Calcium chloride + Aluminium**	**Calcium is more reactive than aluminium**
5	Copper Chloride	+	Silver	→	**No displacement**	**Copper is more reactive than silver**
6	Calcium oxide	+	Zinc	→	**Zinc oxide + calcium**	**Calcium is more reactive than zinc**
7	Aluminium oxide	+	Zinc	→	**No displacement**	**Aluminium is more reactive than zinc**
8	Iron oxide	+	Carbon	→	**Iron + carbon dioxide**	**Carbon is more reactive than iron**
9	Gold oxide	+	Hydrogen	→	**Gold + water**	**Hydrogen is more reactive than gold**

L5: The pH scale and neutralisation

Task: 1a) **7** b) **it is neutral** c) **it decreased / it became more acidic**
d) an alkali

L5, L6 & L7: Neutralisation reactions

Task 1: Magnesium nitrate, calcium sulphate, aluminium nitrate, potassium sulphate.

Task 2:

ACID + ALKALI
Hydrochloric acid + sodium hydroxide
Nitric acid + sodium hydroxide
Sulphuric acid + sodium hydroxide

SALT (+ WATER)
Sodium nitrate + water
Sodium sulphate + water
Sodium chloride + water

Task 3:

1. Calcium carbonate + hydrochloric acid → calcium chloride + water + carbon dioxide
2. Sodium hydroxide + hydrochloric acid → sodium chloride + water
3. Copper oxide + sulphuric acid → copper sulphate + water
4. Iron oxide + nitric acid → iron nitrate + water
5. Potassium carbonate + sulphuric acid → potassium sulphate + water + carbon dioxide
6. Magnesium hydroxide + nitric acid → Magnesium nitrate + water

L8: Thermal decomposition

Task

1. Calcium carbonate → calcium oxide + carbon dioxide
2. $CaCO_3 \rightarrow CaO + CO_2$
3.

a) Magnesium oxide + carbon dioxide

b) Copper oxide + carbon dioxide

c) Sodium oxide + carbon dioxide

Challenge

$MgCO_3 \rightarrow MgO + CO_2$

L9: Redox reactions (HT only)

Task 1: 1) Reduction 2) oxidation 3) Redox

Task 2: 2) potassium, iron oxide 3) sodium, zinc oxide

4) Zinc, copper oxide 5) Calcium, carbon dioxide

L10: Exothermic and endothermic reactions

Task 1: 1) transferred 2) increase 3) neutralisation 4) decrease

5) Thermal decomposition

Task 2) 1) Endothermic 2) Exothermic 3) endothermic 4) endothermic