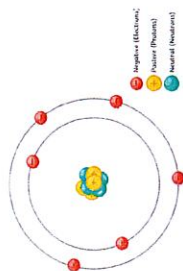


Atomic Structure and the Periodic Table – Foundation and Higher

Atoms

Contained in the nucleus are the **protons** and **neutrons**. Moving around the nucleus are the **electron** shells. They are negatively charged.

Particle	Relative Mass	Charge
proton	1	+1
neutron	1	0
electron	Very small	-1



Overall, atoms have no charge; they have the same number of protons as electrons. An ion is a charged particle - it does not have an equal number of protons to electrons.

Atomic Number and Mass Number



Elements

Elements are made of atoms with the same atomic number. Atoms can be represented as symbols.

N = nitrogen F = fluorine Zn = zinc Ca = calcium

Isotopes – an isotope is an element with the **same number of protons** but a **different number of neutrons**. They have the same atomic number, but different mass number.

Isotope	Protons	Electrons	Neutrons
${}^1_1\text{H}$	1	1	$1 - 1 = 0$
${}^2_1\text{H}$	1	1	$2 - 1 = 1$
${}^3_1\text{H}$	1	1	$3 - 1 = 2$

Compounds – a compound is when two or more elements are chemically joined.

Examples of compounds are carbon dioxide and magnesium oxide. Some examples of formulas are CO_2 , NaCl , HCl , H_2O , Na_2SO_4 . They are held together by chemical bonds and are difficult to separate.

Equations and Maths

To calculate the **relative atomic mass**, use the following equation:

relative atomic mass (A_r) =

$$\frac{\text{sum of (isotope abundance} \times \text{isotope mass number)}}{\text{sum of abundances of all isotopes}}$$

Balancing Symbol Equations

There must be the same number of atoms on both sides of the equation:



C = 1

O = 4

H = 4

Chemical Equations

A chemical reaction can be shown by using a **word equation**.

e.g. magnesium + oxygen $\rightarrow$ magnesium oxide
On the left-hand side are the reactants, and the right-hand side are the products.

They can also be shown by a **symbol equation**.



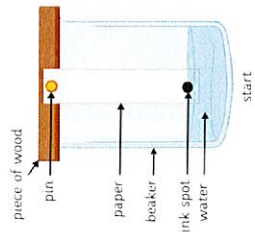
Equations need to be **balanced**, so the same number of atoms are on each side. To do this, numbers are put in front of the compounds.



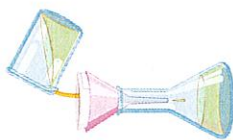
Mixtures, Chromatography and Separation

Mixtures – in a mixture there are no chemical bonds, so the elements are easy to separate. Examples of mixtures are air and salt water.

Chromatography – to separate out mixtures.

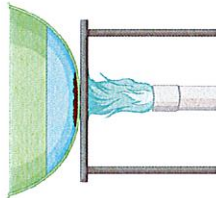


Filtration – to separate solids from liquids.



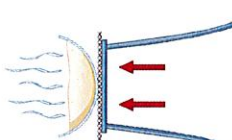
Evaporation – to separate a soluble salt from a solution;

a quick way of separating out the salt.



Crystallisation – to separate a soluble salt from a solution;

a slower method of separating out the salt.



Separating out salt from rock salt:

1. Grind the mixture of rock salt.
2. Add water and stir.
3. Filter the mixture, leaving the sand in the filter paper
4. Evaporate the water from the salt, leaving the crystals.



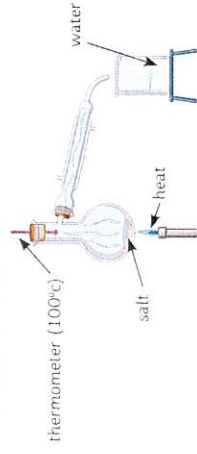
Science

Atomic Structure and the Periodic Table – Foundation and Higher

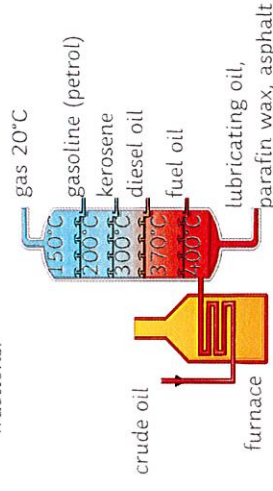
Distillation

To separate out mixtures of liquids.

1. **Simple distillation** – separating a liquid from a solution.



2. **Fractional distillation** – separating out a mixture of liquids. Fractional distillation can be used to separate out crude oil into fractions.



Metals and Non-metals

They are found at the **left** part of the periodic table. Non-metals are at the **right** of the table.

Metals

Are strong, malleable, good conductors of electricity and heat. They bond metallically.

Non-Metals

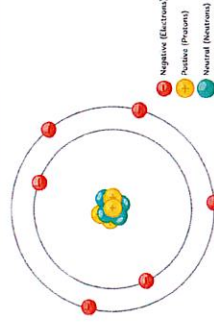
Are dull, brittle, and not always solids at room temperature.

History of the Atom

Scientist	Time	Discovery
John Dalton	start of 19 th century	Atoms were first described as solid spheres.
JJ Thomson	1897	Plum pudding model – the atom is a ball of charge with electrons scattered.
Ernest Rutherford	1909	Alpha scattering experiment – mass concentrated at the centre; the nucleus is charged. Most of the mass is in the nucleus. Most atoms are empty space.
Niels Bohr	around 1911	Electrons are in shells orbiting the nucleus.
James Chadwick	around 1940	Discovered that there are neutrons in the nucleus.

Electronic Structure

Electrons are found in shells. A maximum of two in the most inner shell, then eight in the 2nd and 3rd shell. The inner shell is filled first, then the 2nd then the 3rd shell.



Group 7 Elements and Noble Gases

Halogens

The halogens are **non-metals**: fluorine, chlorine, bromine, iodine. As you go down the group they become less reactive. It is harder to gain an extra electron because its outer shell is further away from the nucleus. The melting and boiling points also become higher.

Noble Gases

The **noble gases** (group 0 elements) include: **helium, neon** and **argon**. They are un-reactive as they have full outer shells, which makes them very stable. They are all colourless gases at room temperature.

The boiling points all increase as they go down the group – they have greater intermolecular forces because of the increase in the number of electrons.

Development of the Periodic Table

In the early 1800s, elements were arranged by atomic mass. The periodic table was not complete because some of the elements had not been found. Some elements were put in the wrong group.

Dimitri Mendeleev (1869) left gaps in the periodic table. He put them in order of **atomic mass**. The gaps show that he believed there was some undiscovered elements. He was right! Once found, they fitted in the pattern.

The Modern Periodic Table

Elements are in order of **atomic mass/proton number**. It shows where the metals and non-metals are. **Metals** are on the **left** and **non-metals** on the **right**. The **columns** show the **groups**. The **group number** shows the number of **electrons** in the **outer shell**. The rows are **periods** – each period shows another full shell of electrons. The periodic table can be used to predict the reactivity of elements.

Alkali Metals

The alkali metals (group 1 elements) are soft, very reactive metals. They all have **one electron** in their **outer shell**, making them **very reactive**. They are **low density**. As you go down the group, they become more reactive. They get bigger and it is easier to lose an electron that is further away from the nucleus.

They form ionic compounds with non-metals.

They react with water and produce hydrogen.

E.g.

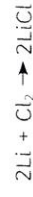
lithium + water → lithium hydroxide + hydrogen



They react with chlorine and produce a metal salt.

E.g.

lithium + chlorine → lithium chloride



They react with oxygen to form metal oxides.



a Draw and label an atom. Include labels for the following:
neutron, proton, electron.

- True or false?
1. The radius of an atom is 0.1nm
 2. Most of the mass is in the shell of the atom.

b Fill in the table to show the charges and mass of the components of an atom.

Name	Charge	Relative Mass
proton		
neutron		
electron		

What is the overall charge of an atom?

- Positive
Negative
No charge

c A compound is 2 or more _____, chemically

Which of the following are compounds?

Put a ring round them.

oxygen, salt water, magnesium oxide, sodium chloride, nitrogen

Why have you circled the ones you have?

d What are the symbols for the following elements?

Element	Symbol
oxygen	
lithium	
sodium	
potassium	
helium	
carbon	
magnesium	

e Complete the following diagram for sodium, include the atomic number and the atomic mass number.

Na

What is the mass number?

How do you calculate neutron number?

f Isotopes are elements with a different number of _____ but the same number of _____, e.g. carbon 12 and carbon 14.

How can you use isotopes to calculate the relative atomic mass? Write down the equation.

g Complete and balance the following equations. What is the name of the compound formed?



Mixtures

Write the definition of a mixture. Give two examples.

i Name the compounds and the elements they contain.

NaCl -

MgO -

MgS -

FeS -

j What is the ratio of the elements in the following compounds?

e.g. CaO = 1:1

NaCl =

MgCl₂ =

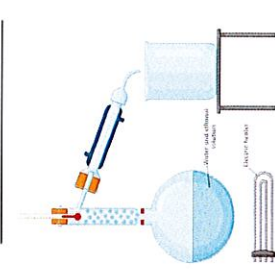
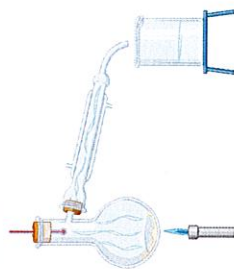
lithium fluoride =

K₂O =

sodium hydroxide =

Separating Mixtures

What are the following separation techniques?



What separation technique would you use to separate out different inks in pens?

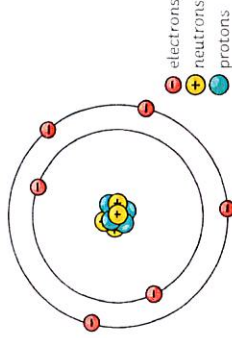
How can salt be collected using the process of crystallisation?

Sand and water can be separated by using a process called

Describe, in 4 steps, how to collect salt from rock salt.

- 1.
- 2.
- 3.
- 4.

Draw and label an atom. Include labels for the following:
neutron, proton, electron.



True or false?

- The radius of an atom is 0.1nm. **True**
- Most of the mass is in the shell of the atom. **False, most of the mass is in the centre**

Fill in the table to show the charges and mass of the components of an atom.

Name	Charge	Relative Mass
proton	+1	1
neutron	0	1
electron	-1	very small

What is the overall charge of an atom?
No charge

A compound is 2 or more elements, chemically joined.

Which of the following are compounds?
Put a ring round them.

oxygen, salt water, **magnesium oxide, sodium chloride,**
nitrogen

Why have you circled the ones you have?

They have 2 or more elements in the word equation.

What are the symbols for the following elements?

Element	Symbol
oxygen	O
lithium	Li
sodium	Na
potassium	K
helium	He
carbon	C
magnesium	Mg

Complete the following diagram for sodium, include the atomic number and the atomic mass number.

23 mass number

Na

11 atomic number

What is the mass number?

Total number of protons and neutrons.

How do you calculate neutron number?

Atomic mass – proton number

Isotopes are elements with a different number of **neutrons** but the same number of **protons**, e.g. carbon 12 and carbon 14.

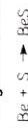
How can you use isotopes to calculate the relative atomic mass? Write down the equation.

$Ar = \frac{\text{sum of (isotope abundance} \times \text{isotope mass number)}}{\text{sum of abundances of all the isotopes}}$

Complete and balance the following equations. What is the name of the compound formed?



magnesium oxide



beryllium sulphide



beryllium fluoride



potassium chloride

Mixtures

Write the definition of a mixture. Give two examples.

Two or more elements together, not chemically joined and can be easily separated.

Salt water, sand and water

Name the compounds and the elements they contain.

NaCl - sodium chloride, sodium and chlorine

MgO - magnesium oxide, magnesium and oxygen

MgS - magnesium sulfide, magnesium and sulfur

FeS - iron sulfide, iron and sulfur

What is the ratio of the elements in the following compounds?

e.g. **CaO = 1:1**

NaCl = 1:1

MgCl₂ = 1:2

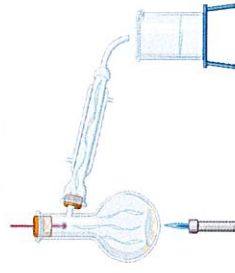
lithium fluoride = 1:1

K₂O = 2:1

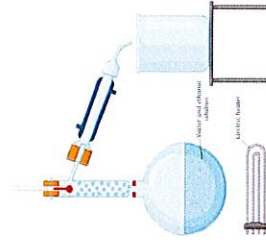
sodium hydroxide = 1:1:1

Separating Mixtures

What are the following separation techniques?



Distillation



Fractional distillation

What separation technique would you use to separate out different inks in pens?

Chromatography

How can salt be collected using the process of crystallisation?

By heating up a mixture of salt and water, the water will evaporate and leave the salt in the bowl.

Sand and water can be separated by using a process called **filtration**.

Describe, in 4 steps, how to collect salt from rock salt.

- Grind the mixture;**
- Add water and stir;**
- Filter the mixture;**
- Evaporate the salt water and salt is left over.**

Complete the electronic structure diagrams for:
oxygen

magnesium

Describe why the noble gases are so unreactive.

The boiling points of the noble gases increase/decrease as you go down the group. (delete the wrong answer) Can you explain your answer?

Describe what happens to the reactivity of the alkali metals as you go down the group.

Why?

Complete the word and symbol equation for sodium reacting with water:

sodium + water → sodium hydroxide + _____

Na + _____ → NaOH + _____

List 3 halogens _____

How many electrons do they have in their outer shell?

Describe how the reactivity changes as you go down the group.

Write balanced symbol equations for the following reactions:

bromine + potassium iodide

chlorine + sodium iodide

fluorine + potassium chloride

Underline the properties of metals and circle the properties of non-metals:

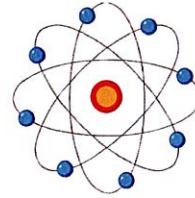
Strong, low density, malleable, dull, good conductors of heat and electricity, high melting and boiling point, brittle, not good conductors of electricity.

James Chadwick discovered the... (underline the correct answer)

proton

neutron

electron



Complete the following dot and cross diagrams for:
NaCl

MgO

Complete word equations for the following reactions:

sodium + chlorine →

lithium + iodine →

potassium + bromine →

How are the groups arranged in the periodic table?

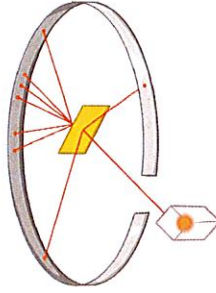
How can you tell that the alkali metals are very reactive?

How can you tell the noble gases are unreactive?

Describe the plum pudding model of the atom.
Draw a diagram.

Why did scientists believe this model?

Describe what the alpha scattering experiment showed scientists.



Niels Bohr discovered that

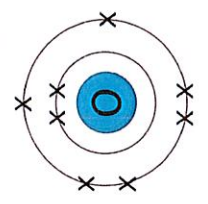
Why did Mendeleev leave gaps in the periodic table?

What happened to some of the gaps he left?

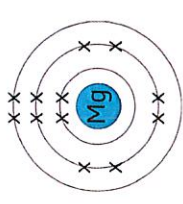
a

Complete the electronic structure diagrams for:

oxygen



magnesium



b

Describe why the noble gases are so unreactive.

Their outer shell is full of electrons.

The boiling points of the noble gases increase as you go down the group.

This is because there are more forces to bond the atoms together, therefore more energy is required to break the bonds.

c

Describe what happens to the reactivity of the alkali metals as you go down the group.

It increases

Why?

The number of electrons increases. They are further away from the nucleus. There is less pull on the outer electrons so the atom is more likely to lose an electron.

Complete the word and symbol equation for sodium reacting with water:

sodium + water → sodium hydroxide + hydrogen

$$2\text{Na} + 2\text{H}_2\text{O} \rightarrow 2\text{NaOH} + \text{H}_2$$

d

List 3 halogens

chlorine, fluorine, iodine, astatine

How many electrons do they have in their outer shell?

7 electrons

Describe how the reactivity changes as you go down the group.

They become less reactive, the atom becomes larger because there are more electron shells, further from the nucleus so the pull of the nucleus is less. So the electron is less likely to be gained as there is less of a positive pull.

Write balanced symbol equations for the following reactions:

bromine + potassium iodide

$$\text{Br}_2 + 2\text{KI} \rightarrow 2\text{KBr} + \text{I}_2$$

chlorine + sodium iodide

$$\text{Cl}_2 + 2\text{NaI} \rightarrow 2\text{NaCl} + \text{I}_2$$

fluorine + potassium chloride

$$\text{F}_2 + \text{KCl} \rightarrow 2\text{KF} + \text{Cl}_2$$

e

Underline the properties of metals and circle the properties of non-metals:

Strong, low density, malleable, dull, good conductors of heat and electricity, high melting and boiling point, brittle, not good conductors of electricity

f

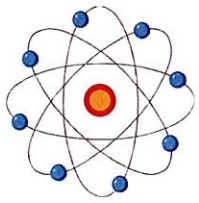
James Chadwick discovered the...

(underline the correct answer)

proton

neutron

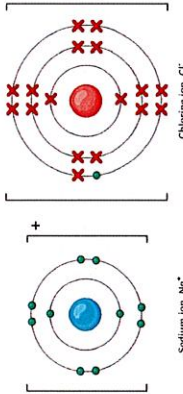
electron



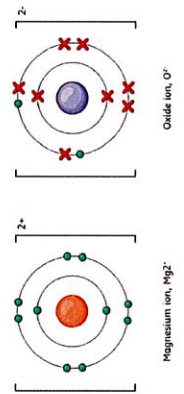
g

Complete the following dot and cross diagrams for:

NaCl



MgO



h

Complete word equations for the following reactions:

sodium + chlorine → **sodium chloride**

lithium + iodine → **lithium iodide**

potassium + bromine → **potassium bromide**

i

How are the groups arranged in the periodic table?

According to their properties.

How can you tell that the alkali metals are very reactive?

According to their properties.

How can you tell the noble gases are unreactive?

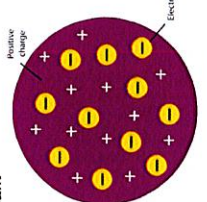
Full shell of outer electrons.

j

Describe the plum pudding model of the atom.

Draw a diagram.

A sphere of positive charge with electrons dotted about; looking like a plum pudding.



Plum pudding model

Why did scientists believe this model?

Lack of experimental evidence.

k

Describe what the alpha scattering experiment showed scientists.

Most alpha particles go straight through, some are scattered, some rebound off the gold foil. This shows that the nucleus of an atom has a very small radius. Most of the mass is concentrated in the nucleus.

l

Niels Bohr discovered that

electrons orbit the nucleus in shells.

Why did Mendeleev leave gaps in the periodic table?

He knew that the elements existed but they hadn't been found, based on their mass.

What happened to some of the gaps he left?

They have been filled. Scientists have found some of the elements.

C5-7: Bonding

Lesson sequence

1. Ionic bonding
2. Ionic compounds
3. Properties of ionic compounds
4. Covalent bonding
5. Covalent structures
6. Allotropes of carbon
7. Metallic bonding
8. Classifying materials

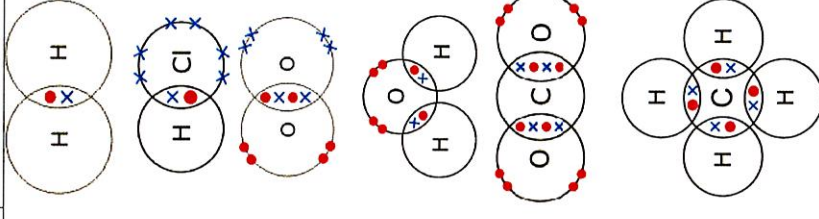
1. Ionic bonding	
*Bond	An attraction between two atoms that holds them together.
*Ion	An atom that has gained a charge by gaining or losing electrons.
*Charge	Whether an ion is positive or negative.
*Cation	Positive ion formed by losing electrons. Formed by metal atoms.
*Anion	Negative ion formed by gaining electrons. Formed by non-metal atoms.
**Size of charge	The number of electrons transferred affects the size of charge: losing two electrons makes a 2+ charge, gaining three electrons makes a 3- charge.
**How many electrons are gained or lost?	Metals: however many electrons are in the outer shell Non-metals: however many electrons are needed to fill the outer shell.
*Electrostatic force	A force of attraction between a positive and negative particle.
*Ionic bond	When two oppositely charged ions are held together by an electrostatic force.

**Forming ionic bonds	Electrons are transferred from a metal atom to a non-metal atom to form a positive metal cation and a negative metal anion. The oppositely charged ions are attracted to each other.
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2. Ionic compounds	
*Chemical formula	Shows the number of atoms of each element present in one 'unit' of a compound.
*Writing formulae	- Each chemical symbol starts with a capital letter. - The number of each atom present is shown with a subscript number after the symbol. E.g. H_2SO_4.
**Determining ionic formulae	- Ensure the total number of positive and negative charges balance. - Change the number of each ion present by changing the subscript numbers.
*Compound ions	An ion made from two or more atoms that share a charge.
*Common compound ions	Hydroxide: OH^- Nitrate: NO_3^- Sulfate: SO_4^{2-} Sulfite: SO_3^{2-} Carbonate: CO_3^{2-} Ammonium: NH_4^+
**Including compound ions in formulae	If you need more than one, put brackets around it. E.g. $\text{Mg}(\text{OH})_2$
*Ionic lattice	The structure of ionic compounds: a repeating 3D pattern of alternating positive and negative ions.
**Crystal	A piece of material with a regular shape and straight edges formed by the regular pattern of ions in an ionic lattice.

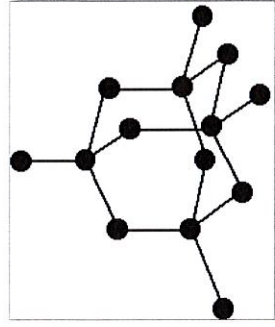
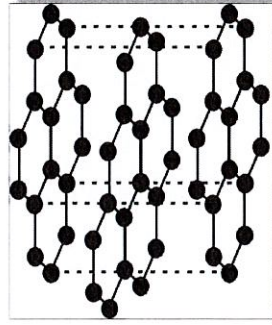
3. Properties of ionic compounds	
**Melting point of ionic compounds	High because melting needs a lot of energy to break strong ionic bonds.
*Solubility of ionic compounds	Many ionic compounds dissolve in water.
**Electrical conductivity of ionic compounds	Solid: Do not conduct because ions can't move. Liquid (molten or solution): Do conduct because ions can move.
**How ionic compounds conduct electricity	When they are in a liquid form, the positive cations move to the negative electrode (cathode) and the negative anions move to the positive electrode (anode).
4. Covalent bonding	
*Covalent bond	An electrostatic attraction between two atoms and a share pair of electrons.
**Double bond	A covalent bond involving two shared pairs of electrons.
*Dot and cross diagram	A bonding diagram showing the electrons in the outer shell of each atom, with electrons drawn as dots or crosses.
*Hydrogen, H_2	Two overlapping circles both labelled H. One pair in the overlap.
**Hydrogen chloride, HCl	Two overlapping circles labelled H and Cl. One pair in the overlap, 6 electrons around Cl.
**Oxygen, O_2	Two overlapping circles both labelled O. Two pairs in the overlap, 4 electrons around each O.
**Water, H_2O	Three overlapping circles in a line labelled H, O, H. A pair in each overlap, 4 electrons around O.
**Carbon dioxide, CO_2	Three overlapping circles in a line labelled O, C, O. Two pairs in each overlap, 4 electrons around each O.
**Methane, CH_4	Five circles with one in the centre labelled C and 4 labelled H around it. A pair in each overlap.

**Valency	The number of covalent bonds an atom can form.
**Valency and groups	Group 4 = 4 (4 electrons needed) Group 5 = 3 (3 electrons needed) Group 6 = 2 (2 electrons needed) Group 7 = 1 (1 electron needed)
**Working out molecular formulae	Find the lowest common multiple of the valency of each atom. Use the number of an atom required to reach the LCM.



5. Covalent structures	
*Molecule	A particle made from two or more atoms bonded together.
*Simple molecular structure	A structure made of small molecules in which a few atoms join together to form a small particle.
**Structure of molecular substances	Atoms in a molecule are held together by strong covalent bonds. Neighbouring molecules are held close by weak intermolecular forces.
**Intermolecular force	A weak electrostatic force that holds two neighbouring molecules together.
**Melting point of simple molecular compounds	Low because melting only needs a little energy to break weak intermolecular forces.
**Electrical conductivity of simple molecular compounds	Do not conduct because there are no electrons that are free to move.
*Examples of simple molecular substances	Hydrogen gas, oxygen gas, water, carbon dioxide, methane.
*Giant molecular structure	A structure made of a repeating pattern of atoms covalently bonded together.
**Melting point of giant molecular compounds	High because melting requires breaking strong covalent bonds.
**Electrical conductivity of simple molecular compounds	Do not conduct (except graphite) because there are no electrons free to move.
*Examples of simple molecular substances	Silicon dioxide (silica), diamond, graphite.
*Polymer	A large molecule made of a small unit repeated many times.
*Monomer	A small molecule that can be joined together many times to form a polymer.

6. Allotropes of carbon	
*Allotrope	A different structural form of an element made of the same atoms just bonded together differently.
*Carbon's allotropes	Graphite, diamond, graphene, fullerenes
**Graphite	Structure: stacked sheets of carbon in a honeycomb pattern with delocalised electrons between them. Properties: sheets slide apart easily, excellent conductor Uses: lubricants
**Diamond	Structure: Repeating pattern of 4 atoms bonded to 4 others. Properties: Extremely hard. Uses: Cutting tools and drills
**Graphene	Structure: A single layer of atoms in a honeycomb pattern. Properties: Very strong, excellent conductor. Uses: None yet, but potentially many.
**Buckminster fullerene	Structure: Ball-shaped molecules of C ₆₀ . Properties: Low melting point Uses: None



**Carbon nanotubes	Structure: Cylinders made of carbons bonded in a honeycomb pattern. Properties: Very strong, excellent conductors Uses: Strong and flexible materials, electronics.
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7. Metallic bonding	
*Structure of metals	A lattice of positive metal ions surrounded by a cloud of delocalised electrons.
**Delocalised electrons	Electrons that are not bound to a single atom but move freely around many.
**Metallic bonding	The electrostatic attraction between the lattice of positive metal ions and the cloud of delocalised electrons.
**Electrical conductivity of metals	Metals are good conductors because the electrons are free to move.
**Comparing the conductivity of metals	Metals with more electrons in the outer shell – such as Al – are better conductors than those with fewer – such as Li – because there are more delocalised electrons that are able to move.
*Malleable	When a substance dents when it is hit instead of shattering.
**Malleability of metals	Metals are malleable because the atoms are arranged in regular sheets and these sheets can easily slide over each other when hit.

**Melting point of metals	High because melting them requires breaking the strong force of attraction between the lattice of metal ions and the cloud of delocalised electrons.
----------------------------------	--

8. Bonding models	
**Classifying materials	The properties of a material can be used to determine the type of bonding in it.
**Properties of ionic compounds	High melting point, often soluble in water, solid does not conduct electricity, liquid/solution does.
**Properties of simple molecular compounds	Low melting point, does not conduct electricity, sometimes soluble in water.
**Properties of giant molecular compounds	High melting point, does not conduct electricity (except graphite), insoluble in water.
**Properties of metallic compounds	High melting point, does conduct electricity, insoluble in water.
**Bonding models	The ideas and drawings that we use to explain the bonding of atoms.
**Problems with bonding models	- Dot and cross diagrams make electrons seem different, they are not - Atoms appear stationary but are actually vibrating - Atoms don't appear to be touching when they actually are.

The three states of matter are solid, liquid and gas. For a substance to change from one state to another, energy must be transferred. The particles gain energy. This results in the breaking of some of the attractive forces between particles during melting. To evaporate or boil a liquid, more energy is needed to overcome the remaining chemical bonds between the particles. Note the difference between boiling and evaporation. When a liquid evaporates, particles leave the surface of the liquid only. When a liquid boils, bubbles of gas form throughout the liquid before rising to the surface and escaping. The amount of energy needed for a substance to change state is dependent upon the strength of the attractive forces between particles. The stronger the forces of attraction, the more energy needed to break them apart. Substances that have strong attractive forces between particles generally have higher melting and boiling points.	Solid The particles in a solid are arranged in a regular pattern. The particles in a solid vibrate in a fixed position and are tightly packed together. The particles in a solid have a low amount of kinetic energy. Solids have a fixed shape and are unable to flow like liquids. The particles cannot be compressed because the particles are very close together.	Liquid The particles in a liquid are randomly arranged. The particles in a liquid are able to move around each other. The particles in a liquid have a greater amount of kinetic energy than particles in a solid. Liquids are able to flow and can take the shape of the container that they are placed in. As with a solid, liquids cannot be compressed because the particles are close together.	Gas The particles in a gas are randomly arranged. The particles in a gas are able to move around very quickly in all directions. Of the three states of matter, gas particles have the highest amount of kinetic energy. Gases, like liquids, are able to flow and can fill the container that they are placed in. The particles in a gas are far apart from one another which allows the particles to move in any direction. Gases can be compressed; when squashed, the particles have empty space to move into.
Identifying the Physical State of a Substance If the given temperature of a substance is lower than the melting point, the physical state of the substance will be solid. If the given temperature of the substance is between the melting point and boiling point, the substance will be a liquid. If the given temperature of the substance is higher than the boiling point, the substance will be a gas.	Limitations of the Particle Model (HT only) The chemical bonds between particles are not represented in the diagrams above. Particles are represented as solid spheres – this is not the case. Particles like atoms are mostly empty space. Particles are not always spherical in nature.	State Symbols In chemical equations, the three states of matter are represented as symbols: solid (s) liquid (l) gas (g) aqueous (aq) Aqueous solutions are those that are formed when a substance is dissolved in water.	Identifying the Physical State of a Substance If the given temperature of a substance is lower than the melting point, the physical state of the substance will be solid. If the given temperature of the substance is between the melting point and boiling point, the substance will be a liquid. If the given temperature of the substance is higher than the boiling point, the substance will be a gas.

AQA GCSE Chemistry (Combined Science) Unit 2: Bonding, Structure and Properties of Matter

Formation of Ions

Ions are charged particles. They can be either positively or negatively charged, for example Na^+ or Cl^- .

When an element loses or gains electrons, it becomes an ion.

Metals **lose** electrons to become **positively charged**.

Non-metals **gain** electrons to become **negatively charged**.

Group 1 and 2 elements **lose** electrons and group 6 and 7 elements **gain** electrons.

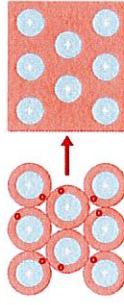
Group	Ions	Element Example
1	+1	$\text{Li} \rightarrow \text{Li}^+ + \text{e}^-$
2	+2	$\text{Ca} \rightarrow \text{Ca}^{2+} + 2\text{e}^-$
6	-2	$\text{Br} + \text{e}^- \rightarrow \text{Br}^-$
7	-1	$\text{O} + 2\text{e}^- \rightarrow \text{O}^{2-}$

Metals and Non-metals

Metals are found on the **left-hand side** of the **periodic table**. Metals are strong, shiny, malleable and good conductors of heat and electricity. On the other hand, non-metals are brittle, dull, not always solids at room temperature and poor conductors of heat and electricity. **Non-metals** are found on the **right-hand side** of the periodic table.

Metallic Bonding

Metallic bonding occurs between **metals only**. Positive metal ions are surrounded by a **sea of delocalised electrons**. The ions are tightly packed and arranged in rows.



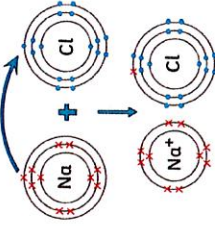
There are strong electrostatic forces of attraction between the positive metal ions and negatively charged electrons.

Pure metals are too soft for many uses and are often mixed with other metals to make alloys. The mixture of the metals introduces different sized metal atoms. This **distorts the layers** and **prevents them from sliding over one another**. This makes it harder for alloys to be bent and shaped like pure metals.



Ionic Bonding

Ionic bonding occurs between a metal and a non-metal. Metals lose electrons to become positively charged. Opposite charges are attracted by electrostatic forces – an ionic bond.



Ionic Compounds

Ionic compounds form structures called giant lattices. There are **strong electrostatic forces of attraction** that **act in all directions** and act between the **oppositely charged ions** that make up the giant ionic lattice.



Properties of Ionic Compounds

- High melting point – lots of energy needed to overcome the electrostatic forces of attraction.
- High boiling point
- **Cannot conduct electricity** in a solid as the ions are not free to move.
- Ionic compounds, when **molten** or in **solution**, can **conduct electricity** as the ions are free to move and can carry the electrical current.

Covalent Bonding

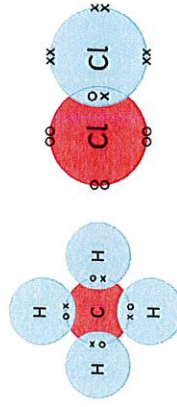
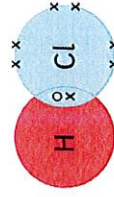
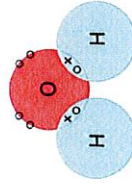
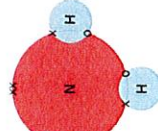
Covalent bonding is the sharing of a pair of electrons between atoms to gain a full outer shell. This occurs between **non-metals only**. Simple covalent bonding occurs between the molecules below. Simple covalent structures have **low melting and boiling points** – this is because the **weak intermolecular forces** that hold the molecules together break when a substance is heated, not the strong covalent bonds between atoms. They **do not conduct electricity** as they do not have any free delocalised electrons.

Dot and cross diagrams are useful to show the **bonding in simple molecules**. The **outer electron shell** of each atom is represented as a **circle**, the circles from each atom overlap to show where there is a **covalent bond**, and the electrons from each atom are either drawn as **dots or crosses**. There are **two different types of dot and cross diagram** – one with a circle to represent the outer electron shell and one without.

You should be able to draw the dot and cross

diagrams for the following simple covalent structures:

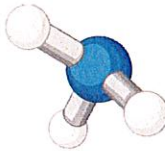
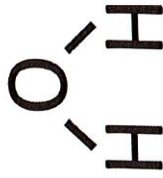
chlorine, oxygen, nitrogen, water, ammonia, hydrogen chloride and methane.



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Structural Formulae

In this type of diagram, the element symbol represents the type of atom and the straight line represents the covalent bonding between each atom.



The structure of small molecules can also be represented as a 3D model.

Giant Covalent Structure – Diamond

Each carbon atom is **bonded** to **four** other carbon atoms, making diamond very strong. Diamond has a high melting and boiling point. **Large** amounts of **energy** are needed to break the strong covalent bonds between each carbon atom. Diamond **does not conduct** electricity because it has **no free electrons**.

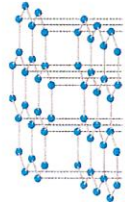


Silicon dioxide (silicon and oxygen atoms) has a similar structure to that of diamond, in that its atoms are held together by **strong covalent bonds**. Large amounts of energy are needed to break the strong covalent bonds therefore silicon dioxide, like diamond, has a high melting and boiling point.



Giant Covalent Structure – Graphite

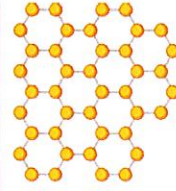
Graphite is made up of layers of carbon arranged in **hexagons**. Each carbon is bonded to **three** other carbons and has **one free delocalised electron** that is able to move between the layers. The layers are held together by weak intermolecular forces. The layers of carbon can slide over each other easily as there are no strong covalent bonds between the layers. Graphite has a high melting point because a lot of energy is needed to break the covalent bonds between the carbon atoms. Graphite can **conduct** electricity.



Graphite is made up of layers of carbon arranged in **hexagons**. Each carbon is bonded to **three** other carbons and has **one free delocalised electron** that is able to move between the layers. The layers are held together by weak intermolecular forces. The layers of carbon can slide over each other easily as there are no strong covalent bonds between the layers. Graphite has a high melting point because a lot of energy is needed to break the covalent bonds between the carbon atoms. Graphite can **conduct** electricity.

Giant Covalent Structure – Graphene

Graphene is one layer of graphite. It is very **strong** because of the covalent bonds between the carbon atoms. As with graphite, each carbon in graphene is bonded to three others with one **free delocalised electron**. Graphene is able to **conduct electricity**. Graphene, when added to other materials, can make them even stronger. Useful in electricals and composites.



Nanoscience

Nanoscience refers to structures that are **1–100nm** in size, of the order of a few hundred atoms. Nanoparticles have a **high surface area to volume ratio**. This means that smaller amounts are needed in comparison to normal sized particles. As the side length of a cube decreases by a factor of 10, the surface area to volume ratio increases approximately

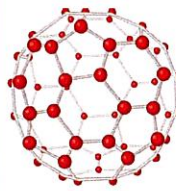
Name of Particle	Diameter
nanoparticle	1–100nm
fine particles (PM _{2.5})	100–2500nm
coarse particles (PM ₁₀)	2500–10000nm

Polymers

Polymers are long chain molecules that are made up of many smaller units called **monomers**. Atoms in a polymer chain are held together by **strong covalent bonds**. Between polymer molecules, there are **intermolecular forces**. Intermolecular forces **attract** polymer chains towards each other. Longer polymer chains have stronger forces of attraction than shorter ones therefore making stronger materials.

Fullerenes and Nanotubes

Molecules of carbon that are shaped like hollow tubes or balls, arranged in hexagons of five or seven carbon atoms. They can be used to **deliver drugs into the body**.



Buckminsterfullerene has the formula C₆₀

Carbon Nanotubes are tiny carbon cylinders that are very long compared to their width. Nanotubes can conduct electricity as well as strengthening materials without adding much weight. The properties of carbon nanotubes make them useful in electronics and nanotechnology.



Possible Risks of Nanoparticles

As nanoparticles are so **small**, it makes it possible for them to be inhaled and enter the lungs. Once inside the body, nanoparticles may **initiate harmful reactions** and toxic substances could bind to them because of their large surface area to volume ratio. Nanoparticles have many applications. These include medicine, cosmetics, sun creams and deodorants. They can also be used as catalysts.

Modern nanoparticles are a relatively new phenomenon therefore it is difficult for scientists to truly determine the risks associated with them.



Science

a The three types of chemical bonding are...

1.

2.

3.

Describe the movement and arrangement of subatomic particles in each of the above.

1.

2.

3.

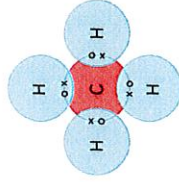
b Draw a dot and cross diagram for the following ionic bonding:
sodium chloride

Which four groups are more likely to make ions?

c Describe the bonding in ionic compounds

Why can ionic compounds conduct electricity when in solution?

d Using this example, draw dot and cross diagrams for H_2O , NH_3 and O_2 .

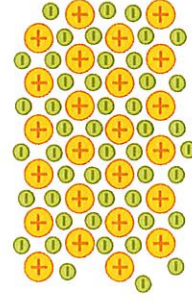


1. H_2O

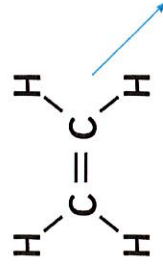
2. NH_3

3. O_2

e Describe how metals conduct heat and electricity. Use the diagram to help explain.



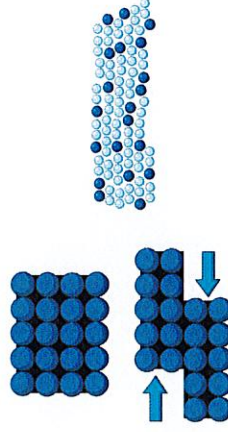
f Complete the polymer diagram for the following monomer.



What is a monomer?

What is a polymer?

g Properties of metals and alloys.



Describe how the 2 pictures are different to each other.

Why are some alloys harder than pure metals?

h Match up the following with the state symbol.

solid

liquid

gas

solution

(g)

(l)

(s)

(aq)

What happens to the intermolecular forces when a liquid turns into a gas?

i Describe the changes of state during:

evaporation:

condensation:

melting:

j Small molecules form substances with **high/low** boiling points because they have **strong/weak** intermolecular forces.

They **do/do not** conduct electricity because they do not have any **free** electrons.

k My main areas for improvement are:

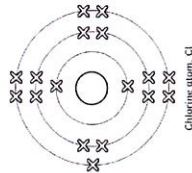
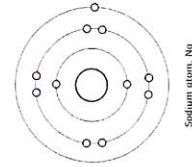
The three types of chemical bonding are...

1. ionic
2. covalent
3. metallic

Describe the movement and arrangement of subatomic particles in each of the above.

1. Electrons are lost and gained to fill the outer shell.
2. Electrons are shared to fill the outer shell.
3. Positive metal ions are surrounded by free electrons.

Draw a dot and cross diagram for the following ionic bonding:
sodium chloride



Which four groups are more likely to make ions?

- 1, 2, 6 and 7

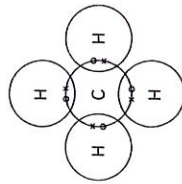
Describe the bonding in ionic compounds

They are held together by the strong ionic forces of oppositely charged ions. Metal ions have a positive charge and non-metals ions have a negative charge so they are attracted. They have very strong bonds.

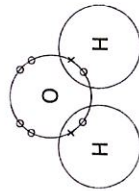
Why can ionic compounds conduct electricity when in solution?

The ions are free to move about and can conduct electricity.

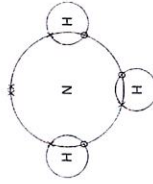
Using this example, draw dot and cross diagrams for H_2O , NH_3 and O_2



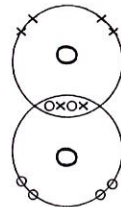
1. H_2O



2. NH_3

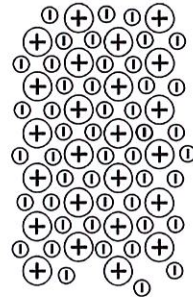


3. O_2

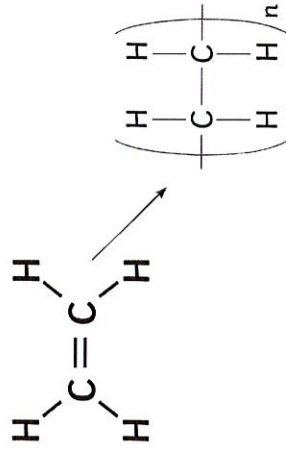


Describe how metals conduct heat and electricity. Use the diagram to help explain.

Metals have free Electrons that are able to move around and transfer energy.



Complete the polymer diagram for the following monomer.



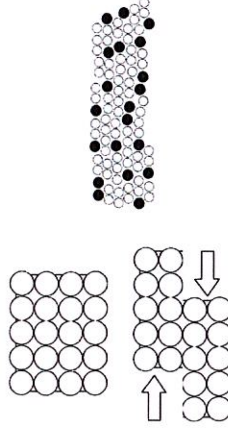
What is a monomer?

One molecule.

What is a polymer?

A long chain of monomers.

Properties of metals and alloys.



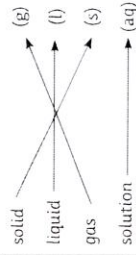
Describe how the 2 pictures are different to each other.

Alloys have different sized particles. In pure metals, all the atoms are the same.

Why are some alloys harder than pure metals?

They have different sized particles so the layers can not slide across each other as easily.

Match up the following with the state symbol.



What happens to the intermolecular forces when a liquid turns into a gas?

The forces of attraction become less as the particles gain energy and move about more.

Describe the changes of state during:

evaporation:

liquid changes to a gas.

condensation:

gas changes to a liquid.

melting:

solid changes to a liquid.

Small molecules form substances with low boiling points because they have weak intermolecular forces.

They do not conduct electricity because they do not have any free electrons.

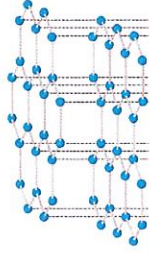
My main areas for improvement are:

Draw a diagram of the structure of diamond.

Why is this structure so strong? Choose the correct answer.

1. Many strong ionic bonds.
2. Many strong covalent bonds.
3. Many strong metallic bonds.

What is this a diagram of?

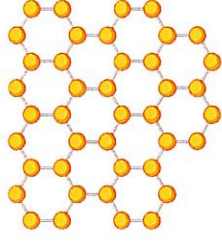
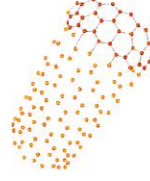


Explain why it can conduct electricity and heat.

The topic I understand the most in this unit is

The topic I need to work on is

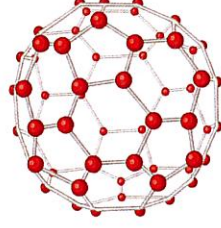
This is a carbon _____.
It has high _____ strength, high _____ and _____ conductivity.



_____ is a single layer of graphite.

Why is this material so strong?

Where is this product used?

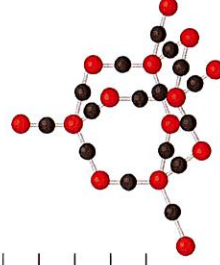


What is this structure?

How many carbon atoms are there?

- a) 20 b) 30 c) 40 d) 50 e) 60

Explain the differences and similarities between silicon dioxide and diamond.



What are the formulas for the following?

Match up the answers.

Iron (II) oxide

Iron (II) hydroxide

Iron (III) oxide

$\text{Fe}(\text{OH})_2$

FeO

Fe_2O_3

How many:

mm in 1m?

m in 1mm?

What are the abbreviated units for the following:

metre; _____

centimetre; _____

millimetre; _____

nanometre; _____

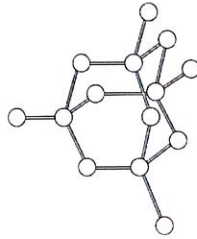
micrometre; _____

Compare diamond and graphite.

Describe the structure, hardness and conductivity.

My main areas for improvement are:

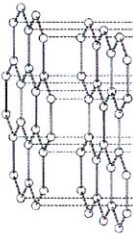
Draw a diagram of the structure of diamond.



Why is this structure so strong? Choose the correct answer.

2. Many strong covalent bonds.

What is this a diagram of?



Graphite

Explain why it can conduct electricity and heat.

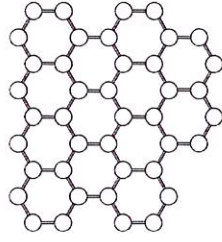
Graphite has free delocalised electrons that can pass between layers; the electrons can carry the charge.

The topic I understand the most in this unit is

The topic I need to work on is

This is a carbon nanotube

It has high tensile strength, high heat and electrical conductivity.



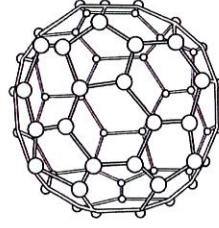
Graphene is a single layer of graphite.

Why is this material so strong?

It has strong covalent bonds.

Where is this product used?

In electronics and composites.



What is this structure?

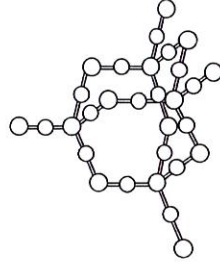
Buckminsterfullerene

How many carbon atoms are there?

e) 60

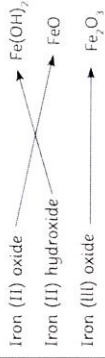
Explain the differences and similarities between silicon dioxide and diamond.

Silicon dioxide contains silicon and oxygen atoms instead of carbon but has a similar structure to diamond.



What are the formulas for the following?

Match up the answers.



How many:

mm in 1m? 1000mm

m in 1mm? 0.001m

What are the abbreviated units for the following:

metre; m

centimetre; cm

millimetre; mm

nanometre; nm

micrometre; μm

Compare diamond and graphite.

Describe the structure, hardness and conductivity.

Both – forms of carbon.

Single covalent bonds

Have many atoms.

Graphite – flat sheets, conducts electricity, each carbon atom forms 3 covalent bonds.

Diamond – tetrahedral structure, each carbon atom forms 4 covalent bonds, does not conduct electricity.

My main areas for improvement are:
