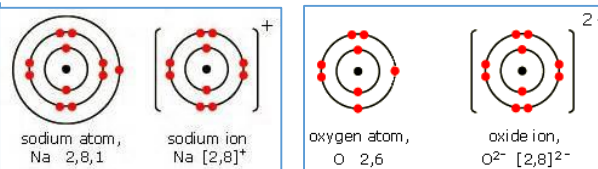
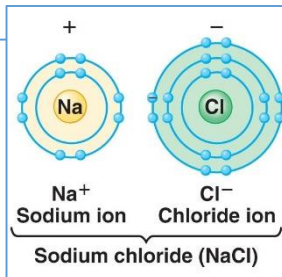
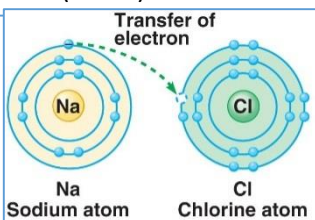


Bonding Knowledge Organiser

Atoms want to have a full outer shell as this makes them stable. To do this they form bonds with other atoms.

Ionic Bonds

Metals and non-metals will form ionic bonds. The **metal** atom **loses electrons** to become a **positive ion (cation)** and the **non-metal** atom **gains electrons** to become a **negative ion (anion)**.



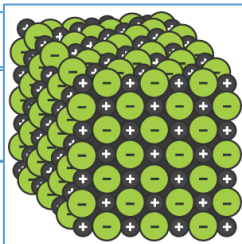
The electrons from the metal transfer to the non-metal so that both atoms have a full outer shell.

The ions formed are attracted by an electrostatic force.

Ionic compounds form a giant structure called a lattice.

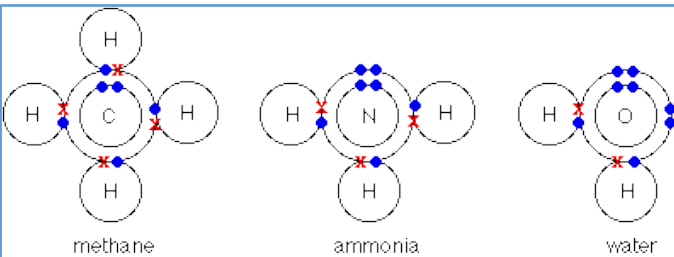
The electrostatic attraction is strong meaning ionic compounds have a high melting point as a lot of energy is needed to overcome the attraction.

Ionic compounds don't conduct when solid because the ions are locked in position. When molten the ions are free to move and can conduct.



Covalent Bonds

Two non-metals will form a covalent bond. The atoms share electrons to make themselves stable.



Although the covalent bond is strong the simple molecules are held together by weak intermolecular forces. This means they have low boiling points.

The covalent molecules don't conduct electricity because there are no free electrons.

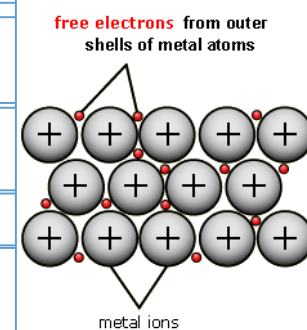
Metallic Bonds

Metallic bonds are metal ions surrounded by delocalised electrons.

Metals can conduct electricity because the electrons are free to move.

The metallic bond is strong so they have a high melting point.

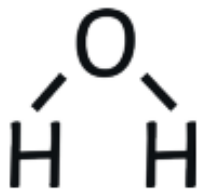
Metals are malleable because the layers are able to slide over each other.



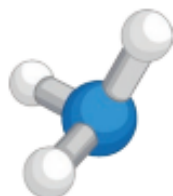
Anion	A negatively charged ion
Boiling point	Temperature at which substance changes from a liquid to a gas
Cation	A positively charged ion
Covalent bond	A shared pair of electrons between atoms
Delocalised electrons	Free moving electrons from the outer shell of metal atoms. Form a strong attraction with metal ions
Dot and cross diagram	Diagram showing how electrons are arranged in a molecule or ion (dots for one atom, crosses for another atom)
Electrical conductivity	Measure of how well a substance conducts electricity
Electron	Negatively charged sub atomic particle
Electron transfer	Movement of electrons from one atom to another
Electrostatic attraction	Force of attraction between oppositely charged ions
Intermolecular force	Relatively weak force of attraction between molecules that keeps them together
Ion	Particle with a charge, positive or negative
Ionic bond	Forms between metals and non-metals. Oppositely charged ions attract to form an ionic bond.
Ionic formula	How ionic compounds are represented
Ionic lattice	Regular arrangement of positive ions surrounded by negative ions
Melting point	Temperature at which substance changes from a solid to a liquid
Metal ions	Positively charged atom in a metal
Metallic bond	Forces that keep atoms together in a metal
Molecule	Two or more atoms chemically joined
Simple covalent molecule	Substance that contains only a few non-metal atoms held together by covalent bonds
Stable	An atom is stable when it has a full outer shell

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.

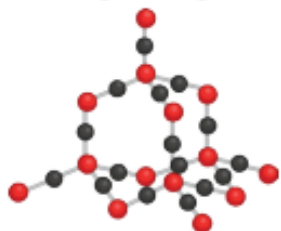


Giant Covalent Structure – Diamond

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**.

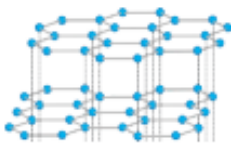


Silicon dioxide (silicon and oxygen atoms) has a similar structure to that of diamond, in that its atoms are held together by **strong covalent bonds**. Large amounts of energy are needed to break the strong covalent bonds therefore silicon dioxide, like diamond, has a high melting and boiling point.



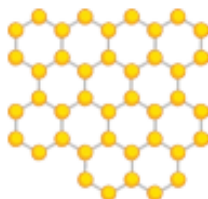
Giant Covalent Structure – Graphite

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.



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

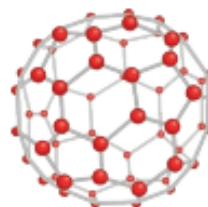
Name of Particle	Diameter
nanoparticle	1–100nm
fine particles (PM _{2.5})	100–2500nm
coarse particles (PM ₁₀)	2500–10000nm

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.

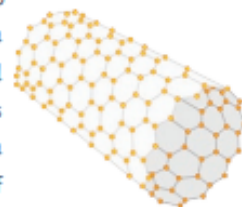
Fullerenes and Nanotubes

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.

Extraction of Metals

A metal ore is a compound found in rock, dug out of the ground, that contains enough metal that it is **economical** to extract it. For example, magnesium oxide. In order for us to use the magnesium we need to **extract** it from the oxide.

Metals more reactive than carbon are extracted from their ore using **electrolysis**.

Metals which are less reactive than carbon are extracted from their ore using **reduction** (by adding carbon). Reduction is the removal of oxygen as seen in the example.

Example: Iron Oxide + Carbon → Iron + Carbon Dioxide

The least reactive metals such as gold and silver are found on their own—they do not form a compound. This means they do not need to be extracted from their ore.

Other methods of extraction

The amount of some metals is running out, this means people are finding new ways to extract metals like copper.

Phytomining uses plants to absorb copper from the soil, the plants are then burnt and the copper extracted.

Bioleaching involves using bacteria to make a **leachate** that contains metal compounds.

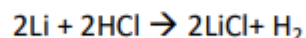
Scrap iron can also be used to **displace copper** from a solution.

Oxidation Reactions

When working out whether a reaction is oxidation or reduction: in terms of electrons, remember OILRIG. This stands for oxidation is loss and reduction is gain.

HT - Oxidation Reactions of Acids

When an acid reacts with a metal a salt and hydrogen are produced. For example the symbol equation for an acid reacting with lithium is:



In this reaction, lithium has been oxidised because it has lost an electron to form a **+1 ion** and hydrogen has been reduced from a **+1 ion** to a **hydrogen molecule**.

The Process of Electrolysis

Electrolysis is the **splitting up** of an ionic substance using **electricity**.

On setting up an electrical circuit for electrolysis, two **electrodes** are required to be placed in the electrolyte. The electrodes are **conducting rods**. One of the rods is connected to the **positive** terminal and the other to the **negative** terminal.

The **electrodes** are **inert** (this means they do not react in the reaction) and are often made from **graphite** or platinum.

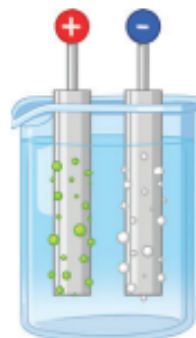
During the process of electrolysis, **opposites attract**. The positively charged ions will be attracted toward the negative electrode. The negatively charged ions will be attracted towards the positive electrode.

When ions reach the electrodes, the charges are lost and they become elements.

The **positive** electrode is called the **anode**.

The **negative** electrode is called the **cathode**.

Electrolysis of Aqueous Solutions



Gases may be given off or metals deposited at the electrodes. This is dependent on the reactivity of the elements involved.

If the metal is **more reactive** than **hydrogen** in the reactivity series, then **hydrogen** will be **produced** at the **negative cathode**. At the **positive anode**, negatively charged ions **lose** electrons. This is called **oxidation** and you say that the ions have been oxidised.

Using Electrolysis to Extract Metals

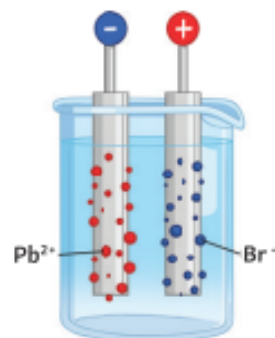
Metals are extracted by electrolysis if the metal in question reacts with carbon or if it is too reactive to be extracted by reduction with carbon. During the extraction process, large quantities of energy are used to melt the compounds.

Aluminium is manufactured by the process of electrolysis. Aluminium oxide has a high melting point and melting it would use large amounts of energy. This would increase the cost of the process, therefore molten **cryolite** is added to aluminium oxide to lower the melting point and thus reduce the cost.

Electrolysis of Molten Ionic Compounds – Lead Bromide

Lead bromide is an ionic substance. Ionic substances, when solid, are **not** able to conduct electricity. When molten or in solution, the ions are free to move and are able to carry a charge.

The **positive** lead ions are attracted toward the **negative cathode** at the same time as the **negative bromide** ions are attracted toward the **positive anode**.



Oxidation is the loss of electrons and reduction is the gaining of electrons. **OIL RIG** (Higher Tier Only).

We represent what is happening at the electrodes by using **half equations** (Higher Tier Only).

The lead ions are attracted towards the negative electrode. When the **lead ions** (Pb^{2+}) reach the cathode, each ion **gains two electrons** and becomes a neutral atom. We say that the lead ions have been **reduced**.



The bromide ions are attracted towards the positive electrode. When the **bromide ions** (Br^-) reach the anode, each ion **loses one electron** to become a neutral atom. Two bromine atoms are then able to bond together to form the covalent molecule Br_2 .

