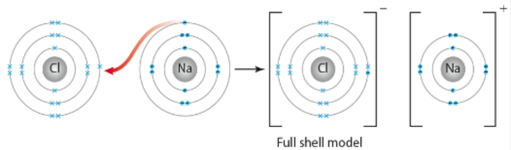
BONDING

Atoms bond because they want to get a full outer shell of electrons. There are three ways that they can do this:

- Transfer electrons from one atom to another **– Ionic bonding**
- Sharing electrons between atoms **– Covalent bonding**
- Losing outer shell electrons **– Metallic bonding**

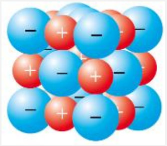
Ionic Bonding

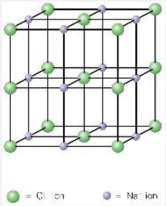
When a metal elements and a non-metal element bond together electrons are transferred from the metal to the non-metal. This makes a positive metal **ion and a negative non-metal ion**. The oppositely charged ions are attracted by **electrostatic attraction** (basically, opposites attract).



The charge on each of the ions is that same as the number of electrons that is has gained or lost.

Properties of Ionic Compounds





- Giant lattice structure
- Strong bonds
- High melting and boiling points due to strong bonds
- Do not conduct electricity when solid
- Conduct electricity when molten (melted) or in solution (dissolved).

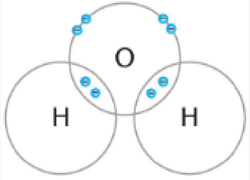
Empirical formula

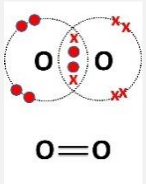
The empirical formula gives the **simplest ratio of ions**. For example, sodium chloride would be found in a lattice, but NaCl is the simplest formula (Na^+ is attracted to Cl^-). Whereas, in a magnesium chloride lattice, the empirical formula would be $MgCl_2$ (one Mg^{2+} ion is attracted to two Cl^- ions).

Covalent Bonding

When two or more non-metal atoms bond together, they both prefer to gain electrons, so rather than transferring an electron the bond by **sharing electrons**. A covalent bond is defined as a shared pair of electrons. If a molecules contains a double bond then this two shared pairs of electrons.

Covalent bonds are very easy to draw. Where you see an overlap of orbitals (drawn as circles) you add in a dot and a cross (one electron from each atom). They you add the electrons on the shells of the atoms until you get to the total for that element. You only need to draw the outer shells of the atoms.





These molecules are all small molecules. As well as the covalent bond within the molecule there are forces of attraction between small molecules. These are called **intermolecular forces**.

All small covalent compounds have similar properties:

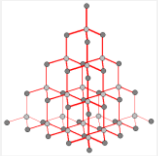
- Gas or liquid at room temperature (it only takes a small amount of energy to overcome the intermolecular forces, the strong covalent bonds are not broken.)
- Low melting an boiling point
- Do not conduct electricity (there are no charges involved in covalent bonding/

It is also possible to get giant structures that contain covalent bonds. These giant compounds are made of carbon. You need to know about the bonding and properties in all of them.

Diamond

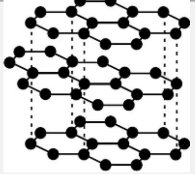
Each carbon atom forms four covalent bonds. All of the carbon outer shell electrons are used in bonding.

- Very strong and very high melting point (there are lots of strong covalent bonds).
- Cannot conduct electricity (all the electrons are used in bonding so there are no mobile charged particles.



Graphite

The carbon atoms make three bonds with other carbon atoms, making six sided **hexagonal** rings, in layers.
There are no covalent bonds between the layers – **weak** forces.
The fourth outer electron becomes delocalised. It is this mobile electron that allows graphite, graphene and carbon nanotubes to conduct electricity.



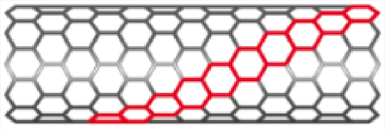
- High melting point (lots of strong covalent bonds).
- Soft and slippery (layers can slide).
- Conducts electricity (one delocalised electron per carbon atom, these are mobile charged particles)
- Used as a lubricant and as electrodes

Graphene

- Graphene is a single layer of graphite so is one atom thick.
- It is made of hexagonal rings of carbon atoms bonded together
- Strong and conducts electricity. The reasons for its properties are all identical to that of graphite above.

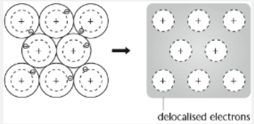
Carbon nanotubules

- Are cylindrical fullerenes
- Have the following properties:
  - high tensile strength
  - high electrical conductivity
  - high thermal conductivity



Metallic Bonding

Metallic elements are made up of lots of the same atom bonded together. Because metal atoms do not want to gain electrons all of the outer shell electrons are lost to a delocalised sea of electrons that can move throughout the structure.

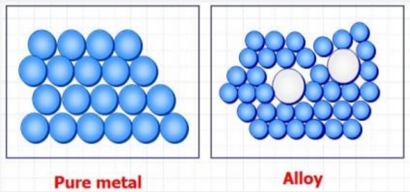


Metals have the following properties:

- Giant structures of atoms arranged in a regular pattern
- **Outer shell electrons** become **delocalised** and are free to move in a **'sea' of electrons**.
- Positive metal ions.
- Good conductors (the electrons are mobile charged particles)
- High melting and boiling points (metallic bonds are strong bonds so lots of energy is needed to overcome them.
- Malleable and ductile (layers of atoms can slide over each other.

Alloys

Alloys are **mixtures** that contain at least one type of metal, but may contain more than one metal. Because a different atom is mixed with the metal atoms the layers of the metal are disrupted.

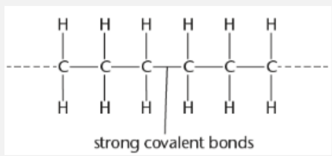


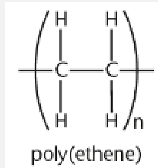
This means that alloys have different properties to metals. The layers can no longer slide over each other, so they are stronger than the pure metal.

Alloy	Composition	Properties	Uses
Brass	Copper, zinc	Does not corrode easily; looks like gold	Coins, musical instruments
Stainless steel	Iron, chromium, nickel, carbon	Resistant to corrosion, strong	Cutlery, utensils
Solder	Tin, lead	Low melting point	For joining metals
Pewter	Tin, antimony, copper	Bright, shiny, looks like silver	Decorative ornaments

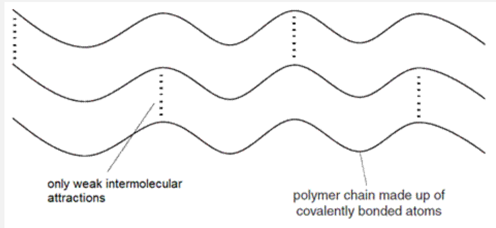
Polymers

Polymers are long chain molecules that contain covalent bonds.



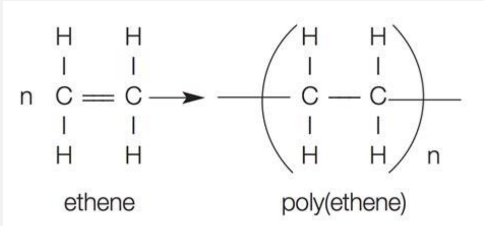


The atoms in the polymer are linked together by **strong covalent bonds** and so form a **chain**. Between different chains there are no bonds, but there are weak intermolecular forces. The more forces there are between the chains the higher the melting point of the polymer will be.



Rather than drawing all the atoms in the chain we can just draw the repeat unit of the polymer. To do this all you need to do is:

- find the monomer (the molecule that bonds to itself to form the polymer)
- draw it out without a double bond
- put a bracket around the molecule
- add two bonds sticking out of either side
- write a subscript n. The n = many, it tells us that this pattern is repeated over and over again.



Intermolecular forces

Chains of polymers are held together to make a bulk substance

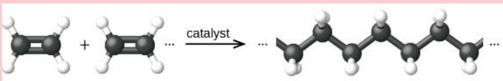
- The **monomers** are held together by **strong covalent bonds** – intramolecular forces
- The chains of polymers – held by weak intermolecular forces

Plastics (e.g. poly(ethane), PVC and nylon) are polymers

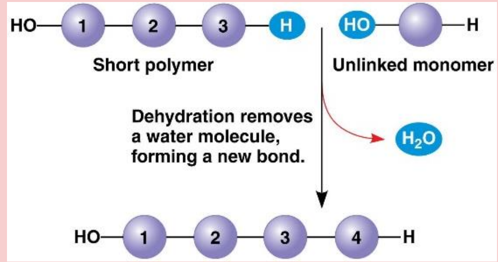
HIGHER TIER ONLY!

Types of polymer

Addition polymers – monomer molecules containing a double bond join together to produce a polymer. There is no other product in this reaction.



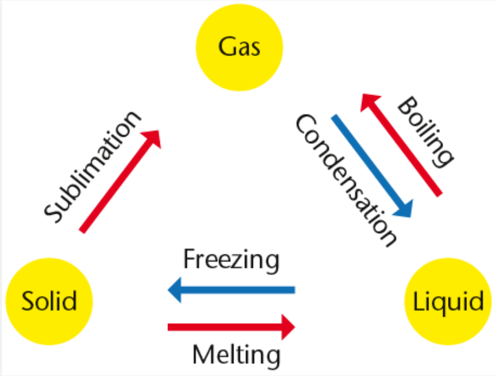
Condensation polymers – monomer molecules join together to make a polymer, but this time another small molecule is also produced when the bond is made between the monomers. This small molecule is often water, hence the name 'condensation polymerisation'.

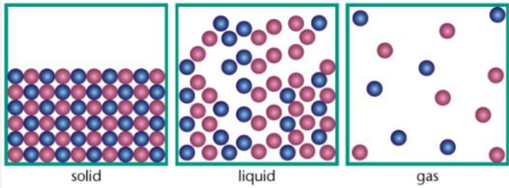


The three states of matter

The three states of matter are solid (s), liquid (l) and gas (g).

- Melting and freezing take place at the melting point
- Boiling and condensing take place at the boiling point





The melting and boiling points depend on the strengths of the forces between these molecules. The stronger the forces, the higher the melting and boiling point. As substances get hotter, the molecules move apart and the forces between the molecules get weaker.