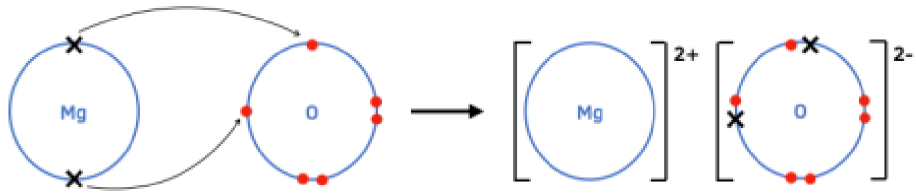
Chemistry Knowledge Organiser
Bonding & structure (Trilogy Science)

Ionic bonding – metal + non-metal



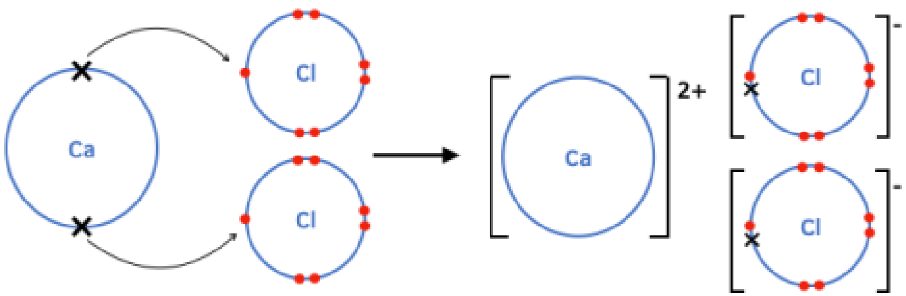
Electrons are **transferred**

Metal atoms **lose electrons** forming **positively** charged ions.

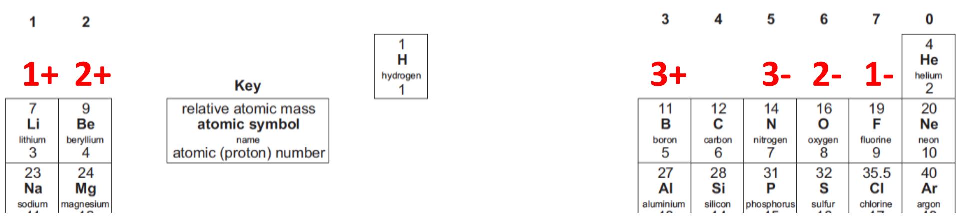
Non-metal atoms **gain electrons** forming **negatively** charged ions.

The ions formed (except by transition metals) have the same structure as noble gases – full outer shell of electrons.

Ionic compounds have no overall charge so positive charge equals the negative charge.



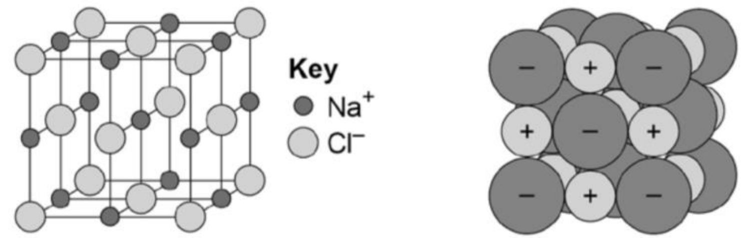
Learn this pattern:



Ionic structures

In ionic bonding the ions are held together by **strong electrostatic forces** of attraction between oppositely charged ions.

This results in an **ionic lattice** structure and the attractions are in all directions to all the surrounding oppositely charged ions.



Property	Explanation
High melting points	**Strong** electrostatic forces of attraction between oppositely charged ions require lots of energy to break
Conduct electricity when molten but not solid	When **solids** the ions are held **in fixed positions** in the lattice and cannot move, when **molten** the ions are **free to move** and **carry the charge**

Formulae of ionic compounds

When working out the formula of an ionic compound the total charge should be zero.

Learn these ions:

Sulfate	SO_4^{2-}	Phosphate	PO_4^{3-}
Nitrate	NO_3^-	Ammonium	NH_4^+
Hydroxide	OH^-		

Example: Aluminium Sulfate

Ions: Al^{3+} & SO_4^{2-}

Lowest common multiple of 3 and 2 is 6

So Al^{3+} x 2 & (SO_4^{2-}) x 3

And the formula is

$Al_2(SO_4)_3$

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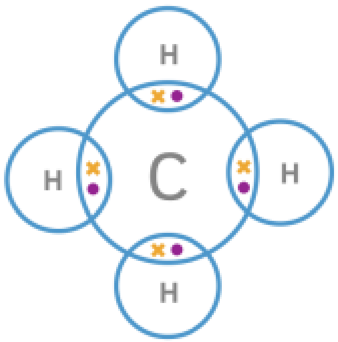
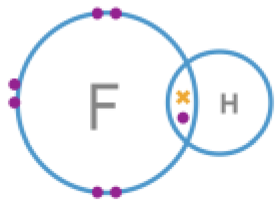
Covalent bonding – non-metal + non-metal



Methane (CH_4)



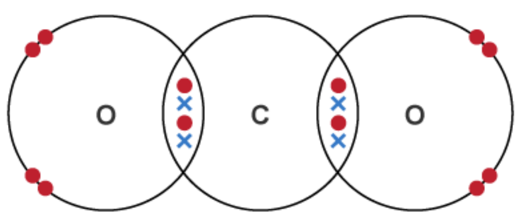
Hydrogen fluoride (HFl)

Electrons **shared** until both atoms have a full outer shell of electrons.

Dot and cross diagrams used to represent covalent bonding.

Electrons from one atom represented by dots and the other by crosses.

Often only the outer shell electrons are shown.

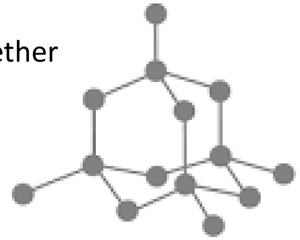


If two pairs of electrons are shared between two atoms then a double bond is formed.

Giant covalent structures

In giant covalent structures atoms are held together by strong covalent bonds **between the atoms**.

Diamond is an example of a substance with a giant covalent structure. There are **4 bonds** per carbon atom pointing in different directions.

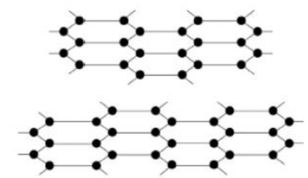


Property	Explanation
High melting points	**Many strong covalent bonds** must be broken which requires lots of energy
Hard	Giant structure with **4 bonds** per carbon atom which are strong
Does not conduct electricity	No delocalised electrons or free charged particles can move and carry the charge.

Silicon dioxide (SiO_2) has a giant structure like diamond.

Allotropes of carbon

Graphite is another allotrope (form) of carbon with a giant structure. Three carbon atoms are joined together forming **flat sheets** which are stacked on top of each other. One electron per carbon atom is delocalised and able to move.



Property	Explanation
High melting points	Many strong covalent bonds must be broken which requires lots of energy
Soft	**Weak intermolecular forces** between the layers so **layers can slide** over each other
Conducts electricity	**Delocalised electrons** free to move **through** the structure and **carry the charge**.

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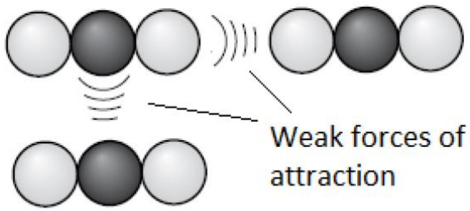
Small molecules

Strong covalent bonds hold the atoms together **within** the molecules and there are weak intermolecular forces **between** the molecules .

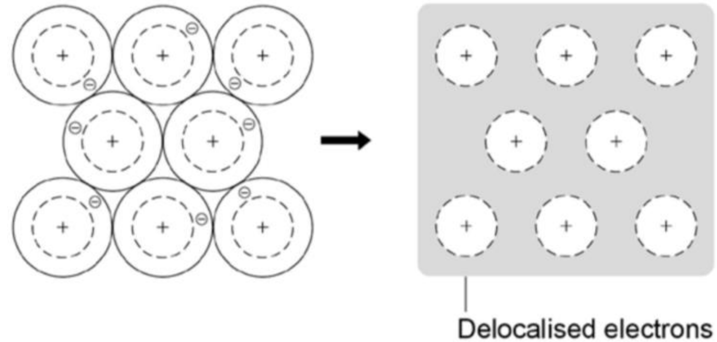


Being a lot **weaker** than the covalent bonds, the intermolecular forces require a lot **less energy** to overcome.

Property	Explanation
Low melting & boiling points – usually gases or liquids	**Weak intermolecular forces** which are **overcome**, not the strong covalent bonds, when the substance melts or boils
Larger the molecule the higher the melting & boiling points	Intermolecular forces **increase** with the **size of the molecules**
Do not conduct electricity	Molecules do not have an overall charge & there are no free moving electrons

Polymers have **very large** molecules. They are made from small molecules **joined together** by strong covalent bonds to **make large molecules**. The intermolecular forces between the polymer molecules are **relatively strong** so they are solids at room temperature.

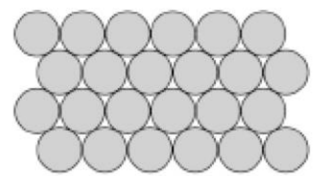
Metallic bonding



In a metal the outer shell electrons are delocalised and so can move through the structure. Metallic bonding is the electrostatic attraction between the resulting positive metal ions and the delocalised electrons.

Metallic structures

In pure metals atoms are arranged in **layers**.



Property	Explanation
High melting points	Strong metallic bonds need to be broken.
Good conductors of electricity and heat	**Delocalised electrons** move **through** the metal **carrying the charge** or thermal energy
Ductile and malleable (soft)	Layers can **slide over** each other.

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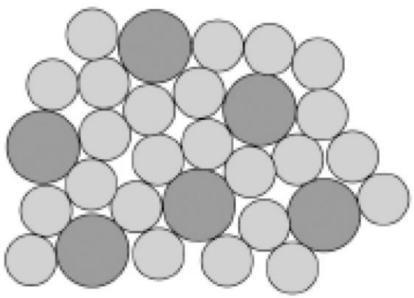
Alloys

Pure metals are so soft, because of their layer structure, that they are not very useful.

They are often mixed with other metals or carbon forming alloys which are harder.

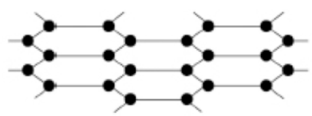


The different sized atoms distorts the layers of atoms in the alloy.

So in the alloy the layers slide over each other less easily that in a pure metal, which makes the alloy harder.

Graphene

Graphite is a single layer of graphite.

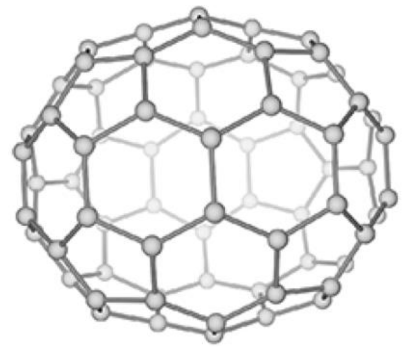


Property	Explanation
Strong	Each carbon is joined to 3 others in a giant lattice with strong covalent bonds which need a lot of energy to break.
Conducts electricity	Delocalised electrons free to move and carry the charge.

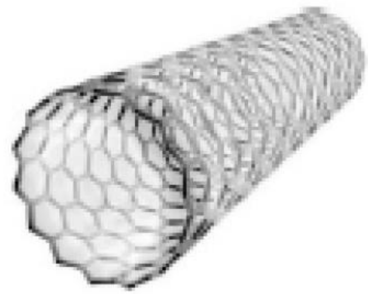
Fullerenes

Fullerenes are molecules of carbon atoms with hollow shapes.

The structure of fullerenes is based on hexagonal rings of carbon atoms but wings with 5 or 7 carbon atoms may also be present in the structure.



Buckminsterfullerene was the first fullerene to be discovered and has a spherical shape.



Carbon nanotubes are cylindrical fullerenes with very high length to diameter ratios

Hollow fullerenes could be used to deliver drugs to particular cells in the body.

Carbon nanotubes are used for strengthening materials.