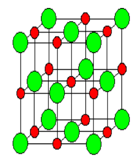
Bonding and Structure 1

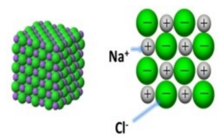
Ions

Ions are charged particles – they can be single atoms (e.g. Cl^-) or group of atoms (e.g. NO_3^-).
When atoms lose or gain electrons to form ions, all they are trying to do is get a full outer shell like a Nobel gas.
Atoms with full outer shells are very stable.
The number of electrons lost or gained is the same as the charge on the ion, e.g. if 2 electrons are lost the charge is 2+ (Mg^{2+}).

Ionic Compounds



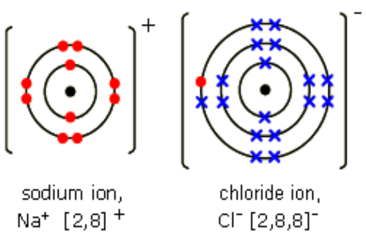
An ionic compound is a giant structure of ions.
Ionic compounds are held together by strong electrostatic forces of attraction between oppositely charged ions.
These forces act in all directions in the lattice – and this is known as ionic bonding.



Ionic Bonding

When a metal atom reacts with a non-metal atom, electrons in the outer shell of the metal atom are transferred.
Metal atoms lose electrons to become positively charged ions.
Non-metals atoms gain electrons to become negatively charged ions.

The ions produced by metals in groups 1 and 2 and by non-metals in groups 6 and 7 have the electronic structure of a noble gas (group 0)



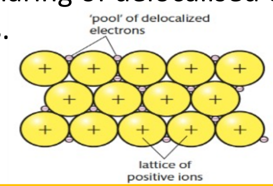
The electron transfer during the formation of an ionic compound can be represented by a dot and cross diagram.

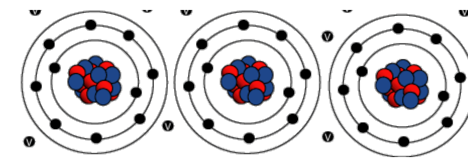
Properties of Ionic Compounds

- Regular structure (giant ionic lattice) in which there are strong electrostatic forces of attraction in all directions between oppositely charged ions.
- High melting and boiling points because of the large amount of energy needed to break the many strong bonds.
- When melted or dissolved in water, ionic compounds conduct electricity because the ions are free to move and so charge can flow.

Metallic Bonding

Metals consist of giant structures of atoms arranged in a regular pattern.
The electrons in the outer shell of metal atoms are delocalised and are free to move through the whole structure.
The sharing of delocalised electrons gives rise to strong metallic bonds.

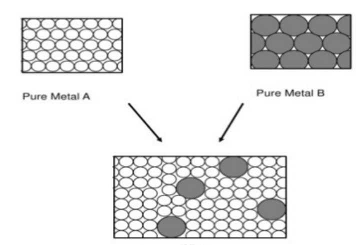




Properties of Metallic Bonding

- Metals have a giant structure of atoms with strong metallic bonding.
- High melting and boiling points.
- Metals are good conductors of electricity because the delocalised electrons in the metal are free to move and can carry electrical charge.
- Metals are good thermal conductors because the energy is transferred by the delocalised electrons.

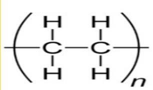
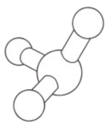
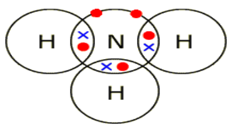
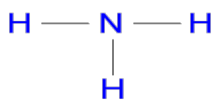
Pure Metals – atoms are arranged in layers, which allow metals to be bent and shaped. They are too soft for many uses
Alloys – metals mixed to make the structure less regular and therefore stronger



Bonding and Structure 2

Covalent Bonding

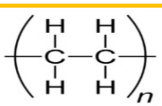
When atoms share pairs of electrons, they form covalent bonds
These bonds between the atoms are strong **(intramolecular)**
Covalently bonded substances may consist of **small molecules** (liquids, e.g. water, and gases, e.g. oxygen).
Some covalently bonded substances have **very large molecules**, such as polymers.
Some covalently bonded substances have giant covalent structures, such as diamond and graphite.

Properties of Small Covalent Molecules

- Usually gases or liquids with relatively low melting and boiling points.
- These substances have weak forces between the molecules (**intermolecular forces**). It is these forces which are overcome (not the covalent bonds) when the substance melts or boils.
- The intermolecular forces increase with the size of the molecules, so larger molecules have higher melting points.
- They do not conduct electricity because the molecules do not have an overall charge.

Properties of Polymers

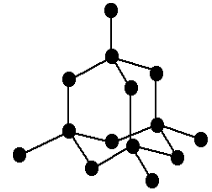


- Polymers have very large molecules.
- The atoms are linked to other atoms by strong covalent bonds.
- The intermolecular forces between the polymer molecules are relatively strong and so they are solid at room temperature.

Giant Covalent Structures

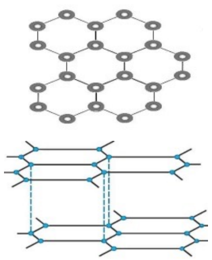
Giant covalent structures are solids with very high melting points
All the atoms in the structure are linked to other atoms by strong covalent bonds.
These bonds must be overcome for the substance to melt or boil.
Diamond, graphite and silicon dioxide are examples.

Diamond



- Each carbon atom forms **four** covalent bonds with other carbon atoms.
- Diamond is very hard.
- Very high melting point.
- Does not conduct electricity.

Graphite



- Each carbon atom forms **three** covalent bonds with three other carbon atoms.
- Forms layers with hexagonal rings which have no covalent bonds between the layers so they can slide over each other.
- One electron from each carbon atom is delocalised and is free to move and carry charge so graphite can conduct electricity.

Graphene and Fullerenes

Graphene is a single layer of graphite and has properties which make it useful in electronics and composites.
Fullerenes are molecules of carbon atoms with hollow shapes. The structure is based on hexagonal rings of carbon atoms but they may also contain rings with 5 or 7 carbon atoms.
The first fullerene to be discovered was Buckminsterfullerene (C_{60}) which has a spherical shape.
Carbon Nanotubes are cylindrical fullerenes with very high length to diameter ratios. Their properties make them useful for nanotechnology, electronics and materials.

Bonding and Structure 3

(Separate Chemistry Only)

Sizes of Particles and their Properties

1 nm is 0.000000001 m or 1×10^{-9} m.

Nanoscience refers to structures 1-100nm in size (few hundred atoms).

Nanoparticles are smaller than fine particles (100-2500nm), coarse particles are 1×10^{-5} to 2.5×10^{-6}m in size (dust).

As the size of cube decreases by a factor of 10 the surface area to volume ratio increases by a factor of 10.

Nanoparticles may have different properties to the bulk atom because of their high surface area to volume ratio.

It also means less nanoparticles are needed to be effective than materials with normal particle size.

Uses of Nanoparticles

Advantages:
Medicine (cancer drug transporters in the body), electronics, cosmetics, deodorants (silver nanoparticles have antibacterial properties), sun creams and catalysts.

Disadvantages:
The way they affect the body is not fully understood (must be tested thoroughly), long term impacts on health are unknown, products should be clearly labelled so people are aware of nanoparticles.