AQA C2 Bonding and Structure

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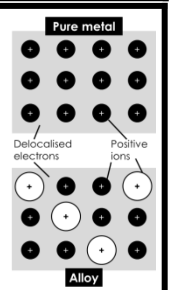
Bonding occurs because chemicals are only stable when the particles have full outer shells of electrons

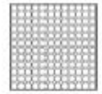
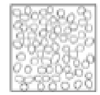
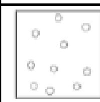
Keywords	
atom	the smallest particle of a chemical element that can exist
element	a chemical made up of only one type of atom
ion	a particle which has a positive or negative charge
electrostatic force	the attraction between positively and negatively charged particles
(chemical) bond	the force of attraction that holds particles together
state (of matter)	whether a substance is a solid, liquid or gas
molecule	a small group of atoms held together by covalent bonds
alloy	a material which contains a metal and at least one other element
delocalised	free to move
malleable	can be bent and shaped
molten	liquid
intermolecular	forces between molecules
intramolecular	covalent bonds within molecules

Alloys

Alloys contain a mixture of a metal and at least one other element. They have the same properties as metals, except that they are harder than pure metals. This is because the layers of ions can't slide over each other due to the different sizes.



States of matter

state	model	state symbol
solid		(s)
liquid		(l)
gas		(g)

Limitations of model: particles are shown as solid spheres and there are no forces between the particles

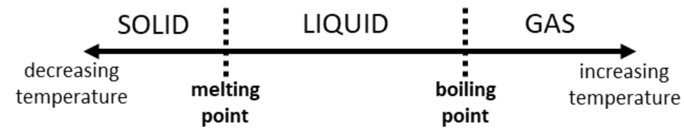
Electrical conductivity

For a material to conduct electricity it needs to have:

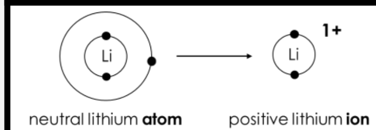
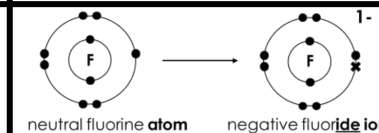
- charged particles (electrons or ions)
- which can move

Changes of state

melting point	At this temperature: • solids melt • liquids freeze	**Stronger bond:** • more energy to overcome bond • higher melting / boiling point
boiling point	At this temperature: • liquids boil • gases condense	**Weaker bond:** • less energy to overcome bond • lower melting / boiling point



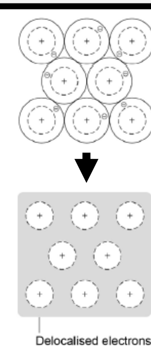
Forming ions

Metals lose electrons forming positive ions	Non-metals gain electrons forming negative ions
	

Metallic bonding – seen in metals and alloys

electrons

Electrons in the outer shells of metals are **delocalised** forming positive metal ions



structure

Metallic structure held together by **strong electrostatic forces between the lattice of positive ions and the delocalised electrons**

properties

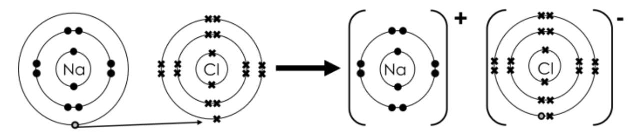
High melting / boiling points (a lot of energy needed to overcome strong metallic bonds).
Conduct electricity (delocalised electrons carry charge through the metal).
Conduct thermal energy (delocalised electrons move through the structure transferring energy).
Malleable (layers of ions slide over each other)

Ionic bonding – between a metal and a non-metal

electrons

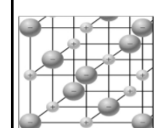
Electrons are transferred from the metal to the non-metal forming ions

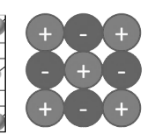
Dot and cross diagram



structure

Giant ionic lattice held together by **strong electrostatic forces between positive and negative ions**





properties

High melting / boiling points (a lot of energy is needed to overcome strong ionic bonds).
When solid they do not conduct electricity (ions are held in fixed positions within a lattice and cannot move).
When dissolved or molten they do conduct electricity (when the lattice breaks apart, the ions are free to move and carry charge).

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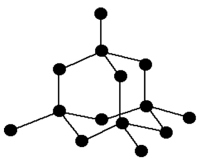
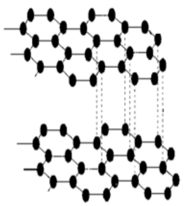
Structure and bonding of carbon

diamond



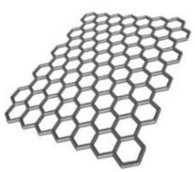
Each carbon atom forms four covalent bonds with other carbon atoms in a giant covalent structure. Because covalent bonds are strong diamond is very hard and has a very high melting point. It does not conduct electricity as the electrons are held between the atoms.

graphite



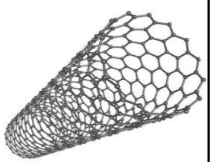
Each carbon atom forms three covalent bonds with three other carbon atoms, forming layers of hexagonal rings. There are weak forces between the layers so they can easily slide over each other.

graphene



Graphene is a single layer of graphite. It has a high melting and boiling point and can conduct electricity, making it useful in electronics and composites.

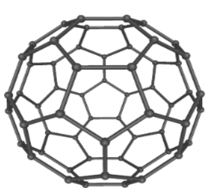
carbon nanotubes



Carbon nanotubes are cylindrical fullerenes with very high length to diameter ratios. They are used for electronics, nanotechnology and materials.

Three electrons from the outer shell of each carbon atom form covalent bonds, then the fourth electron is delocalised. Therefore these structures can conduct electricity.

fullerenes



Fullerenes are large molecules of carbon atoms with hollow shapes. They contain rings of 5, 6, or 7 carbon atoms. The first to be discovered was Buckminsterfullerene (C_{60}).

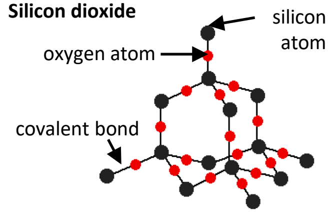
Giant covalent structures – bonds between non-metal atoms

electrons

All of the atoms are linked to other atoms by strong covalent bonds forming a **giant covalent structure. Examples are diamond, graphite and silicon dioxide**

structure

Silicon dioxide



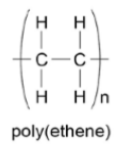
properties

High melting / boiling points (a lot of energy is needed to overcome strong covalent bonds).
Do not conduct electricity (electrons are localised in bonds so cannot move or carry charge).

Polymers

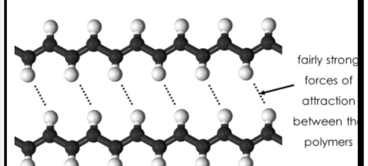
structure

These are very large molecules containing atoms linked to other atoms by strong covalent bonds.



properties

Normally solids at room temperature (the forces between the molecules are fairly strong).

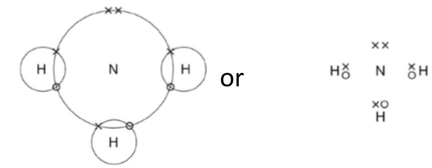


Covalent molecular structures – bonding between non-metals

electrons

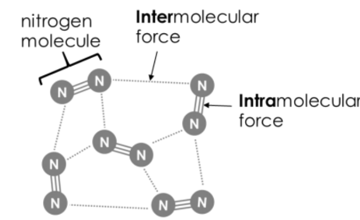
Atoms **share pairs of electrons** forming strong covalent bonds between the atoms.

Dot-cross diagram (eg. ammonia – NH_3):



structure

Small molecules which have strong intramolecular covalent bonds (bonds within molecules) but weak intermolecular forces of attraction (forces between molecules)



properties

Usually gases or liquids (low melting and boiling points)
Low melting and boiling points (weak intermolecular forces don't need much energy to overcome).
Melting and boiling points increase as molecules get bigger (intermolecular forces are stronger when molecules have a higher mass).
Do not conduct electricity (molecules are neutral so there are no charged particles).

Nanoparticles

Size:
1-100 nm
(1 nm = 10^{-9} m)

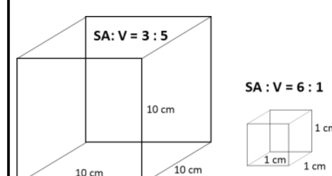
Each particle contains a few hundred atoms

Uses

- medicine
- electronics
- cosmetics
- sun creams
- deodorants
- catalysts

Surface area : volume ratio (SA : V)
Nanoparticles have very large SA : V compared to the same chemical as lumps, powders or sheets.

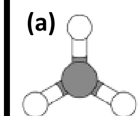
In solids: smaller particles = larger SA : V



Models

Dot-cross, ball and stick **(a)**, 2D and 3D **(b)** models all have limitations such as not showing the bonding electrons, not showing the chemical bonds, or not showing the 3D structure of materials.

(a)



(b)