The three states of matter:

Three common states of matter:

- Solid:

  The particles in a solid are hard to compress because the particles are packed together in a lattice (regular pattern).

  Solids have a fixed shape

  Solid particles vibrate but not move

- Liquid:

  Liquids are hard to compress because the particles are close together

  Liquids take the shape of the container because the particles in a liquid can move

- Gases:

  Gases are easy to compress

  Gases are spread out and fill the container because the particles move quickly and randomly.

Convert solid into liquid (melting):

- When you turn a solid into a liquid, this is called melting. You need to put energy to convert it into a liquid.
- This energy is needed to break the force of attraction in a solid.
- The stronger the force of attraction, the more energy is needed to convert it into a liquid. The more energy needed the more higher the melting point.

Converting liquids into gases (boiling):

- If there are strong forces of attraction between particles, the boiling point will be high. This is because it takes a lot of energy to break the bonds
- To convert gas into liquid, this is called condensing

Limitations of particle model:

- The model shows all particles as solid spheres. Particles have different shapes
- It doesn't show any forces between the particles assuming that there are no bonds

Properties of ionic compounds:

An ion is an atom with a charge

Ionic compounds form giant ionic lattice

The ionic lattices have strong electrostatic forces

Ionic compounds have very high melting and boiling points because they have strong electrostatic forces which require a lot of energy to break

Ionic compounds cannot conduct electricity when they are solids because the ions cannot move because the ions are locked in place due to the forces of attractions and cannot carry the charge

Ionic compounds can conduct electricity when they are melted or dissolved in water because the ions can move and carry the charge

Covalent bonding:

Covalent bonding takes place between two non metal elements

Properties of simple covalent molecules:

Small covalent have low melting and boiling points. This means that they are usually liquids and gases at room temperature.

They have low melting and boiling points because they have weak intermolecular forces between the molecules which don’t require much energy to break.

As we increase the size of the covalent molecule, the intermolecular forces increase. This causes the boiling point to increase.

Small covalent molecules don’t conduct electricity because they don’t have an overall electric charge

Diamond and silicon oxide:

Diamond:

- Giant covalent molecules are always solids at room temperature because they have millions of strong covalent bonds. This means that they have high melting and boiling points.
- Diamond is formed by carbon
- One carbon atom in diamond forms 4 other covalent bonds

- Diamond cannot conduct electricity because it has no free electrons to carry the electrical charge

Silicon Dioxide:

- It has a very high melting and boiling point because it has a large number of strong covalent bonds that must be broken to change the state

Compare the structure and bonding of the three compounds:

- carbon dioxide
- magnesium oxide
- silicon dioxide.

[6 marks]

ou

- (both) carbon dioxide and silicon dioxide are made up of atoms
- (but) magnesium oxide is made up of ions

- (both) silicon dioxide and magnesium oxide are giant structures
- (but) carbon dioxide is small molecules
- with weak intermolecular forces

- all three compounds have strong bonds
- (both) carbon dioxide and silicon dioxide are formed from two non-metals
- (so) bonds formed are covalent
- (so) electron (pairs) are shared (between atoms)
- (but) magnesium oxide is formed from a metal and a non-metal
- (so) bonds in magnesium oxide are ionic
- (so) electrons are transferred
- from magnesium to oxygen
- two electrons are transferred

- bonds in silicon dioxide are single bonds
- (where) each silicon forms four bonds
- (and) each oxygen forms two bonds
- (but) in carbon dioxide the bonds are double bonds
- (where) carbon forms two double bonds
- (and) oxygen forms one double bond

ignore properties e.g. melting point, electrical conductivity

Diamond

- **Structure:** Each carbon atom is covalently bonded to **four other carbon atoms**, forming a **giant tetrahedral structure**.
- **Bonding:** Contains **strong covalent bonds** throughout the structure.
- **Properties:**
    - Very **hard** because of the rigid lattice.
    - **High melting/boiling point** due to the strong covalent bonds.
    - Does **not conduct electricity** because there are no delocalised electrons that carry the charge

Graphite

- **Structure:** Each carbon atom is covalently bonded to **three other carbon atoms**, forming **hexagonal layers**.
- **Bonding:**
    - Strong covalent bonds within the layers.
    - **Weak intermolecular forces** between the layers, allowing them to slide over each other.
- **Properties:**

  - **Soft and slippery** because the layers can slide.
  - **Conducts electricity** due to delocalised electrons (one per carbon atom).
  - Has a **high melting/boiling point** because of the strong covalent bonds within the layers.

Comparison

- Both have giant covalent structures, but diamond is **hard** due to 4 strong covalent bonds per atom, while graphite is **soft** due to weak forces between layers.
- Diamond does **not conduct electricity**, but graphite does because of **delocalised electrons**.
- Both have **high melting points**, as large amounts of energy are needed to break the strong covalent bonds.

<u>Graphite:</u>

Graphite is made up of carbon atoms

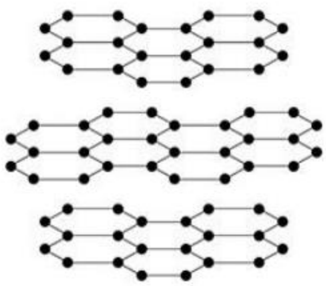
Graphite has a high melting and boiling point because it has many strong covalent bonds which require a lot of energy to break

Graphite is soft and slippery because graphite is made up of many hexagonal rings in layers which are not bonded so this means they can slide over each other

Graphite is a good conductor of electricity and heat because it has delocalised electrons which carry the charge

(f) **Figure 3** represents the structure of graphite.

Figure 3



Explain why graphite is:

- a good electrical conductor
- soft and slippery.

You should answer in terms of structure and bonding.

- bonds are covalent
- giant / macromolecular structure

- three (covalent) bonds per carbon atom
  or
  only three electrons per carbon atom used in (covalent) bonds
- so one electron per carbon atom (is delocalised)
- these delocalised electrons
- can move through the structure
- carrying (electrical) charge
- so graphite conducts electricity

- layered structure
- of (interlocking) hexagonal rings
- with weak (intermolecular) forces between layers
  or
  no (covalent) bonds between layers
- so the layers can slide over each other
- so graphite is soft and slippery

Graphene and fullerenes:

Graphene

- Graphene is the name of one single layer of graphite. This makes graphene one atom thick.
- Graphene is very strong

Fullerenes:

- They are made up of carbon atoms with hollow shapes
- The first fullerene that was discovered was Buckminsterfullerene (C_{60})
- Sphere

Uses of fullerenes:

- Can be used for pharmaceutical/drug delivery
- Can be used as lubricants
- Can be used as catalysts

Carbon nanotubes:

- Has high tensile strength (stretched without breaking)
- Good conductors of electricity and heat

Uses of carbon nanotubes:

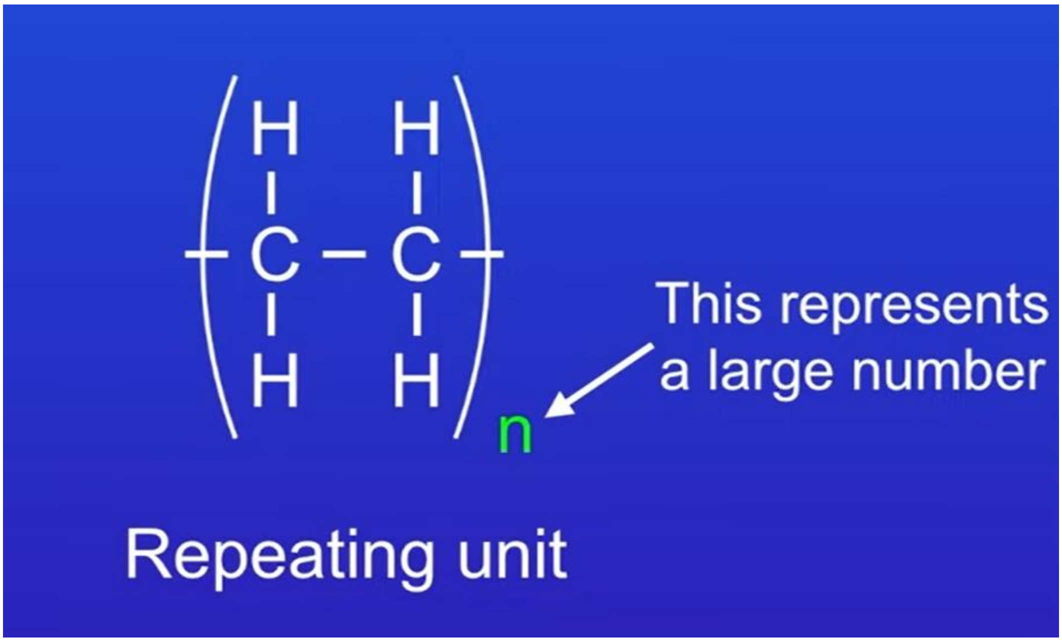
- Reinforce strong materials

<u>Bonding of polymers:</u>

Polymers are created by joining together thousands of small, identical molecules (monomers)

Monomers are often alkene

Repeating unit for polymer:



Most polymers are solid at room temperature because they have strong intermolecular forces which requires a lot of energy to break

Metal and alloys:

Metals consist of a giant structure of atoms arranged in regular layers

The electrons in the outer shell of each atom is delocalised

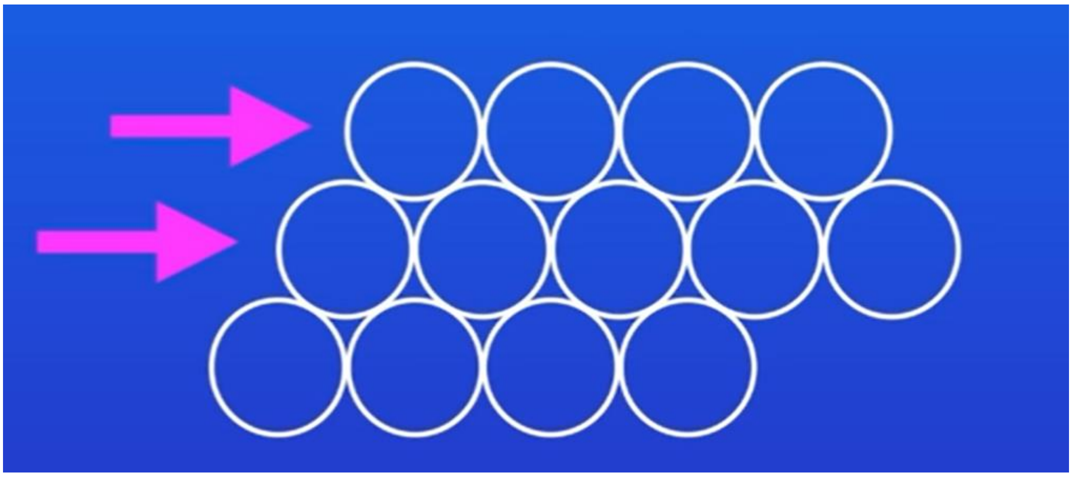
We have strong electrostatic forces between the delocalised electrons and the positive metal ions (the metals ions had lost the electron which is the delocalised electron)

Metallic bonding is electrostatic attractions in metals and these are strong

Metals have high melting and boiling point which requires a lot of energy to break the bonds

Metals are conductors of electricity and heat because they have delocalised electrons which carry the charge

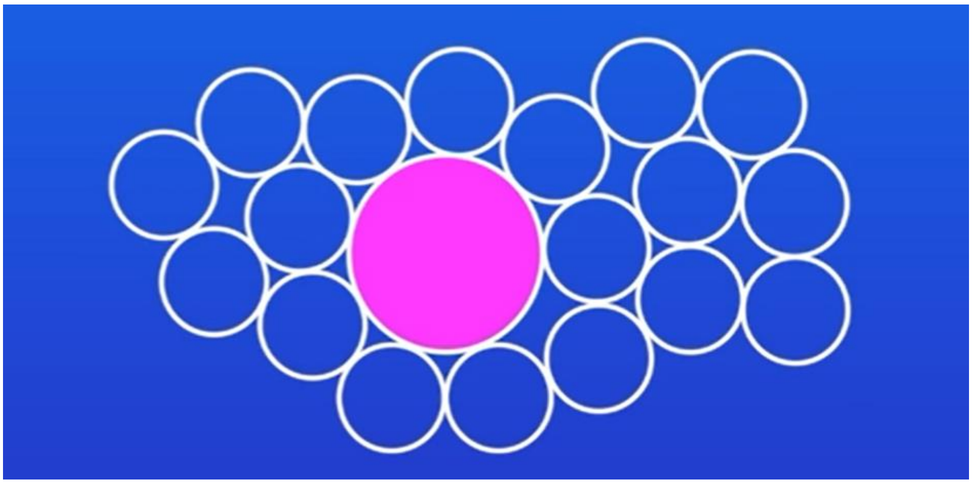
Metals can be bent and shaped because the layers of atoms can slide over each other:



Alloys:

- An alloy is a mixture of metals
- The different size of atom distorts the layer, making it more difficult for the layers to slide over
- Alloys are harder than pure metals

- Key thing – Atoms are different sizes which distorts the layers so layers cannot slide over each other as easily



Nanoparticles:

Coarse particles contains many thousands of atoms

Fine particles contain several thousand atoms

Nanoparticles only contain a few hundred atoms

As the particle size decreases by ten times, the surface area : volume ratio increases by ten times

Nanoparticles have a very large surface area

Uses of nanoparticles:

- Medicines
- Suncreams

- Cosmetics
- Deodorants
- Electronics
- Catalysts

Risks of nanoparticles:

- Nanoparticles can be absorbed into our body. This means that there may be long term effects but scientists don’t know

<u>Limitations of bonding diagrams:</u>

The dot and cross diagram doesn’t show us the shape of the molecule but its clear which element the electron came from

Stick diagrams don’t show which electrons came from which atom and they also don’t show us the real information on the shape of the molecule

The 3D stick diagram shows us the shape of the molecule

The ball and stick diagram (lattice) allows us to see the ions in 3D but the ions in a ball and stick diagram is very widely spaced out even though they are very close together

Space filling diagrams show us how densely packed the ions are but it is difficult to see the packing

The ball and stick and the space filling diagram only shows us one part of the giant lattice so they are inaccurate in terms of sizes