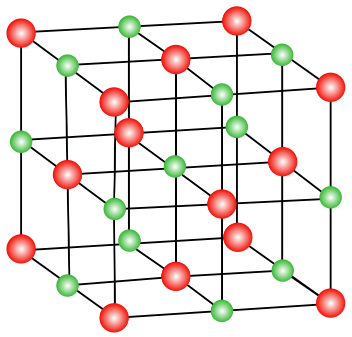
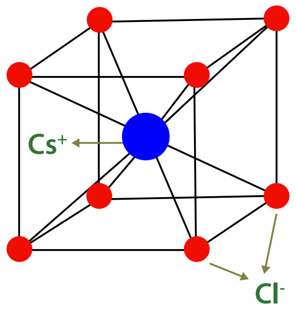
Ionic solids

Ionic solids (crystals) are giant lattices of positive and negative ions. Structures are made of the same base unit repeated over and over again. The structure of the crystal depends on the relative number of ions and their sizes.



NaCl coordination number 6:6

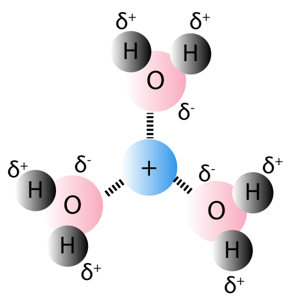


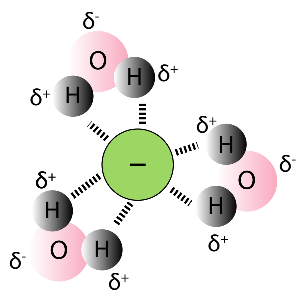
CsCl coordination number 8:8

Cs^+ ion is larger than Na^+ ion therefore more Cl^- ions can fit around it.

Physical properties

- **High melting and boiling temperatures** – It takes a large amount of energy to overcome the strong electrostatic forces between the oppositely charged ions.
- **Often soluble in water** – The oxygen end of the water molecules is attracted to the positive ions, and the hydrogen ends of the water molecules are attracted to the negative ions.

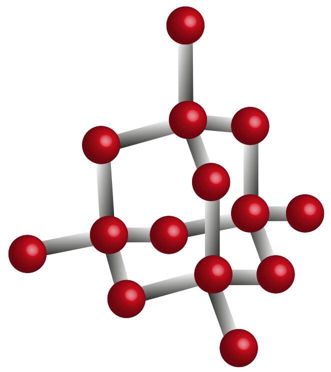




- **Hard but brittle** – When force is applied, layers of ions slide over each other causing ions of the same charge to be next to each other; the ions repel each other and the crystal shatters.
- **Poor electrical conductivity when solid, but good when molten or dissolved** – In the solid state, the ions are fixed in position by the strong ionic bonds; however, when molten or dissolved, the ions are free to move and will move to the electrode of opposite charge, so will carry the current.

Giant covalent solids

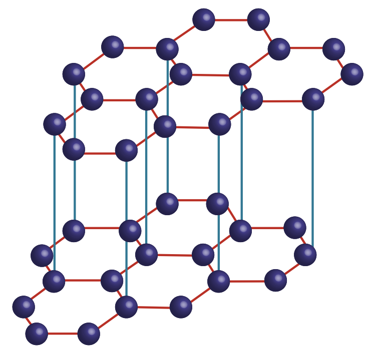
Giant covalent solids consist of networks of covalently bonded atoms arranged into giant lattices.



In **diamond**, each carbon atom is joined to four others by strong covalent bonds. The atoms arrange themselves in a tetrahedral shape. This makes it **very hard**.

It has a **very high melting temperature** – a lot of energy needed to break the numerous strong covalent bonds.

It **does not conduct electricity** – there are no free electrons or ions present.



Graphite consists of hexagonal layers. Each carbon is joined to three others by strong covalent bonds. The extra electrons are delocalised within the layer. The layers are held together by weak van der Waals forces.

It has a **very high melting temperature** – it has strong covalent bonds in the hexagon layers.

It is **soft and slippery** – the weak forces between the layers are easily broken, so the layers can slide over each other.

It is a **good conductor of electricity** – the delocalised electrons are free to move along the layers so an electric current can flow.

1.5 – Solid Structures

Simple molecular solids

These consist of covalently bonded molecules held together by weak intermolecular forces.

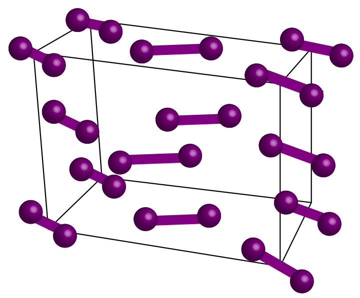
Physical properties

Low melting and boiling temperatures – Although the covalent bonds within the molecules are strong, the intermolecular forces holding the molecules together are weak and do not need much energy to break.

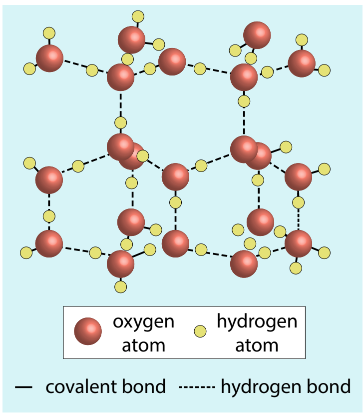
Poor conductors of electricity – They do not contain delocalised electrons or ions.

Two examples of simple molecular solids are iodine and ice.

In **iodine**, atoms are covalently bonded in pairs to form diatomic I2 molecules. These molecules are held together by weak van der Waals forces and are arranged in a regular pattern.

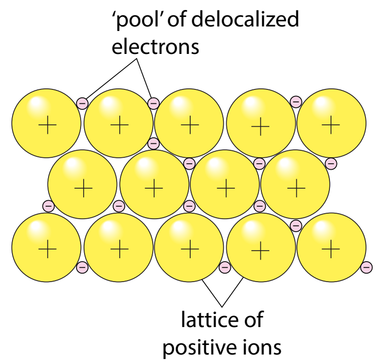


In **ice**, molecules of water are arranged in rings of six held together by hydrogen bonds. In this ordered structure, the water molecules are further apart than they are in the liquid state. Since there are large areas of open space inside the rings, ice is less dense than liquid water at 0˚C.



Metals

Metal atoms bond together to form a giant metallic structure.



Metals consist of a regular arrangement of metal cations (a lattice) surrounded by a 'sea' of delocalised electrons. The strong metallic bond is due to the electrostatic forces of attraction between the nucleus of the cations and the delocalised electrons.

Physical properties

High melting temperatures – A large energy is needed to overcome the strong forces of attraction between the nuclei of the metal cations and the delocalised electrons; the melting temperature is affected by the number of delocalised electrons per cation and the size of the cation.

Hard – The metallic bond is very strong.

Good conductors of electricity both in the solid and molten state – The delocalised electrons can carry a current because, when a potential difference is applied across the ends of a metal, they will be attracted to and move towards the positive terminal of the cell.

Good thermal conductors because the delocalised electrons can pass kinetic energy to each other.

Malleable (can be shaped) and **ductile** (can be drawn into a wire) – When a force is applied to a metal, the layers of cations can slide over each other; however, the delocalised electrons move with the cations and prevent forces of repulsion forming between the layers.