# WJEC Chemistry A-Level

## C1.5: Solid Structures

### Detailed Notes

English Specification

## Bonding and Physical Properties

Physical properties of a substance include the **boiling point, melting point, solubility** and **conductivity**. They differ between substances depending on the **type of bonding** and the **crystal structure** of the compound.

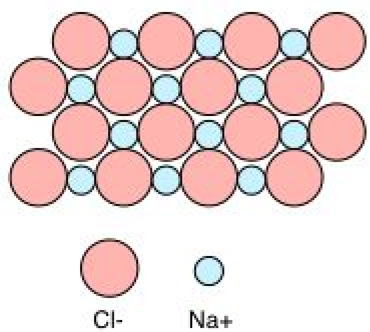
## Crystal Structures

There are four main types of crystal structure; ionic, metallic, simple molecular, macromolecular, each with different physical properties.

### Ionic

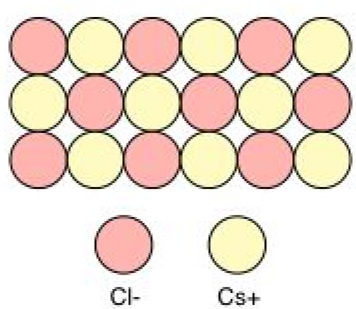
These compounds consist of a **lattice of positive and negative ions** held together by strong **electrostatic forces**. Sodium Chloride is a common example of an ionic compound, made up from Na+ and Cl- ions in a giant lattice structure.

*Example:*




Another example of an ionic compound is caesium chloride, consisting of Cs+ and Cl- ions. However this has a different structure, where ions of the same type **never come into contact** with each other. This is due to the larger size of caesium ions compared to chloride ions.

*Example:*



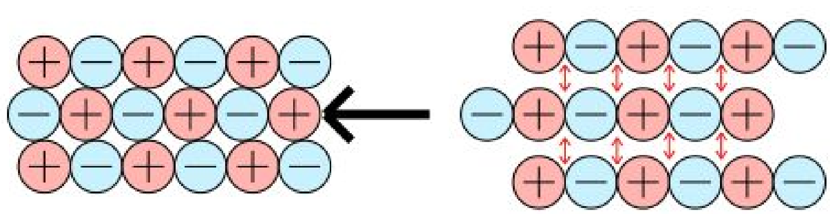

The electrostatic forces of attraction between the ions in ionic compounds are a major influencer on the **physical properties** of the substance.

The substances tend to have **high melting and boiling points** because these electrostatic forces are strong and require a lot of energy to overcome.

When **molten or in solution**, ionic substances can **conduct electricity**. In this state, the ions separate and are no longer held in a lattice. Therefore they are **free to move** and carry a flow of charge which is an electrical current.

Ionic substances are often **brittle** materials. When the layers of alternating charges are distorted, **like charges repel**, breaking apart the lattice into fragments.

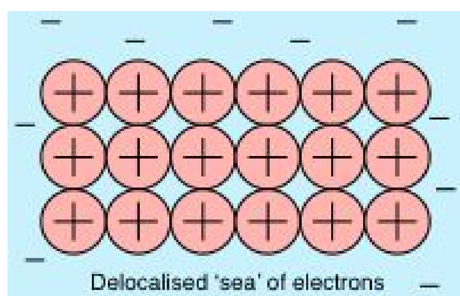
*Example:*



## Metallic

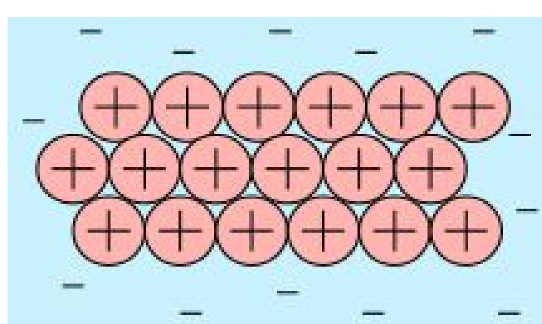
The bonding in metallic compounds consists of a **lattice of positively charged ions** surrounded by a **'sea' of delocalised electrons**. Sodium is one such metal with this bonding structure.

*Example:*




This structure affects the physical properties of metals, giving them specific properties. Metals are often **good conductors**. This is due to the bonding and the 'sea' of delocalised electrons present. This negative charge is able to **move and carry a flow of charge** through the compound structure.
Metals are also **malleable** as the layers of positive ions are able to **slide over one another**.

Example:

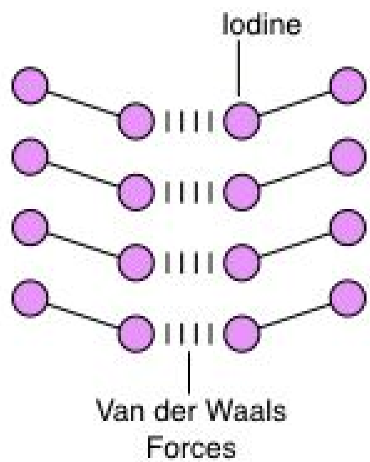


The electrostatic forces of attraction between the positive ions and delocalised electrons are very strong and therefore **require a lot of energy to overcome**. This means metallic substances have **high melting points** and are nearly always solid at room temperature. Mercury is the only metal that is a liquid at room temperature.

### Simple Molecular

Substances with a simple molecular structure consist of **covalently bonded molecules** held together with **weak van der waals forces**. These are a type of intermolecular force that act between the molecules holding them in a structure. Iodine is a very common simple molecular compound.

Example:




These van der waals forces are **very weak** and not much energy is required to overcome them, meaning simple molecular substances have **low melting and boiling points**. Water has a simple molecular structure but has an unusually high boiling point for the size of molecule due to the presence of hydrogen bonding.

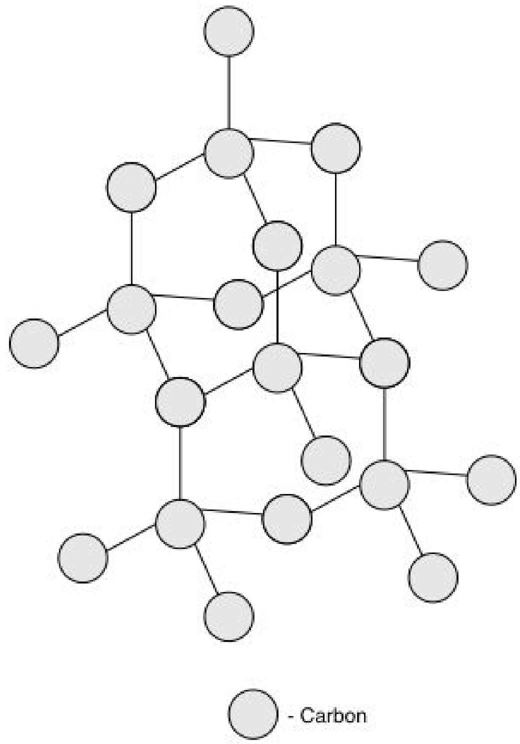
Simple molecular substances are **very poor conductors** as their structure contains no charged particles.

### Macromolecular

Substances that have a macromolecular structure are **covalently bonded** into a **giant lattice** structure. Each atom has **multiple covalent bonds** to other atoms which are very strong, giving the substance a very high melting point.

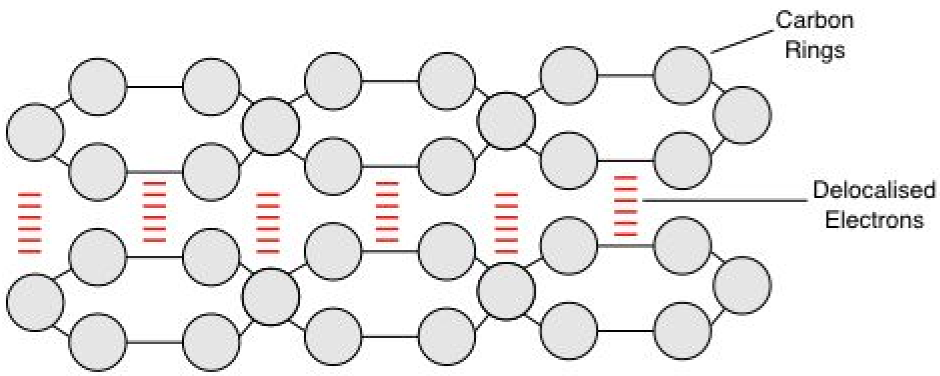
The strength of the covalent lattice makes macromolecular substances **rigid**. Diamond is a macromolecular structure made up of carbon atoms each bonded to four further carbon atoms. This makes diamond one of the **hardest, strongest materials** known.

*Example:*




Graphite is another macromolecular structure made up of carbon atoms. However, in graphite, each carbon atom is bonded to three others in **flat sheets**. The electrons not used in bonding are released as **free electrons** which move between layers, meaning it can **conduct** electricity.

*Example:*



## Unusual Structures

### The Structure of Ice

Ice is unusually **less dense** and takes up a **greater volume** than its liquid state of water. This is due to the presence of **hydrogen bonding** between water molecules. These strong intermolecular forces stay rigid when ice forms creating an open structure. Therefore a sample of ice will occupy a greater volume than the water it formed from.

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### Fullerenes

These are carbon structures where **hexagonal rings** of carbon atoms are arranged into a **hollow structure**. This makes the materials very strong and useful for the production of things such as carbon **nanotubes**.

**Buckminsterfullerene** is another specific example where carbon rings join into **caged-ball** structures known as ‘bucky balls’.