Structure and Bonding

Ionic bonding

- An ion is an electrically charged particle, it forms when atoms gain or lose electrons
- Most atoms do not have a full outer shell so they react to become stable
- Ions have the noble gas electronic structure with a complete outer shell of electrons
- The full outer shell of 8 electrons is called a stable octet
- The attraction between positive ions and negative ions is called ionic bonding
- Ionic bonding happens when a metal and a non-metal react together and electrons are transferred from the outer shell of the metal to the outer shell of the non-metal

Covalent bonding

- Covalent bonding happens when two non-metals share a pair of electrons
- The pairs of electrons that are not used in bonding are called lone pairs
- A double covalent bond is formed when two pairs of electrons are shared between two atoms
- A triple covalent bond is formed when three pairs of electrons are shared between two atoms
- The valency of an atom can be defines as the number of electrons gained or lost to form a complete shell in an ionic or covalent bond

Ionic vs covalent bonding

- In ionic bonding the attractive forces between the positive and negative ions result in the formation of a giant ionic structure. The ions are regularly arranged in the crystal. This arrangement carries on in three dimensions throughout the crystal. This three-dimensional network is called a crystal lattice. The electrostatic attractive forces between ions act in all directions and are very strong. It takes a lot of energy to overcome these forces. This is why giant ionic structures have high melting and boiling points
- The covalent bonds within molecules are very strong. However, the forces between the separate molecules are weak. These weak forces are called intermolecular forces
- Since the forces between molecules are weak it only needs a little energy to overcome these forces and get the molecules to move away from each other. This is why molecular substances have low melting and boiling points
- Ionic compounds have high melting and boiling points because of the strong forces between the ions in the giant ionic lattice
- Covalent bonds have low melting and boiling points because the intermolecular forces are weak
- Ionic compounds are soluble in water but insoluble in organic solvents. They are soluble in water because the water molecules are able to separate the ions
- Covalent bonds are insoluble in water
- Ionic compounds only conduct electricity only when molten or when dissolved in water
- Covalent compounds do not conduct electricity

Giant Covalent Structures

- There is a network of covalent bonds throughout the whole structure
- Giant covalent structures have a rigid three dimensional network of strong covalent bonds throughout the crystal. It takes a lot of energy to break through these bonds. So unlike simple molecules, giant covalent structures have high melting and boiling points
- Different forms of the same element are called allotropes

Diamond

- Carbon forms 4 bonds with other carbon atoms
- Carbons link together to form a giant lattice
- High melting and boiling points
- Cannot be scratched easily
- Used for cutting and drilling metal and glass
- Form glittering colour-less crystals for jewellery

Graphite

- Atoms are arranged in layers
- Each carbon atom is joined to three carbon atoms
- These are arranged in hexagons
- Bonding within is layers strong
- Bonding between layers is weak
- High melting and boiling points
- Layers can slide over each other if force is applied
- Slippery feel and can flake off so can be used as a lubricant
- Graphite can drift along layers when voltage is applied

Silicon (IV) oxide/ silicon dioxide

- Sand is largely silicon dioxide
- Silicon dioxide found in quartz has a similar structure to diamond
- Each silicon atom is bonded to 4 oxygen atoms but each oxygen atom is only bonded to 2 silicon atoms (SiO_2)

Metallic Bonding

- Metals from a third type of giant structure. The metal atoms are packed closely together in a regular arrangement. Because they are so close together, the valence electrons tend to move away from their atoms. A sea of free, delocalised electrons is formed surrounding a lattice of positively charged metal ions. The positively charged ions are held together by their strong attraction to the mobile electrons which move in between the ions. This is metallic bonding, the electrostatic attraction between electrons and the metal ions act in all directions.
- Most metals have high melting and boiling points because it takes a lot of energy to weaken the strong forces of attraction between the metal ions and the delocalised electrons in the lattice
- Metals are good conductors of electricity and heat because when voltage is applied, the delocalised electrons move through the metal lattice towards the positive pole of a cell. Conduction of heat is due to vibration of the atoms passing on energy from one atom to the next.
- Metals are malleable and ductile because of the regular arrangement of their atoms, therefore when a force is applied, the layers can slide over each other.