Bonding

- **Bond** - forces that hold the atom together.
- **Bond energy** - energy required to break a bond.
- **Intramolecular forces** - forces inside the molecule, holding it together.
- **Intermolecular forces** - forces holding the molecules together.

Intermolecular Forces

- The electrostatic interactions that hold the atoms and molecules together.
- Melting and boiling points are related to this.
- They also determine the solubility - the degrees of electrostatic interactions (metallic).
- If something is to dissolve or if two molecules attract one another, it depends on the electrons in the outer most shell.
- Important in controlling the structure and function of DNA.

Ions

- Atoms tend to want to be like the noble gases.
- Metals lose electrons to become **cations**.
- Non-metals gain electrons to become **anions** - or share to form covalent bonds.

Ionic Compounds

- Held together by electrostatic forces.
- An example is NaCl --> the Na gives up one of its electrons to Cl, and therefore becomes positive. The Cl which accepts that electron therefore becomes Negative. It is the positive and negative that attract one another and form NaCl. Hence the forces holding them together are electrostatic forces (positive and negative).

- Cations are smaller because there are less electrons and the nucleus will be able to pull itself together closer, and its the opposite for anions.
- The charges have to be balanced.
- This is referring to the solid crystal.
- The ions align themselves to become as close as possible - to maximise the attraction between the positive and negative ions.
- Their purpose is to form together to form a noble gas electron configuration.
- Since the cations are smaller than the anion, they will essentially occupy the holes in structure if an ionic compound.
- Ionic compounds are packed in a very neat structure and this has consequences.

- Properties:
    1. Hard and brittle.
    2. Poor conductors of electricity, however good when liquid (electrons would be flowing everywhere).
    3. High melting points - because the electrostatic forces are strong.
    4. Many are water soluble - they are strongly polar.

- **Unit Cell** - the smallest repeating uni of a molecule which contains the symmetry characteristics of an atomic, ionic and molecular compound.
- **Lattice Point** - the corners of the uni cells in a crystal lattice.
- **Crystal Lattice** - a whole bunch of the unit cells put together in 3 dimensions.

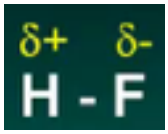
- **Metallic Bonds** - are like metal ions in a 'sea of electrons'.

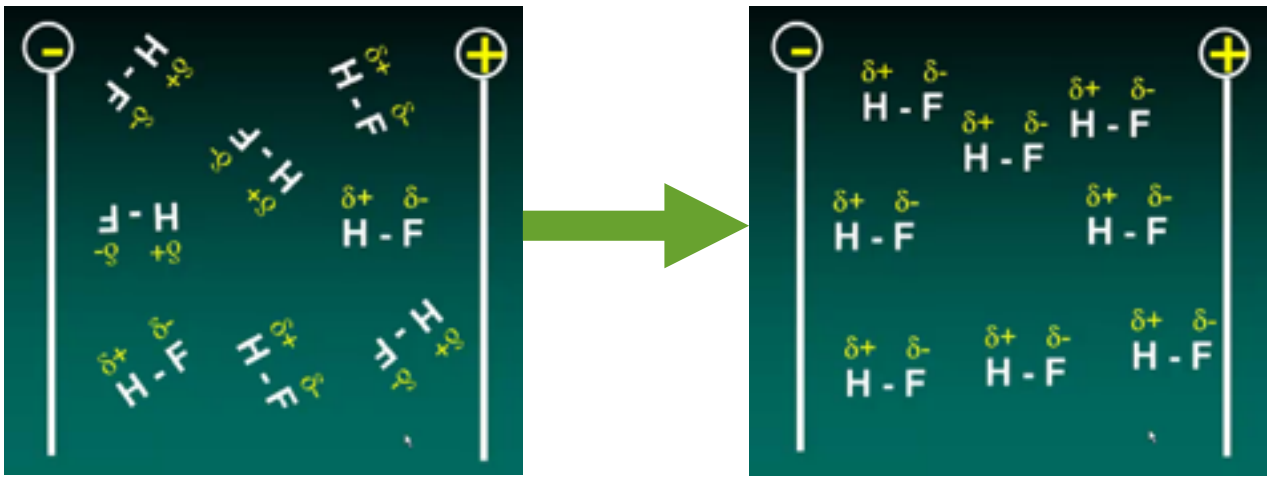
Covalent Compounds

- Electrons are 'shared' - not given - organic chemistry is based on this.
- Seem atoms have more electrons than others.
- The electrons are attracted to the nucleus of the other atoms.
- The electrons and nucleus at some point repel each other - there's a balance.

- As two atoms are brought closer to each other they will attract to each other stronger and stronger until they reach a point known as the **bond length**.
- Any closer than that, then they will start to repel each other - this is the nucleus repelling each other. The force of attraction has to be overcome to break the atoms apart, this is what happens when the atoms are pushed together closer than the bond length.

- Since the electrons are not shared evenly in covalent bonds, one end is more negative and the other end is more positive. This is indicated using the symbol delta 'δ'.
- It can be seen in the picture, the Hydrogen atom doesn't have much electrons around it in comparison to the Fluorine, therefore the Hydrogen is more positive = δ+





Intermolecular Forces

- Forces between molecules, holding them together - arise from electrostatic interactions.

2. **Ion-Dipole Forces** - force between an ion (e.g. Na+) and a polar molecule (e.g. water).
3. **Dipole-Dipole Forces** - force between 2 different polar molecules (e.g. water).
4. **Hydrogen Bonding** - a special type of dipole-dipole force, where Hydrogen atom bonds to a highly electronegative atom with lone pair electrons. For e.g. in water, the

hydrogen atoms are slightly attracted to the slightly positive oxygen atoms, and hence attracts the molecules together. This occurs when H is attacked to N, O and F.

5. **Dispersion Forces** - their attractive forces between molecules are due to <u>temporary dipoles</u>. There would be a change in polarity for a slight moment and this will cause the dispersion forces.

Ion-Dipole Forces

- Dissolving ions in water (e.g. NaCl in water).
- The Na+ will be surrounded by the <u>negative</u> end of the water molecule - the Oxygen atom.
- The Cl- will be surrounded by the <u>positive</u> end of the water molecule - the Hydrogen atoms.

Dipole Moments

- A molecule with a positive side and a negative side is called **dipolar**.
- Any two molecules with different atoms will have a polar bond - there will be a difference in charge between the atoms when connected.
- If they cancel each other out geometrically (linear) and if charges are balanced --> polar.

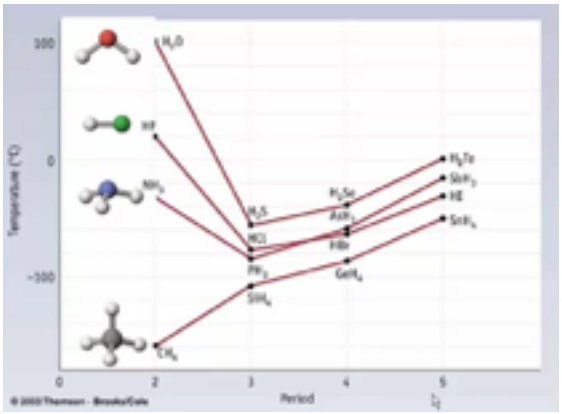
Dipole-Dipole Forces

- The strength of this depends on the molecules concerned.
- They will dent to alight.
- Polar molecules are commonly asymmetric (not symmetric) and contain atoms of differing electronegativity.
- *Like dissolves like* - polar is likely to dissolve with polar - non polar is likely to dissolve with non polar.

Hydrogen-Bonding

- A stronger version of dipole-dipole forces.
- Water is an example and its extremely strong - more than what it should be.
- Occurs when Hydrogen is attached to N, O or F - all of those 3 are the most strongly electronegative atoms in the periodic table. They all consist of either 1, 2 or 3 lone pair electrons which then bond strongly with the Hydrogen atom.

The following graph shows how Hydrogen bonding affects the boiling point of the molecule in comparison with bonding of Hydrogen to the neighbour atoms:



- Methane is non polar - the graph shows the the boiling point of that is much less.

- Hydrogen bonding is used in: DNA Structures, Haemoglobin, Silk.
- It gives substances unusually properties --> the density of ice is less than water due to the longer Hydrogen bonds present in the ice.

Dispersion Forces

- These are momentarily induced polarities due to the distortions of the molecular electron cloud.

Induced Dipole / Induced Dipole

- If we bring close 2 non polar atoms (the electrons are moving around randomly), for one slip second the electrons may be lined up so that they are repelling each other - all the electrons will be near the outside of the molecule.
- There will also be an equal number of times where for a fraction second the electrons are aligned in a way that they attract each other - due to a polar interaction.
- These will not last and move away very quickly.
- The forces increase as the molecular weight (number of atoms involved) will increase.

Dipole / Induced Dipole

- The negative portion of a polar molecule will 'push' the electrons of the oxygen molecule away from it and create a temporary dipole - which makes that oxygen much more reactive that it would normally be.
- This behaviour is responsible for oxygen being able to dissolve in water, which is vital for fishes.

Properties of Water

- **Surface Tension** - water has a lot of surface tension, it results in it not spearing too much.
- **Capillary Action** - water is also responsible for the tendency of the molecules to rise above the surface level. This is important for the movement of blood in our bodies and also for plants to drag up the water in the soil. They are interacting with the walls of the capillary tubes.
- **Viscosity** - the 'stickiness' of a liquid will depend on the degree of interaction between the molecules (intermolecular forces).
- **Vaporisation** - this depends on the bond energy - to break the molecules apart.
- **Vapour Pressure** - when vaporisation and condensation reach equilibrium.
- **Molecular Solids** - molecules held together in a regular lattice by intermolecular forces.
- **Network Solids** - atoms held together by covalent bonds (sharing of electrons).
  - Allotrope - different solid forms of the same substance (Graphite & Diamond).
  - They are hard, poor conductors have a wide range of melting points.
- **Amorphous Solids** - covalently bonded atoms which no regular arrangement.