Edexcel IAL Chemistry A-level

Topic 7: Intermolecular Forces

Detailed notes

Intermolecular Forces

There are **three main types of intermolecular force**. Each one differs in strength and in what they act between.

Van der Waals Forces

Van der Waals forces are the **weakest** type of intermolecular force. They act as an **induced dipole** between molecules. They are also called **London forces** or instantaneous dipole-induced forces.

The strength of van der waals forces varies depending on the Mr of the molecule and its shape. The **larger the Mr** of the molecule, the **stronger the intermolecular forces**. Straight chain molecules experience stronger van der waals forces than branched-chain molecules as they can **pack much closer together**. This **reduces the distance** over which the force acts, making the intermolecular force stronger.

Boiling Point Trends of Alkanes

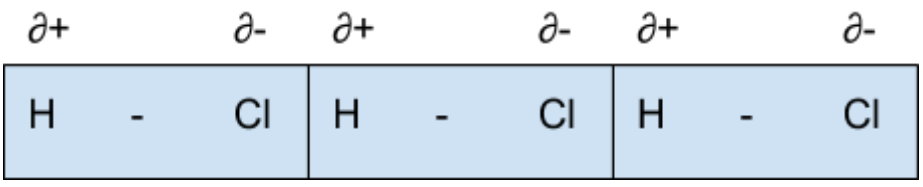
Van der waals forces act between organic **alkane chains** and are affected by the **chain length** and any **branching**. As the chain length of the alkane increases, so does the **Mr** of the molecule. This results in **stronger** intermolecular forces between the chains, and so the compound has a **higher boiling point** as a result.

Branching of alkane chains weakens van der waal forces between the chains as they are less able to **pack tightly** together. This means the distance over which the intermolecular forces act is increased, weakening the **attractive forces.** Therefore, branched-chain alkanes have **lower boiling points** than straight-chain alkanes.

Permanent Dipole

Permanent dipoles are a type of intermolecular force that acts between molecules with a **polar bond**. The ***∂+*** and ***∂-*** regions of neighbouring polar molecules attract each other and hold the molecules together in a **lattice-like structure**. Polar bonds form due to a difference in **electronegativity**.

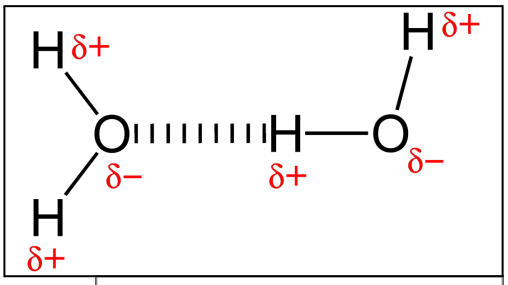
Example:



Hydrogen Bonding

Hydrogen bonding is the **strongest** type of intermolecular force. Hydrogen bonds only act between hydrogen and the three most electronegative atoms: **nitrogen, oxygen and fluorine**. The **lone pair** on these atoms form a bond with a δ+ hydrogen atom from another molecule, shown with a **dotted line**. **H_2O, NH_3** and **HF** all have hydrogen bonds between molecules.

Example:



Images courtesy of The Curious Wavefunction

Properties

Molecules held together with hydrogen bonds have **much higher melting and boiling points** compared to similar-sized molecules without hydrogen bonding. This shows how the type of intermolecular force heavily influences the **physical properties** of a substance.

Water has a simple molecular structure but has an **unusually high boiling point** for the size of the molecule. This is due to the presence of hydrogen bonds that require a lot of energy to be overcome. Hydrogen bonds also result in ice having a much **lower density** than liquid water because they hold the molecules in a **rigid structure** with lots of air gaps.

Example:

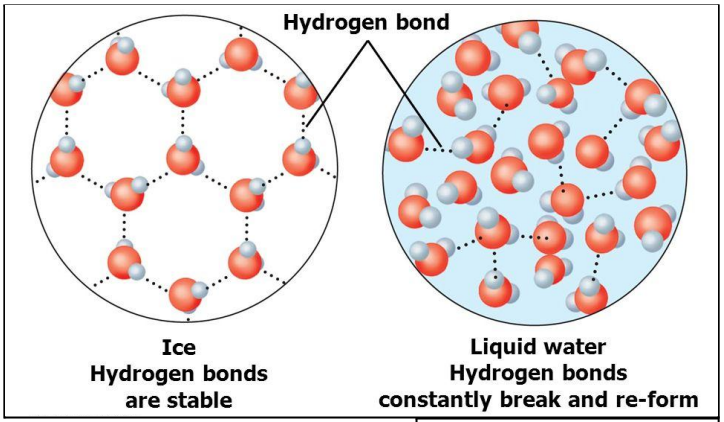
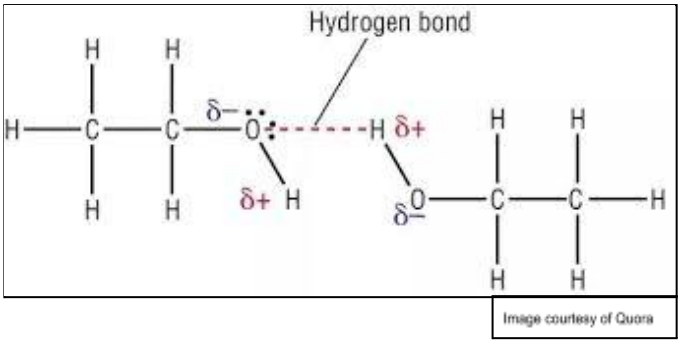


Image courtesy of Chemistry Stack Exchange

Hydrogen bonding is also responsible for the fact that **alcohols** have **much higher boiling points** than alkanes with a similar Mr value. This is because the lone electron pair on the oxygen atom is able to form **hydrogen bonds** with a hydrogen on another alcohol molecule.

Example:



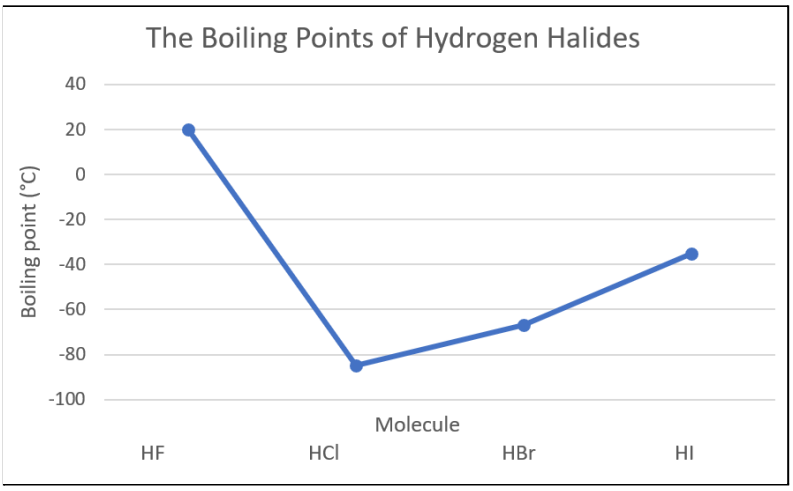
Solvents

Water is a popular choice of **solvent**. Its hydrogen bonding capabilities allow it to dissolve some **ionic compounds** by solvating the individual ions, and to dissolve some alcohols by forming **hydrogen bonds** with their **hydroxyl** group.

However, both water and alcohols are poor solvents for the dissolving of some **polar molecules** such as halogenoalkanes that cannot form hydrogen bonds.

Non-aqueous solvents are often used for compounds which have the same type of intermolecular force.

Boiling Point Trends of Hydrogen Halides



Hydrogen fluoride is the only hydrogen halide that forms **hydrogen bonds** between molecules. This gives it the highest boiling point because hydrogen bonds are much **stronger** than van der waals and permanent dipole forces.

The boiling point **increases** as you move down the group past hydrogen fluoride because as the halide increases in size, their **number of electrons** also increases. This means more **van der waals** forces form between molecules, so more energy is required to separate them.