





Organic Chemistry

Part 2

Intermolecular Forces

Grade 11 Revision of Intermolecular Forces (IMFs)

Downloaded from eduresourceza.com

- An **intermolecular force (IMF)** is a force between molecules.
- **Van der Waals forces** are a category of intermolecular forces which occur between polar and/or non-polar molecules.
 1. A **London force** is the force of attraction between two non-polar molecules.
 2. A **dipole-dipole force** is the force of attraction between two polar molecules.
 3. A **hydrogen bond** is a type of dipole-dipole force involving a hydrogen atom bonded to nitrogen, oxygen or fluorine (NOF) in a molecule and the lone pair of electrons on the nitrogen, oxygen or fluorine atom bonded to hydrogen in an adjacent molecule.

Downloaded from eduresourceza.com

IMFs & Physical Properties

- The strength of the IMFs between molecules affects many of the physical properties of the molecule, such as:
 1. **Melting and Boiling Points** - the STRONGER the IMFs, the MORE energy (in the form of heat) required to break the IMFs, and the HIGHER the MP and BP.
 2. **Volatility & Vapour Pressure** - the STRONGER the IMFs, the LONGER it takes to evaporate, the LOWER the volatility and the SMALLER the vapour pressure.
[Note: Boiling point is inversely proportional to vapour pressure.]
 3. **Solubility** – like dissolves like.

Summary of the IMFs between Organic Molecules

Downloaded from eduresourceza.com

Homologous Series	Polarity of Molecule	IMF Present
Alkanes	Non-polar	
Alkenes		
Alkynes		
Alkyl Halides	Polar	
Aldehydes		
Ketones		
Esters		
Alcohols	Polar	
Carboxylic Acids		

Downloaded from eduresourceza.com

Physical Properties of Hydrocarbons

Downloaded from eduresourceza.com

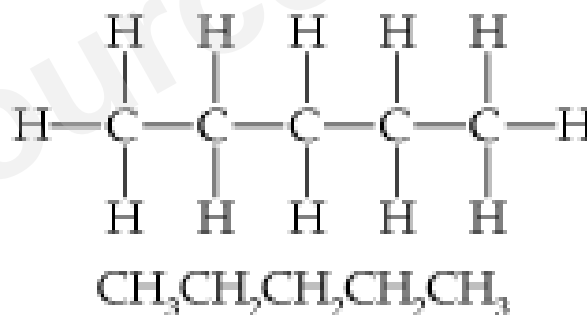
- Hydrocarbons (London forces) are insoluble in water (hydrogen bonds).
- Due to weak London forces, hydrocarbons have relatively low MPs & BPs.
- As the molecular mass of a hydrocarbon increases (i.e. as the **chain length increases**), the strength of the London forces also increase.
- $\therefore$ Bigger alkanes will have higher MPs & BPs than smaller ones.

n	Name	Formula	Molecular mass (gram)	Melting point ($^{\circ}$ C)	Boiling point ($^{\circ}$ C)	Phase at room temperature
1	methane	CH ₄	16	-183	-162	gas
2	ethane	C ₂ H ₆	30	-182	-88	gas
3	propane	C ₃ H ₈	44	-187	-25	gas
4	butane	C ₄ H ₁₀	58	-138	-0,5	gas
5	pentane	C ₅ H ₁₂	72	-130	36	liquid
6	hexane	C ₆ H ₁₄	86	-95	69	liquid
7	heptane	C ₇ H ₁₆	100	91	98	liquid
8	octane	C ₈ H ₁₈	114	-56	126	liquid

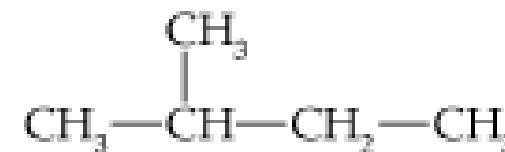
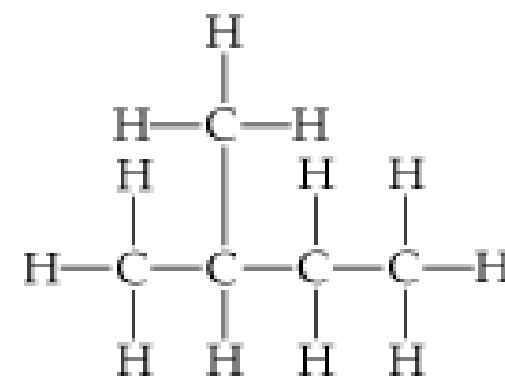
Downloaded from eduresourceza.com

Physical Properties of Hydrocarbons

- The London forces between branched alkane molecules are weaker than the London forces between straight chain alkane molecules.
- This is because branched alkanes are more spherical meaning there is less surface area over which the London forces can act.
- $\therefore$ Branched alkanes have lower BPs than straight chain hydrocarbons.



Pentane
m.p. -130°C
b.p. $+36^\circ\text{C}$



Isopentane
(2-methylbutane)
m.p. -160°C
b.p. $+28^\circ\text{C}$

Polarity of Organic Molecules

- Alkyl halides, aldehydes, ketones, esters, alcohols and carboxylic acids all consist of a POLAR and a NON-POLAR part.
- The functional group forms the POLAR part of the molecule.
The alkyl group forms the NON-POLAR part of the molecule.
- The larger the alkyl group, the less polar the molecule (overall).
[The smaller the alkyl group, the more polar the molecule (overall)].
- Branched alkyl groups will decrease the overall polarity of the molecule less than straight chain alkyl groups.

Physical Properties of Alkyl Halides

Downloaded from eduresourceza.com

- Alkyl halides are POLAR and therefore have DIPOLE-DIPOLE FORCES between their molecules.
- Since dipole-dipole forces are stronger than London forces, alkyl halides will have higher MPs and BPs than the corresponding alkanes.
- Alkyl halides (dipole-dipole forces) are insoluble in water (hydrogen bonds).

Downloaded from eduresourceza.com

Physical Properties of Aldehydes, Ketones & Esters

- Aldehydes, ketones & esters are POLAR* and therefore have DIPOLE-DIPOLE FORCES between their molecules.
- Since dipole-dipole forces are stronger than London forces, aldehydes, ketones & esters will have higher MPs and BPs than the corresponding alkanes.
- Aldehydes, ketones & esters are soluble* in water (hydrogen bonds).
 - Aldehydes, ketones & esters CANNOT form hydrogen bonds between themselves since the oxygen atom is not bonded to a hydrogen.
 - Aldehydes, ketones & esters CAN form hydrogen bonds with water though.

*the larger the alkyl group, the less polar and soluble the molecule becomes.

Physical Properties of Alcohols

Downloaded from eduresourceza.com

- Alcohols are POLAR* with an oxygen atom bonded to hydrogen and therefore have HYDROGEN BONDS between their molecules.
- Since hydrogen bonds are stronger than dipole-dipole and London forces, alcohols will have higher MPs and BPs than the corresponding alkanes, alkyl halides, aldehydes and ketones.
- The presence of hydrogen bonds means alcohols are soluble in water*.

*roughly speaking, if the alkyl group has less than

six carbons, the alcohol will be POLAR and SOLUBLE.

Downloaded from eduresourceza.com

Physical Properties of Alcohols

Structural formula	Name	Boiling point (°C)	Solubility of alcohol in water
CH ₃ OH CH ₄	methanol methane	65 -164	very soluble
CH ₃ CH ₂ OH CH ₃ CH ₃	ethanol ethane	79 -89	very soluble
CH ₃ CH ₂ CH ₂ OH CH ₃ CH ₂ CH ₃	1-propanol propane	97 -42	very soluble
CH ₃ CH ₂ CH ₂ CH ₂ OH CH ₃ CH ₂ CH ₂ CH ₃	1-butanol butane	117 -0,5	very soluble
CH ₃ CH ₂ CH ₂ CH ₂ CH ₂ OH CH ₃ CH ₂ CH ₂ CH ₂ CH ₃	1-pentanol pentane	138 36	soluble
CH ₃ CH ₂ CH ₂ CH ₂ CH ₂ CH ₂ OH CH ₃ CH ₂ CH ₂ CH ₂ CH ₂ CH ₃	1-hexanol hexane	156 69	insoluble

Physical Properties of Carboxylic Acids

Downloaded from eduresourceza.com

- Carboxylic acids are VERY POLAR* molecules with an oxygen atom bonded to hydrogen and therefore have HYDROGEN BONDS between their molecules.
- **Carboxylic acids are able to form two hydrogen bonds per molecule whereas alcohols can only form one hydrogen bond per molecule. (NB!!!)**
- As a result, carboxylic acids have higher MPs and BPs than the corresponding alcohols.
- The presence of hydrogen bonds means carboxylic acids are soluble* in water.

*to a certain extent (see next slide).

Downloaded from eduresourceza.com

Polarity & Acidity of Carboxylic Acids

- Roughly speaking...
 - ... if the alkyl group has up to four carbons, the carboxylic acid will be VERY POLAR and VERY SOLUBLE in water.
 - ... if the alkyl group has up to ten carbons, the carboxylic acid will be POLAR and SOLUBLE in water.
 - ... if the alkyl group has more than ten carbons, the carboxylic acid will be NON-POLAR and INSOLUBLE in water.
- Carboxylic acids are weak acids, i.e. they ionise partially in water, e.g.



Melting/Boiling Point Questions

Downloaded from eduresourceza.com

- When answering melting/boiling point questions, always use these 4 steps:
 1. Identify the IMFs.
 2. Compare the strength of the IMFs.
 3. Mention that more energy (in the form of heat) is required to break the stronger IMF.
 4. Mention that a higher temperature is reached for more energy required.

Downloaded from eduresourceza.com