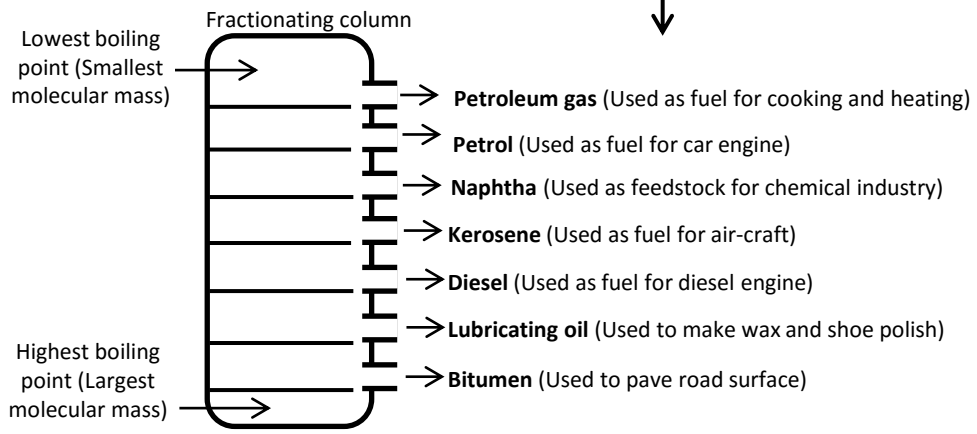
Introduction to organic chemistry

Fuel: Substance that burns exothermically.

3 main fossil fuel			
	Coal	Petroleum	Natural gas
Component	Carbon	Mixture of hydrocarbons of different size	CH_4
Amount of soot, CO and SO_2 produced when burned	A lot	Moderate	little

Separated using **fractional Distillation.**



1. Petroleum is ***BOILED*** into ***VAPOUR*** in a furnace***.***

↓

2. The vapour is ***PUMPED*** into a huge ***fractionating column*** which is ***cool at the top*** but ***hot at the bottom.***

↓

3. Hot vapour rises up the column and begins to ***cool down*** and ***condense***.

↓

4***. Smaller hydrocarbon has lower boiling point*** and collected at the ***top column.***

↓

5. ***Larger hydrocarbon has higher boiling point*** and collected at the ***bottom column.***

Homologous series: A family of organic compounds with same general formula and similar chemical properties.

Members in the same homologous series

1. Has same functional group, general formula and similar chemical properties

***Functional group** : An atom or group of atoms that gives a molecule its characteristic properties.

2. Has a gradual change in their physical properties up the series
(Mp/bp ↑, density ↑, viscosity ↑, flammability ↓)

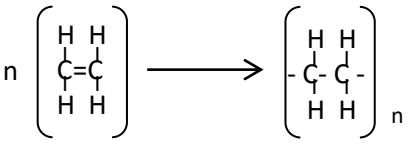
3. Differs from the next by a $–CH_2-$ unit.

	Alkane	**Alkene**	**Alcohol (liquid)**	**Carboxylic acid (liquid)**
General formula	C_nH_{2n+2}	C_nH_{2n}	$C_nH_{2n+1}OH$	$C_nH_{2n+1}COOH$
Functional group	C-C	C=C	-O-H	-COOH
First 4 members	1C : Methane (CH_4 ***GAS***) 2C : Ethane (C_2H_6 ***GAS)*** 3C : Propane (C_3H_8 ***GAS***) 4C : Butane (C_4H_{10} ***GAS***)	2C: Ethene (C_2H_4 ***GAS***) 3C : Propene (C_3H_6 ***GAS***) 4C : Butene (C_4H_8 ***GAS***)	1C : Methanol (CH_3OH) 2C : Ethanol (C_2H_5OH) 3C : Propanol (C_3H_7OH) 4C : Butanol (C_4H_9OH)	1C : Methanoic acid (HCOOH) 2C : Ethanoic acid (CH_3COOH) 3C : Propanoic acid (C_2H_5COOH) 4C : Butanoic acid (C_3H_7COOH)

Isomer

Compound with same molecular formula but different structural formula.

Alkane and Alkene (Hydrocarbon)

Reaction		Equation	Condition	Application
Alkane (Saturated)	Combustion	Complete: Alkane + O_2 → CO_2 + H_2O Incomplete : Alkane + O_2 → CO + H_2O (soot might be formed)		
	Substitution	Methane + Cl_2 → chloromethane + HCl CH_4 (g) + Cl_2 (g) → CH_3 Cl (g) + HCl (g)	UV light	
	Cracking	Long alkane → Small alkane + small alkene + H_2 $C_{10}H_{22}$ → $2C_4H_8$ + C_2H_6 *Total number of C and H atoms in products must be same as those in reactants.	Catalyst Al_2O_3 & SiO_2 (Broken porous/china pot), high temperature, more than 600°C	To meet the high demand of small alkanes that are used as fuel.
Alkene (Unsaturated)	Combustion	Complete: Alkene + O_2 → CO_2 + H_2O Incomplete: Alkene + O_2 → CO + H_2O		*Alkene is less flammable than alkane due to higher % of carbon
	Addition: H_2 (hydrogenation)	Alkene + H_2 → Alkane	Nickel catalyst, 200°C	To convert vegetable oil (alkene) into margarine (alkane)
	Addition: Br_2 (Bromination)	Alkene + Br_2 → Dibromoalkane	Room temperature	TEST for alkene!!! Reddish- brown aqueous Br_2 will turn colourless immediately if alkene is present.
	Addition: H_2O (Hydration)	Alkene + steam → Alcohol	300°C, 65 atm, Phosphoric (v) acid, H_3PO_4 as catalyst	
	Addition polymerisation	n (monomer) → polymer n (ethene) → $(ethene)_n$ Ethene → poly(ethene) 		To make plastic water bucket, cling film etc. *Disadvantage of plastic: Non-biodegradable, takes up landfill site

Alcohol and Carboxylic acid

Reaction		Equation	Condition	Application/remarks
Alcohol	Combustion	Alcohol + O_2 → CO_2 + H_2O		Advantages of ethanol as fuel - **Clean fuel** (Little carbon monoxide or soot is formed) - **carbon neutral** fuel (no ↑ in the amount of CO_2 in air when burnt) - Renewable fuel
	Oxidation	Alcohol + [O] → Carboxylic acid + H_2O Eg: Propanol + [O] → Propanoic acid + H_2O * Test for alcohol	Acidified potassium manganate (VII) ($KMnO_4$), heat under reflux	Oxygen gas in the presence of bacteria can oxidize alcohol too **Note: $KMnO_4$ can be used to test for alcohol**
	Fermentation	*yeast* Glucose → Ethanol + carbon dioxide $C_6H_{12}O_6$ → $2C_2H_5OH$ + $2CO_2$	- 37°C - Yeast - Absence of oxygen gas to prevent the oxidation of ethanol into ethanoic acid by the oxygen.	Disadvantages of fermentation - Slow - Fermentation gives **low yield** (15%) as **high concentration of ethanol kills the yeast** - Need to carry out **fractional distillation** to obtain pure ethanol from the reaction mixture. Uses of alcohol: Solvent for organic compound, alcoholic drinks (ethanol), and fuel.
Carboxylic acid	Acid's reactions **(Neutralization)**	- Acid + metal → salt + H_2 - Acid + base → salt+H_2O - Acid + carbonate → salt + H_2O + CO_2 Eg: Magnesium + ethanoic acid → Magnesium ethanoate + H_2		**Carbonate can be used to test for carboxylic acid** since effervescence is observed.
	Esterification	Alcohol + carboxylic acid ↔ ester + H_2O Eg: Ethanol + butanoic acid ↔ Ethyl butanoate + H_2O C_3H_7COOH + C_2H_5OH ↔ $C_3H_7COOC_2H_5$ + H_2O	Concentrated sulfuric acid as catalyst, heat under reflux	Uses of ester (has a sweet smelling): To make perfume, food flavouring, and solvent for organic chemicals

Macromolecules (Polymer) : Large molecules formed by joining many monomers by covalent bonds

Addition polymerisation (A reaction whereby many monomers are bonded together to form a single polymer w/o any by-product)

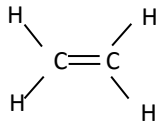
Condensation polymerisation (A reaction whereby many monomers are bonded together to form a polymer with the removal of small molecules as by-product)

- Polyester
- Polyamide

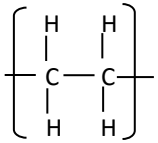
~ Monomer used: Alkene
~ Name of the polymer: poly(alkene)

Eg: If the monomer is ethene (gas @rtp)
Then the polymer is poly(ethene) (solid @rtp)

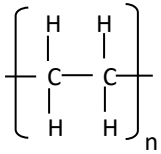
* Polymer is used to make plastic



Monomer : ethene



A repeated unit



The structure of the polymer, poly(ethene)

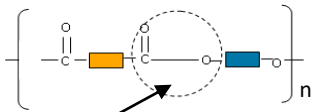
Addition polymerisation
1. Double bond is broken during addition polymerisation.
2. Percentage composition/empirical formula/mass of the polymer remains the same as monomer.
3. Molecular formula, density, mp/bp of polymer is higher than the monomer. Mp/bp increases due to increase in M_r and stronger intermolecular forces of attraction between molecules.

Advantages of plastic	Disadvantages of plastic
Light, non-fragile, cheap, durable	Non-biodegradable, (Not decomposed by bacteria), take up landfill site for disposal. Give out HCl (poisonous gas) when burned.

~ Monomer used:

1. Diol and Dicarboxylic aicd

Poly(ester)

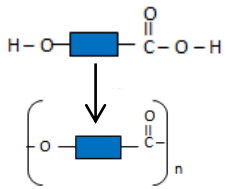


Ester linkage

Eg of polyester: terylene):
~ Use : Make clothing materials

Natural polymer that has the same linkage is **Fats**

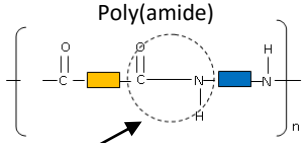
2.



~ Monomer used:

1. Diamine and Dicarboxylic aicd

Poly(amide)



Amide linkage

Eg of polyamide: Nylon
~ Use : To make fishing line, parachute

Natural polymer that has the same linkage is **Proteins**

2.