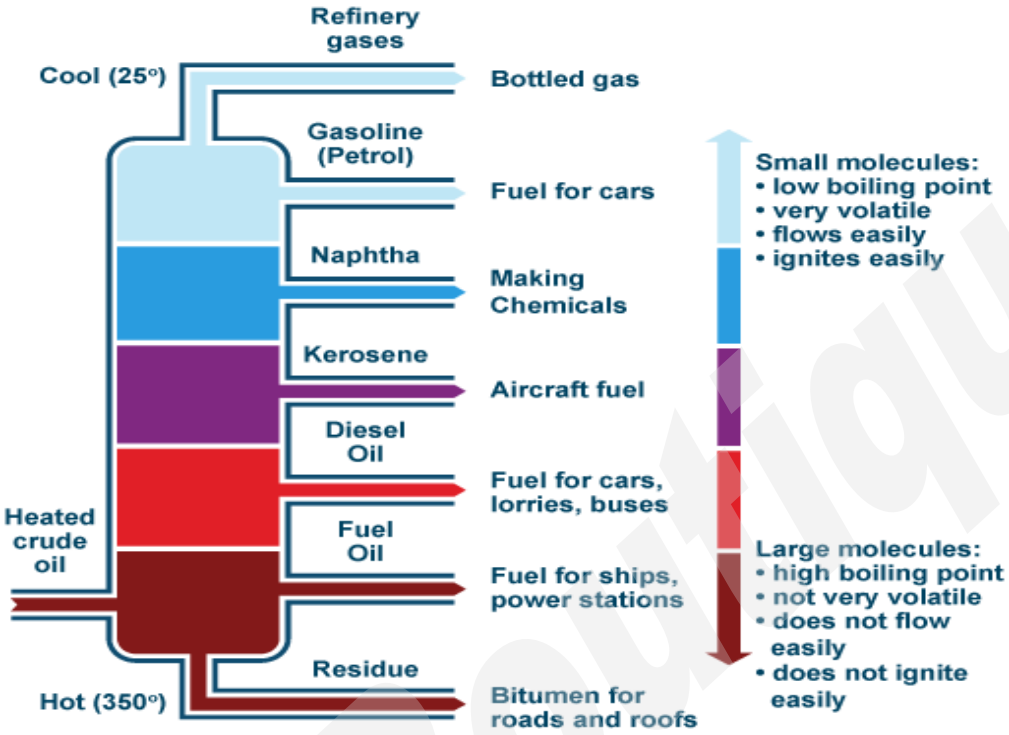
Organic Chemistry

(IGCSE Chemistry Syllabus 2016-2018)

Number of carbon(s)	Root	Alkanes	Alkenes	Alcohols	Carboxylic acids
1	Meth-	Methane	Methene	Methanol	Methanoic acid
2	Eth-	Ethane	Ethene	Ethanol	Ethanoic acid
3	Prop-	Propane	Propene	Propanol	Propanoic acid
4	But-	Butane	Butene	Butanol	Butanoic acid
5	Pent-	Pentane	Pentene	Pentanol	Pentanoic acid
6	Hex-	Hexane	Hexene	Hexanol	Hexanoic acid

<u>Fuels</u>

- Petroleum is separated into fractions which are useful via **fractional distillation** (based on their boiling point)

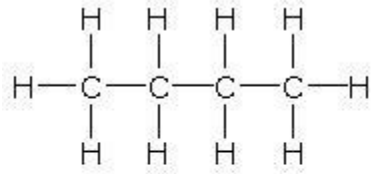


Homologous Series

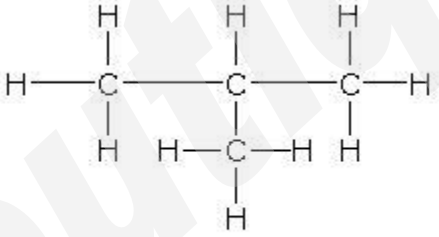
- Characteristics of a homologous series are as follows:
  - Same general formula
  - Consecutive members of the series differ by CH_2
  - Similar chemical properties
  - Same functional group
  - Gradual change in physical properties

Isomerism

- Molecule with the **same molecular formula** but **different structural formula**
- IUPAC naming:
  - Choose the longest chain
  - Determine the position of the side chain, using the smallest number
- Examples:
  a. Draw and name the isomers of butane
  Note: To draw the isomers of hydrocarbon, straight chain hydrocarbon can be converted into branch chain hydrocarbon

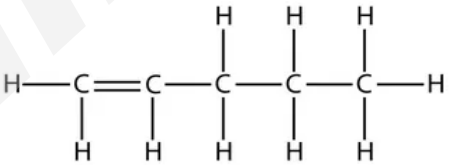


Butane (C_4H_{10})
(a continuous chain alkane)

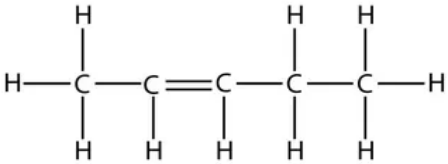


2-methyl propane (C_4H_{10})
(a branched chain alkane)

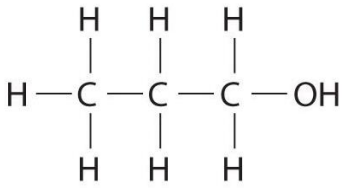
  b. Draw and name the isomers of propanol
  Note: To draw the isomers of alkene, alcohol, and halogenoalkane, the **functional group** can be shifted from the either end of carbon to the middle carbon



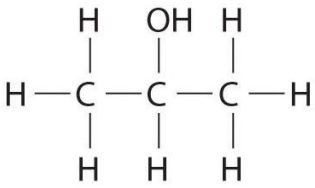
1-Pentene



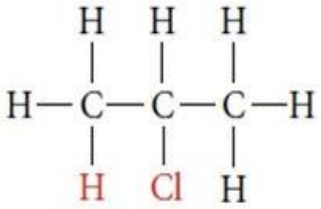
2-Pentene



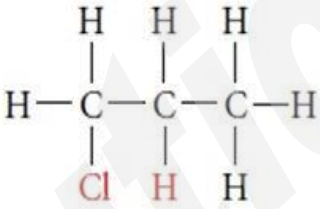
1-Propanol



2-Propanol



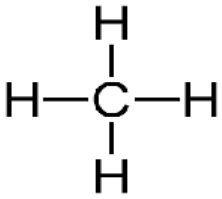
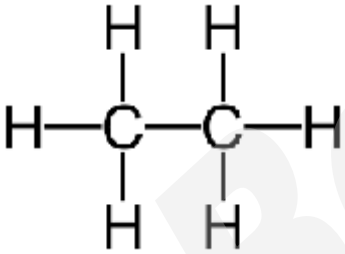
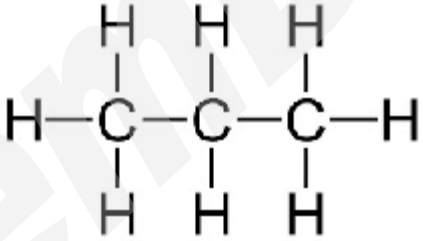
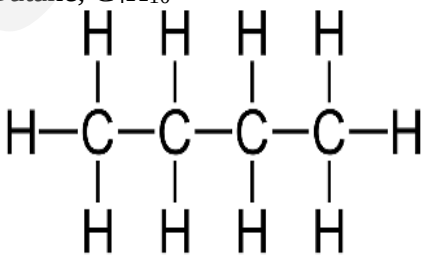
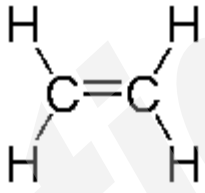
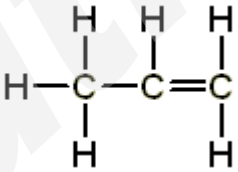
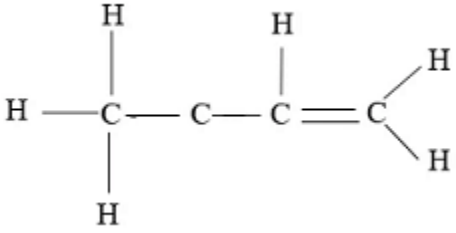
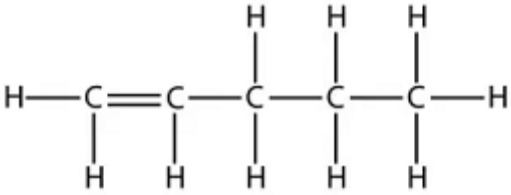
2-chloropropane



1-chloropropane

Alkanes and alkenes

- Alkane and alkenes are hydrocarbon – molecule that contains carbon and hydrogen only

	Alkanes	**Alkenes**
General formula	C_nH_{2n+2}, n= 1, 2, 3…	C_nH_{2n}, n=2, 3, 4…
Functional group	C-C single bond	C=C double bond
Hydrocarbon	Saturated	Unsaturated
Member	Methane, CH_4  Ethane, C_2H_6  Propane, C_3H_8  Butane, C_4H_{10} 	Ethene, C_2H_4  Propene, C_3H_6  Butene, C_4H_8  Pentene, C_5H_{10} 

<table>
<tr><td>Physical properties</td><td colspan="2">Simple covalent molecule
▪ Low melting point and boiling point – due to weak intermolecular forces
▪ Insoluble in water
▪ Does not conduct electricity
▪ Volatility decreases down the group</td></tr>
<tr><td>Chemical properties</td><td>1. Combustion
Excess O_2:
$CH_4 + 2O_2 \rightarrow CO_2 + 2H_2O$

Limited O_2:
$CH_4 + 3/2O_2 \rightarrow CO + 2H_2O$
$2\ CH_4 + 3O_2 \rightarrow 2CO + 4H_2O$

Very limited O_2:
$CH_4 + 2O_2 \rightarrow C + 2H_2O$

2. Substitution
Condition: UV light, halogen (e.g. Cl_2, Br_2, I_2)
$CH_4 + Cl_2 \rightarrow CH_3Cl + HCl$
Chloromethane
Note: This process can happen continuously if chlorine gas is in excess and in the presence of UV light
$CH_3Cl + Cl_2 \rightarrow CH_2Cl_2 + HCl$
Dichloromethane

$CH_2Cl_2 + Cl_2 \rightarrow CHCl_3 + HCl$
Trichloromethane

$CHCl_3 + Cl_2 \rightarrow CCl_4 + HCl$
Tetrachloromethane</td><td>1. Combustion
Excess O_2:
$C_2H_4 + 3O_2 \rightarrow 2CO_2 + 2H_2O$

Limited O_2:
$C_2H_4 + 2O_2 \rightarrow 2CO + 2H_2O$

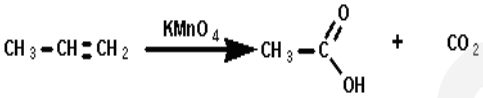
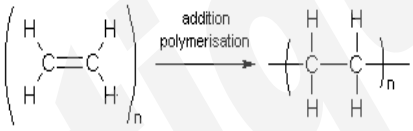
Very limited O_2:
$C_2H_4 + O_2 \rightarrow 2C + 2H_2O$

2. Addition
i. Hydrogen
Alkene + H_2 → Alkane
$C_2H_4 + H_2 \rightarrow C_2H_6$

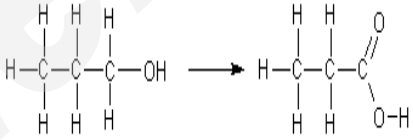
ii. Hydrogen halide (e.g. HCl)
Alkene + HCl → Halogenalkane
$C_2H_4 + HCl \rightarrow C_2H_5Cl$

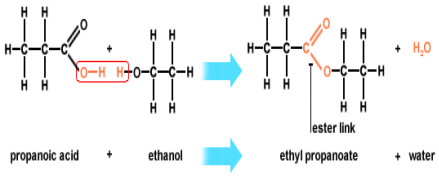
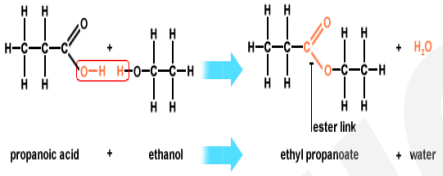
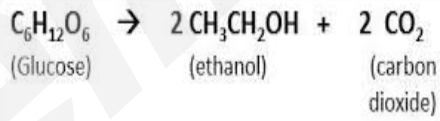
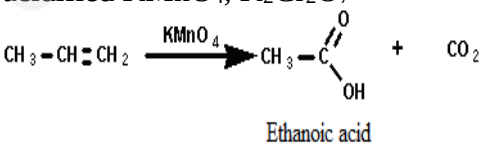
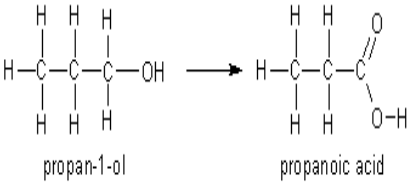
iii. Water
Alkene + water → Alcohol
$C_2H_4 + H_2O \rightarrow C_2H_5OH$
Ethanol

iv. Halogen (e.g. Br_2)
$C_2H_4 + Cl_2 \rightarrow C_2H_4Cl_2$
(dichloroethane)</td></tr>
</table>

	3. Thermal cracking Use of heat and catalyst to break large molecule into smaller molecule Alkane → Alkane + Alkene $C_{17}H_{36} \rightarrow C_{10}H_{22} + C_7H_{14}$ Alkane → Alkene + Alkene + H_2 $C_{17}H_{36} \rightarrow C_{10}H_{20} + C_7H_{14} + H_2$	3. Oxidation Condition: oxidizing agent, e.g. acidified $KMnO_4$, $K_2Cr_2O_7$  Ethanoic acid 4. Addition polymerization  The polymerisation of ethene in to poly(ethene)

Alcohols and carboxylic acids

	Alcohols	**Carboxylic acids**
General formula	$C_nH_{2n+1}OH$	$C_nH_{2n+1}COOH$
Functional group	-OH (hydroxyl group)	-COOH (carboxyl group)
Physical properties	Covalent molecule - Melting point and boiling point are higher than alkane and alkene due to the presence of -OH group which can form hydrogen bond with water molecules - Does not conduct electricity - Volatility decreases down the group	Covalent molecule - Melting point and boiling point are higher than alkane and alkene due to the presence of -COOH group which can form hydrogen bond with water molecules - Does not conduct electricity
Chemical properties	1. Combustion Excess O_2: $CH_3OH + 3/2O_2 \rightarrow CO_2 + 2H_2O$ $2CH_3OH + 3\ O_2 \rightarrow 2CO_2 + 4H_2O$ Limited O_2: $CH_3OH + O_2 \rightarrow CO + 2H_2O$ Very limited O_2: $CH_3OH + 1/2O_2 \rightarrow C + 2H_2O$ $2CH_3OH + O_2 \rightarrow 2C + 4H_2O$ 2. Oxidation Condition: oxidizing agent, e.g. acidified $KMnO_4$, $K_2Cr_2O_7$  propan-1-ol propanoic acid	1. Neutralization i. Metal (e.g. Na) $2CH_3COOH + 2Na \rightarrow 2CH_3COONa + H_2$ Sodium ethanoate ii. Metal oxide (e.g. MgO) $2CH_3COOH + MgO \rightarrow (CH_3COO)_2Mg + H_2O$ Magnesium ethanoate iii. Metal carbonate (e.g. $CaCO_3$) $2CH_3COOH + CaCO_3 \rightarrow (CH_3COO)_2Ca + H_2O + CO_2$ Calcium ethanoate iv. Metal hydroxide (e.g. NaOH) $CH_3COOH + NaOH \rightarrow CH_3COONa + H_2O$ Sodium ethanoate

	3. Dehydration Condition: hot phosphoric acid or hot aluminium oxide $C_2H_5OH \rightarrow C_2H_4 + H_2O$ 4. Esterification  	2. Esterification 
Production	1. Alkene + water $C_2H_4 + H_2O \rightarrow C_2H_5OH$ Ethanol **Advantages**: Fast **Disadvantages**: Not environmental friendly (use non-sustainable resource) 2. Fermentation  **Advantages**: Environmental friendly **Disadvantages**: Slow, many side-products	1. Oxidation of alkene Condition: oxidizing agent, e.g. acidified $KMnO_4$, $K_2Cr_2O_7$  2. Oxidation of alcohol Condition: oxidizing agent, e.g. acidified $KMnO_4$, $K_2Cr_2O_7$ 
Uses	- Solvent - Sanitizer	- Vinegar - Perfume making