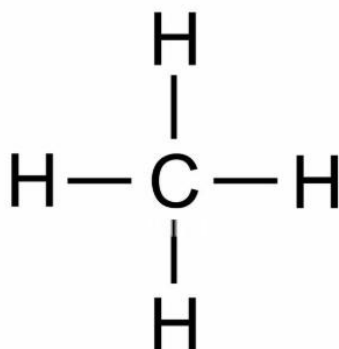


11 Organic chemistry

11.1 Formulae, functional groups and terminology

1 Draw and interpret the displayed formula of a molecule to show all the atoms and all the bonds

- Example: display formula of methane,



2 Write and interpret general formulae of compounds in the same homologous series, limited to: [n is the number of carbon atoms]

(a) alkanes, $\text{C}_n\text{H}_{2n+2}$

(b) alkenes, C_nH_{2n}

(c) alcohols, $\text{C}_n\text{H}_{2n+1}\text{OH}$

(d) carboxylic acids, $\text{C}_n\text{H}_{2n+1}\text{COOH}$

3 Identify a functional group as an atom or group of atoms that determine the chemical properties of a homologous series

- The carbon-carbon double bond in alkene is the functional group.
- hydroxide(OH) is the functional group in alcohols.

- carboxyl(COOH) is the functional group in carboxylic acids

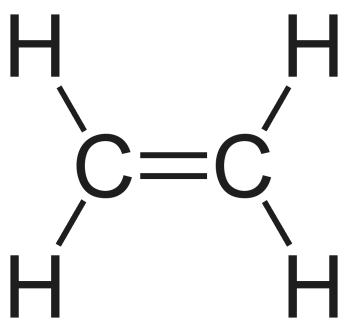
4 State that a homologous series is a family of similar compounds with similar chemical properties due to the presence of the same functional group

5 State that a saturated compound has molecules in which all carbon-carbon bonds are single bonds

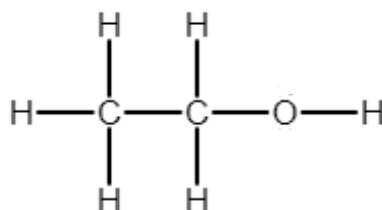
6 State that an unsaturated compound has molecules in which one or more carbon-carbon bonds are not single bonds

7 State that a structural formula is an unambiguous description of the way the atoms in a molecule are arranged, including $\text{CH}_2=\text{CH}_2$, $\text{CH}_3\text{CH}_2\text{OH}$, $\text{CH}_3\text{COOCH}_3$

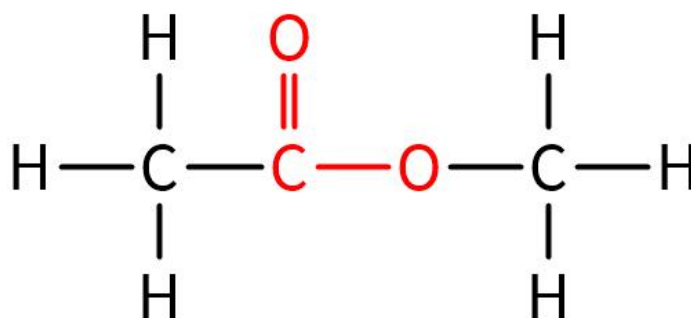
- The structural formula of ethene is $\text{CH}_2=\text{CH}_2$ AND the display formula is,



- The structural formula of ethanol is $\text{CH}_3\text{CH}_2\text{OH}$ AND the display formula is,



- The structural formula of methyl ethanoate is $\text{CH}_3\text{COOCH}_3$ AND the display formula is,



8 Define structural isomers as compounds with the same molecular formula, but different structural formulae, including C_4H_{10} as $\text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_3$ and $\text{CH}_3\text{CH}(\text{CH}_3)\text{CH}_3$ and C_4H_8 as $\text{CH}_3\text{CH}_2\text{CH}=\text{CH}_2$ and $\text{CH}_3\text{CH}=\text{CHCH}_3$

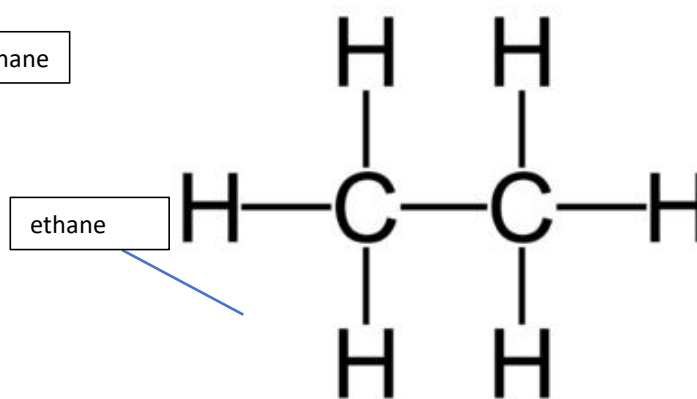
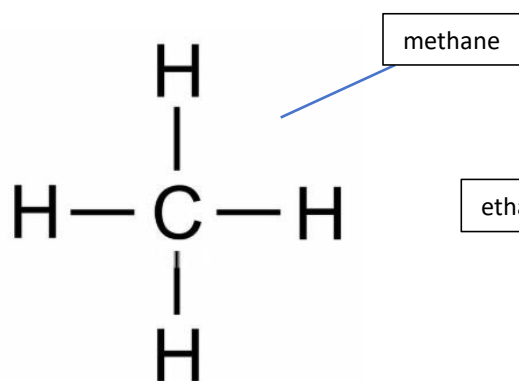
9 Describe the general characteristics of a homologous series as:

- (a) having the same functional group
- (b) having the same general formula
- (c) differing from one member to the next by a $-\text{CH}_2-$ unit
- (d) displaying a trend in physical properties
- (e) sharing similar chemical properties

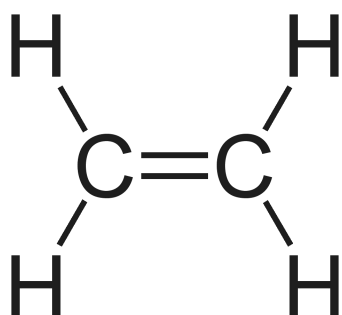
11.2 Naming organic compounds

1 Name and draw the displayed formulae of:

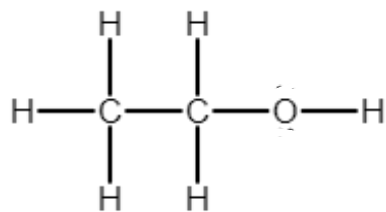
- (a) methane and ethane



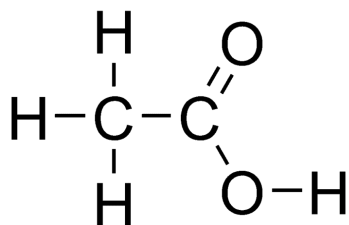
(b) ethene



(c) ethanol



(d) ethanoic acid



(e) the products of the reactions stated in sections 11.4–11.7 (in cyan)

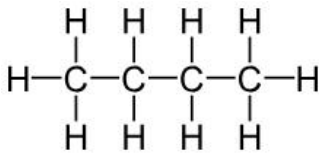
2 State the type of compound present, given a chemical name ending in -ane, -ene, -ol, or -oic acid or from a molecular formula or displayed formula

- compounds ending in -ane are alkane
- Compounds ending in -ene are alkene
- Compounds ending in -ol are alcohols
- Compounds ending in -oic acid are carboxylic acids

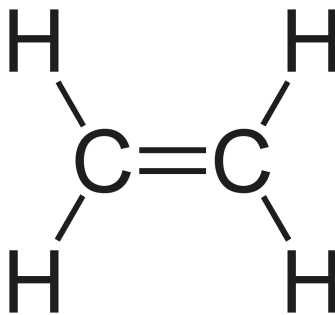
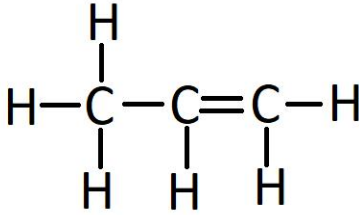
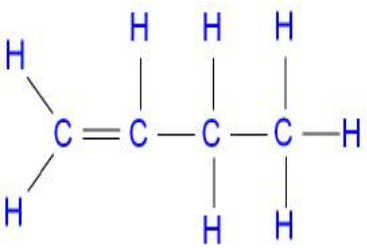
3 Name and draw the structural and displayed formulae of unbranched:

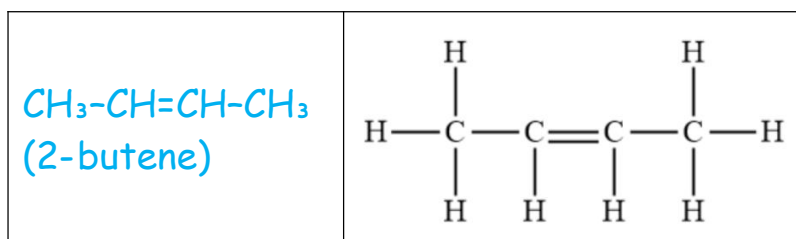
(a) alkanes

Carbon Atoms (n)	Name	Molecular Formula	Structural Formula	Display Formula (description)
1	Methane	CH ₄	CH ₄	<pre> H H — C — H H </pre>
2	Ethane	C ₂ H ₆	CH ₃ -CH ₃	<pre> H H H — C — C — H H H </pre>
3	Propane	C ₃ H ₈	CH ₃ -CH ₂ -CH ₃	<pre> H H H H — C — C — C — H H H H </pre>

4	Butane	C_4H_{10}	CH_3-CH_2- CH_2-CH_3	
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(b) alkenes, including but-1-ene and but-2-ene

Carbon Atoms (n)	Name	Molecular Formula	Structural Formula	Display Formula (description)
2	Ethene	C_2H_4	$CH_2=CH_2$	
3	Propene	C_3H_6	$CH_2=CH-CH_3$	
4	Butene	C_4H_8	$CH_2=CH-CH_2-CH_3$ (1-butene)[1- means that the double bond is on the first carbon atom]	



(c) alcohols, including propan-1-ol, propan-2-ol, butan-1-ol and butan-2-ol

Name	Molecular Formula	Structural Formula	Expanded Display Formula
Methanol	CH_4O	$\text{CH}_3\text{-OH}$	
Ethanol	$\text{C}_2\text{H}_6\text{O}$	$\text{CH}_3\text{-CH}_2\text{-OH}$	
Propan-1-ol	$\text{C}_3\text{H}_8\text{O}$	$\text{CH}_3\text{-CH}_2\text{-CH}_2\text{-OH}$	
Propan-2-ol	$\text{C}_3\text{H}_8\text{O}$	$\text{CH}_3\text{-CHOH-CH}_3$	
Butan-1-ol	$\text{C}_4\text{H}_{10}\text{O}$	$\text{CH}_3\text{-CH}_2\text{-CH}_2\text{-CH}_2\text{-OH}$	

Butan-2-ol	$C_4H_{10}O$	$CH_3-CH_2-CHOH-CH_3$	<pre> H H H H H - C - C - C - C - H H OH H H </pre>
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(d) carboxylic acids containing up to four carbon atoms per molecule

Name	Molecular Formula	Structural Formula	Expanded Display Formula
Methanoic acid	$HCOOH$	$H-COOH$	<pre> O H - C - OH </pre>
Ethanoic acid	CH_3COOH	CH_3-COOH	<pre> H O H - C - C - OH H </pre>
Propanoic acid	C_2H_5COOH	CH_3-CH_2-COOH	<pre> H H O H - C - C - C - O - H H H </pre>
Butanoic acid	C_3H_7COOH	$CH_3-CH_2-CH_2-COOH$	<pre> H H H O H - C - C - C - C - O - H H H H </pre>

4 Name and draw the displayed formulae of the unbranched esters which can be made from unbranched alcohols and carboxylic acids, each containing up to four carbon atoms

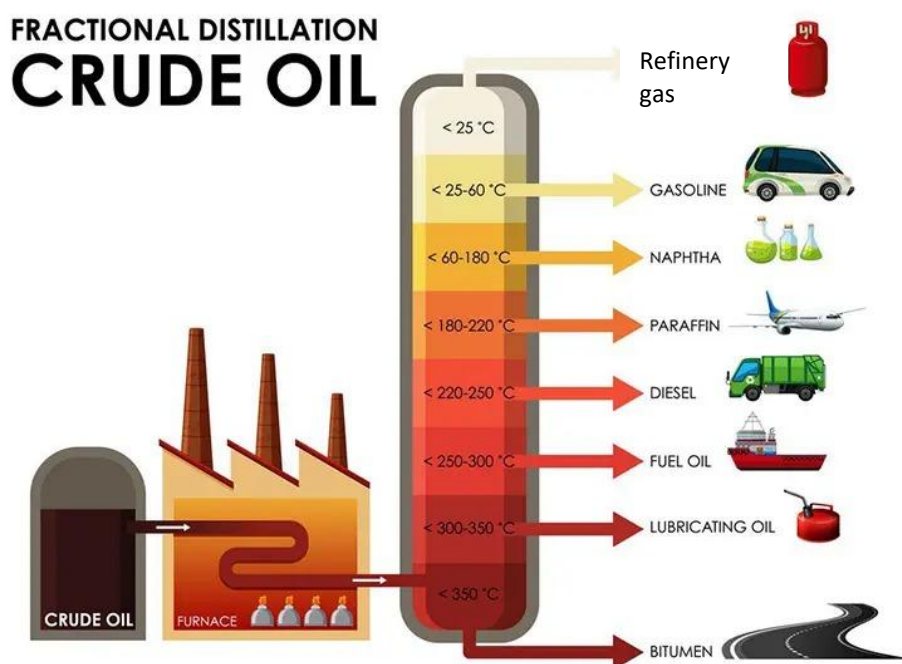
● Carboxylic acid + Alcohol → Ester + Water

- When writing the name of an ester, the alkyl group is written first (methyl, ethyl, propyl) followed by the carboxyl (ethanoate, methanoate, propanoate)
- When drawing the ester, the carboxyl is drawn first followed by the alkyl.

Ester Name	Molecular Formula	Structural Formula	Expanded Display Formula
Methyl methanoate	$C_2H_4O_2$	$H-COO-CH_3$	
Methyl ethanoate	$C_3H_6O_2$	$CH_3-COO-CH_3$	
Ethyl methanoate	$C_3H_6O_2$	$H-COO-CH_2-CH_3$	
Ethyl ethanoate	$C_4H_8O_2$	$CH_3-COO-CH_2-CH_3$	
Propyl methanoate	$C_4H_8O_2$	$H-COO-CH_2-CH_2-CH_3$	
Methyl propanoate	$C_4H_8O_2$	$CH_3-CH_2-COO-CH_3$	

11.3 Fuels

- 1 Name the fossil fuels: coal, natural gas and petroleum
- 2 Name methane as the main constituent of natural gas
- 3 State that hydrocarbons are compounds that contain hydrogen and carbon only
- 4 State that petroleum is a mixture of hydrocarbons
- 5 Describe the separation of petroleum into useful fractions by fractional distillation



- 6 Describe how the properties of fractions obtained from petroleum change from the bottom to the top of the fractionating column, limited to:
 - (a) decreasing chain length
 - The chain length increases down the column (bitumen has the longest chain length)

(b) higher volatility

- Volatility decreases doing down the column(fractions at the bottom and solids and fractions at the top are gases)

(c) lower boiling points

- Boiling point increases doing down the group as the chain length increases and the fractions become solid.

(d) lower viscosity

- The viscosity(resistance to flow) decreases down the group as fractions become solids(only gases and liquids are viscous)

7 Name the uses of the fractions as: [Ryan Got No Ketchup Dipping For Lucnh Break]

(a) Refinery gas fraction for gas used in heating and cooking

(b) Gasoline/petrol fraction for fuel used in cars

(c) Naphtha fraction as a chemical feedstock

(d) Kerosene/paraffin fraction for jet fuel

(e) Diesel oil/gas oil fraction for fuel used in diesel engines

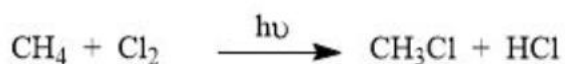
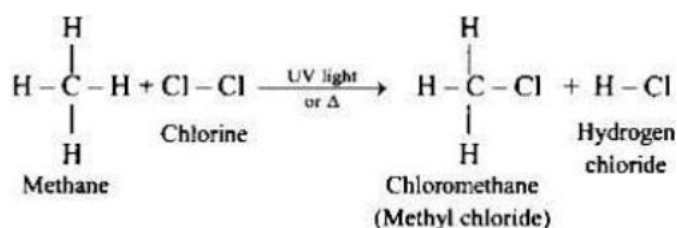
(f) Fuel oil fraction for fuel used in ships and home heating systems

(g) Lubricating oil fraction for lubricants, waxes and polishes

(h) Bitumen fraction for making roads

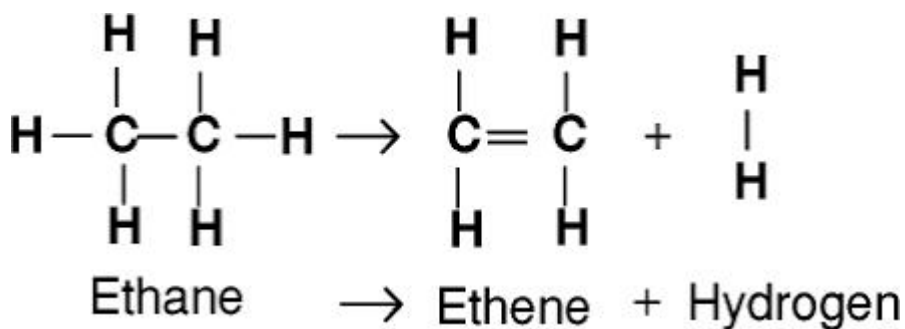
11.4 Alkanes

- 1 State that the bonding in alkanes is single covalent and that alkanes are saturated hydrocarbons
- 2 Describe the properties of alkanes as being generally unreactive, except in terms of combustion and substitution by chlorine
- 3 State that in a substitution reaction one atom or group of atoms is replaced by another atom or group of atoms
- 4 Describe the substitution reaction of alkanes with chlorine as a photochemical reaction, with ultraviolet light providing the activation energy, E_a , and draw the structural or displayed formulae of the products, limited to monosubstitution



11.5 Alkenes

- 1 State that the bonding in alkenes includes a double carbon-carbon covalent bond and that alkenes are unsaturated hydrocarbons
- 2 Describe the manufacture of alkenes and hydrogen by the cracking of larger alkane molecules using a high temperature and a catalyst



3 Describe the reasons for the cracking of larger alkane molecules

- Large alkanes are less useful as fuels. When cracked, they give alkenes which are more useful as fuels and used to make plastics.
- This helps balance supply and demand by using less demanding alkanes which are abundant to make alkenes which are more demanding and less abundant.

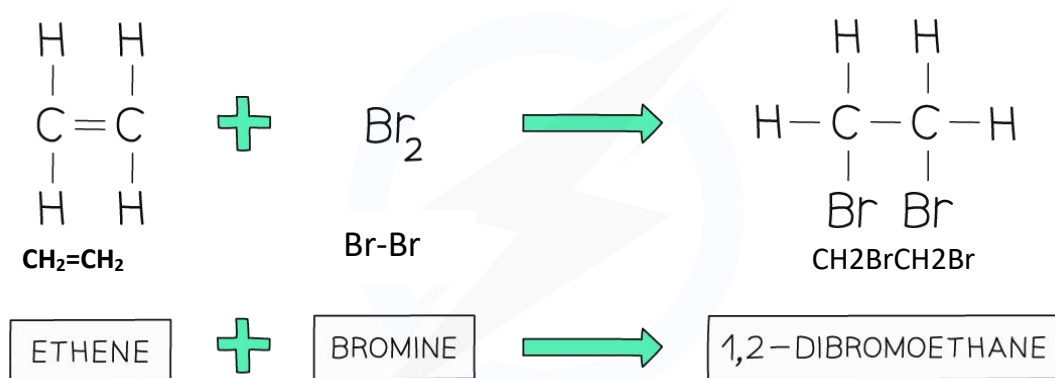
4 Describe the test to distinguish between saturated and unsaturated hydrocarbons by their reaction with aqueous bromine

- Saturated hydrocarbons have no effect on the colour of aqueous bromine(orange). No colour change is seen.
- Unsaturated hydrocarbons decolourise aqueous bromine(turns colourless).

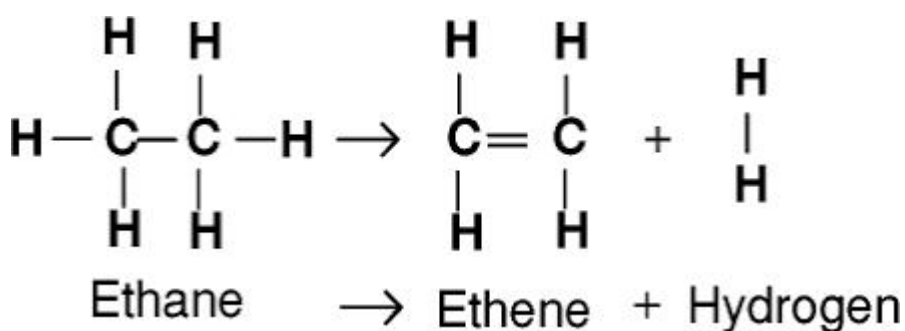
5 State that in an addition reaction only one product is formed

6 Describe the properties of alkenes in terms of addition reactions with:

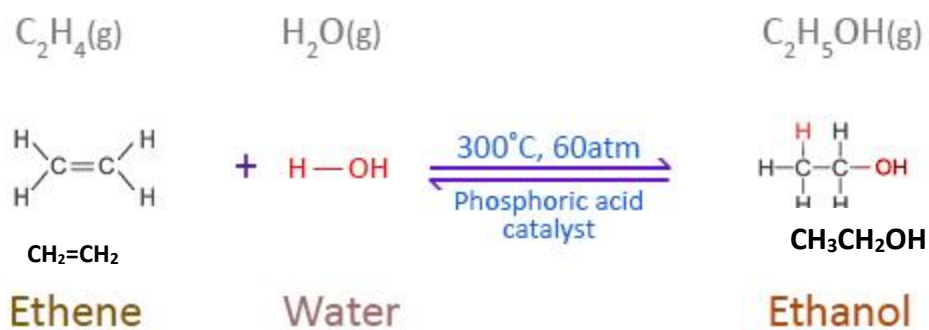
(a) bromine or aqueous bromine



(b) hydrogen in the presence of a nickel catalyst



(c) steam in the presence of an acid catalyst



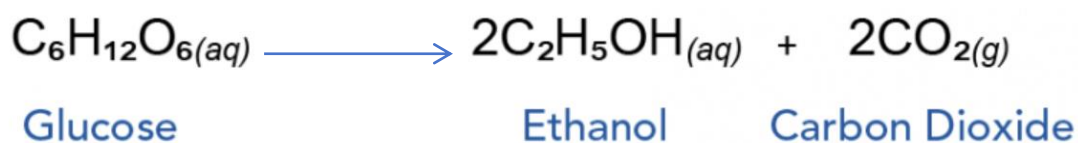
and draw the structural or displayed formulae of the products

11.6 Alcohols

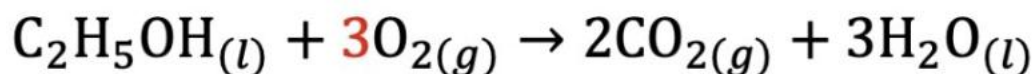
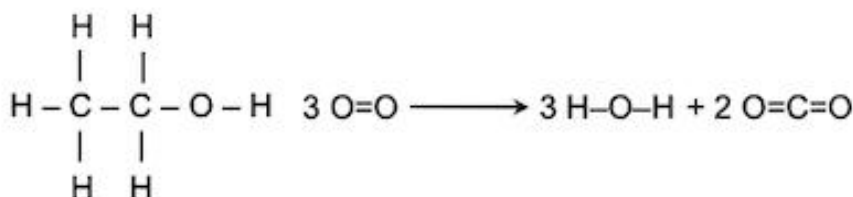
1 Describe the manufacture of ethanol by:

(a) fermentation of aqueous glucose at 25– 35°C in the presence of yeast and in the absence of oxygen

(b) catalytic addition of steam to ethene at 300°C and 6000kPa/60 atm in the presence of an acid catalyst



2 Describe the combustion of ethanol



3 State the uses of ethanol as:

(a) a solvent

- It dissolves many substances like oils and esters which are insoluble in water

(b) a fuel

- Ethanol is flammable so can be burned(combustion)

4 Describe the advantages and disadvantages of the manufacture of ethanol by: [check mark means adv. And x means dis.]

(a) fermentation

(b) catalytic addition of steam to ethene

Aspect	Fermentation (from sugars)	Catalytic addition of steam to ethene
Raw materials	✓ Renewable (glucose from crops)	✗ Non-renewable (ethene from crude oil)
Conditions	✓ Mild (35–40 °C, atmospheric pressure, enzymes)	✗ Harsh (300 °C, 60 atm, catalyst)
Rate of reaction	✗ Slow (biological process)	✓ Fast (industrial catalytic process)
Purity of ethanol	✗ Impure (10– 15%, needs distillation)	✓ Pure ethanol obtained directly
Energy demand	✓ Low (mild conditions)	✗ High (heat and pressure required)
Sustainability	✓ Renewable, potentially carbon-neutral	✗ Non-renewable, fossil fuel dependent
Cost	✓ Cheaper equipment, but ✗ slower yield	✓ Efficient continuous process, ✗ expensive equipment
Scale	✗ Small-scale, batch process	✓ Large-scale, continuous industrial process

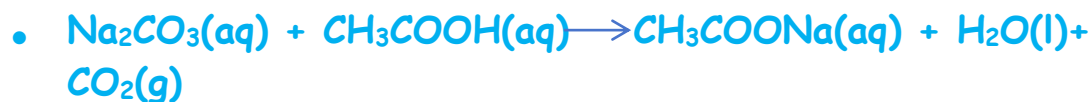
11.7 Carboxylic acids

1 Describe the reaction of ethanoic acid with:

(a) Metals[Mg]



Magnesium
ethanoate

(b) Bases[NaOH]sodium
ethanoate**(c) Carbonates[Na₂CO₃]**

including names and formulae of the salts produced[

2 Describe the formation of ethanoic acid by the oxidation of ethanol:

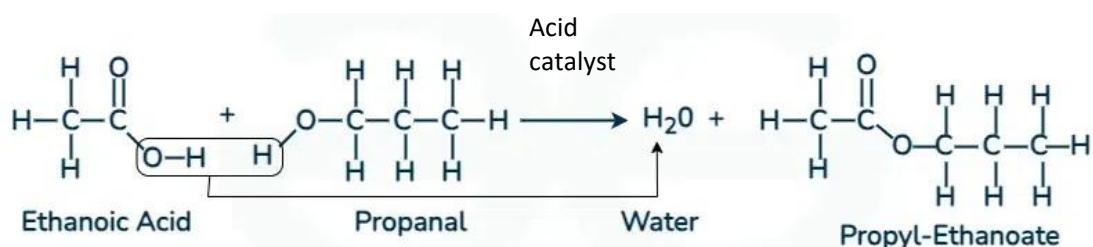
(a) with acidified aqueous potassium manganate(VII)

- Ethanol is heated with acidified aqueous potassium manganate(VII). It gets oxidised(gain oxygen), forming ethanoic acid. Acidified aqueous potassium manganate(VII) is reduced and gets decolourised.

(b) by bacterial oxidation during vinegar production

- Bacteria oxidise ethanol(viniger). This is called acid fermentation.

3 Describe the reaction of a carboxylic acid with an alcohol using an acid catalyst to form an ester



11.8 Polymers

1 Define polymers as large molecules built up from many smaller molecules called monomers

2 Describe the formation of poly(ethene) as an example of addition polymerisation using ethene monomers

3 State that plastics are made from polymers

4 Describe how the properties of plastics have implications for their disposal AND 5 Describe the environmental challenges caused by plastics, limited to:

(a) disposal in landfill sites

(b) accumulation in oceans

(c) formation of toxic gases from burning

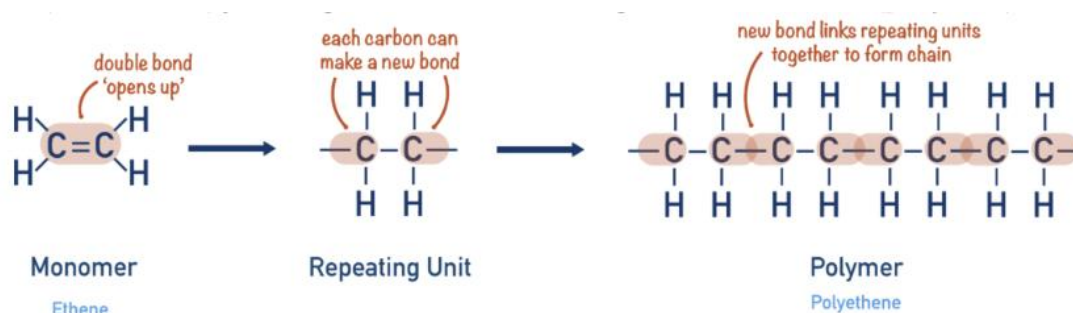
Property of Plastics	Negative Impact on Disposal
Non-biodegradable	Plastics do not decompose naturally, accumulating in landfills and the oceans for a long time.
Durability & chemical resistance	They resist decay and chemical attack because they are unreactive, making them very difficult to break down or recycle.
Lightweight	Easily carried by wind or water, spreading as litter and contributing to ocean and river pollution.
Toxic emissions when burned	Incineration is difficult as they are not flammable but can release harmful gases if done , creating health and environmental hazards.
Fragmentation into microplastics	Instead of decomposing, plastics break into tiny particles that contaminate soil, water, and food chains. Animals in the food chain consume these microplastics and choke on them, leading to their death.

6 Identify the repeat units and/or linkages in addition polymers and in condensation polymers AND 7 Deduce the structure or repeat unit of an addition polymer from a given alkene and vice versa AND 8 Deduce the structure or repeat unit of a condensation polymer from given monomers and vice versa, limited to:

(a) polyamides from a dicarboxylic acid and a diamine

(b) polyesters from a dicarboxylic acid and a diol

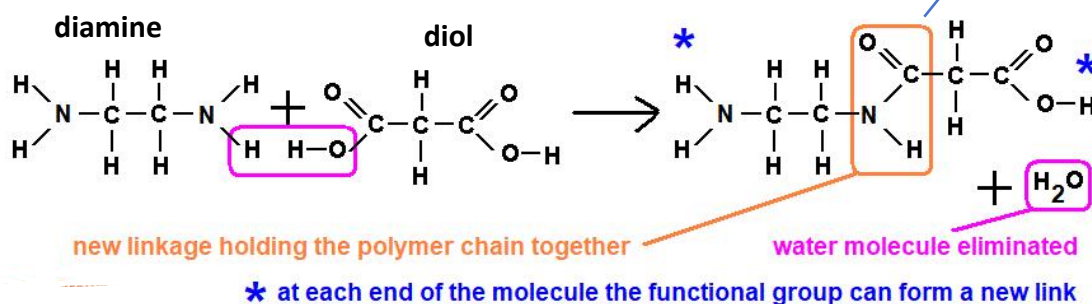
● Addition polymerisation example :



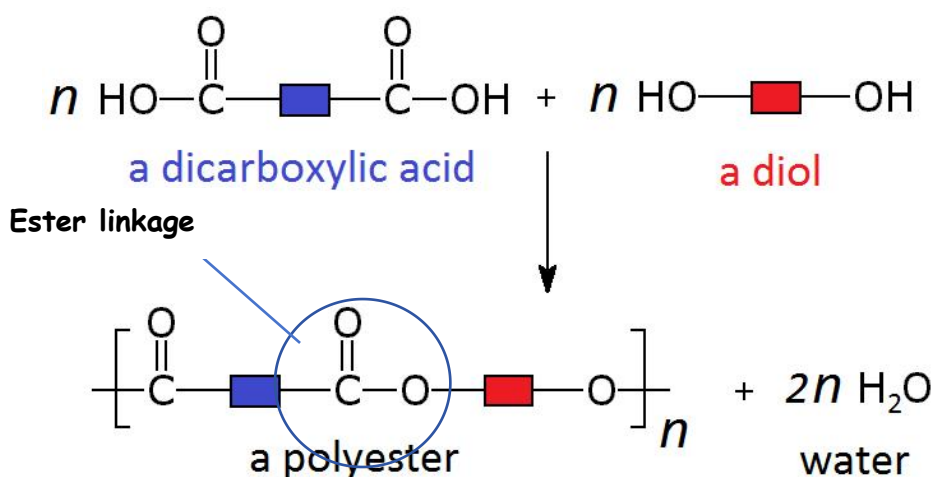
● Polyamide formation(condensation polymerisation):

Amide linkage

How the link bond is formed in making a Nylon by the elimination of water



● Polyester formation(condensation polymerisation):

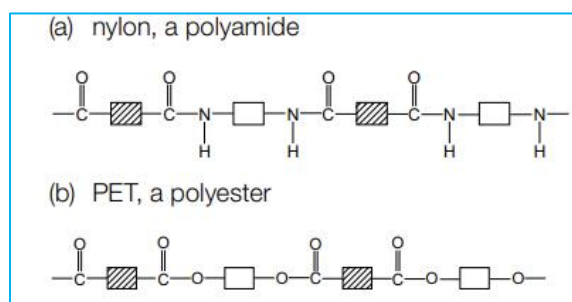


9 Describe the differences between addition and condensation polymerisation

Feature	Addition Polymerisation	Condensation Polymerisation
Monomers	Unsaturated monomers (usually alkenes with C=C double bonds)	Monomers with two different functional groups (e.g., -OH, -COOH, -NH ₂)
Reaction type	Double bonds open and link together	Functional groups react, eliminating a small molecule (often water)
By-products	None (polymer is the only product)	Small molecules are released as a result of elimination reaction
Structure of polymer	Long chains of repeating units with no loss of atoms	Chains formed with alternating monomers, linked by ester or amide bonds
Conditions	Often requires	Often requires

	catalysts, heat, or pressure	heat and sometimes catalysts
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10 Describe and draw the structure of:

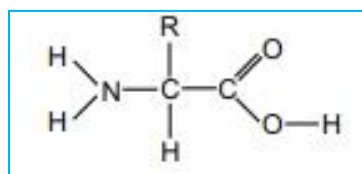


The full name for PET, polyethylene terephthalate, is not required

11 State that PET can be converted back into monomers and re-polymerised

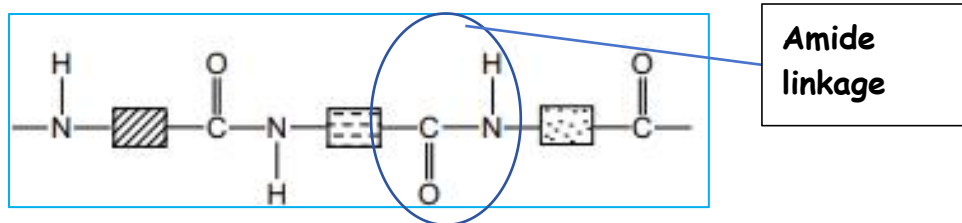
- Water is added to PET polymer causing ester linkage to break. This is called hydrolysis(breaking down with water)

12 Describe proteins as natural polyamides and that they are formed from amino acid monomers with the general structure:



where R represents different types of sidechain

13 Describe and draw the structure of proteins as:



END OF CHAPTER