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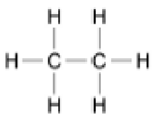
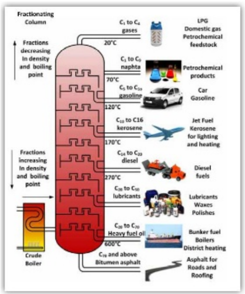
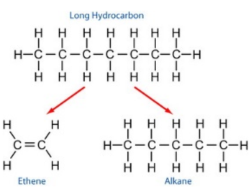
4.7.1	Carbon compounds as fuels and feedstock
4.7.1.1 **Crude oil, hydrocarbons as fuels and feedstock** Alkane molecules can be represented in the following forms: C_2H_6 or 	**Crude oil** is a **finite** resource (it will run out) found in rocks. Crude oil is the remains of an **ancient biomass** consisting mainly of plankton that was buried in mud. Crude oil is a mixture of a **very large number of compounds**. Most of the compounds in crude oil are **hydrocarbons**, which are molecules made up of **hydrogen and carbon atoms only.** Most of the hydrocarbons in crude oil are hydrocarbons called **alkanes**. The general formula for the homologous series of alkanes is $\mathbf{C_nH_{2n+2}}$ The first four members of the alkanes are methane (CH_4), ethane (C_2H_6), Propane (C_3H_8) and butane (C_4H_{10}). **M**onkeys **E**at **P**eanut **B**utter!
4.7.1.2 **Fractional distillation and petrochemicals** 	The many **hydrocarbons** in crude oil may be **separated** into fractions, each of which contains molecules with a similar number of carbon atoms, by **fractional distillation**. The crude oil is **heated**, different hydrocarbons **evaporate** at **different temperatures** because they have **different boiling points**. They are then **condensed** at different temperatures and collected. The fractions can be processed to produce fuels and feedstock for the petrochemical industry. Many of the **fuels** such as petrol, diesel oil, kerosene, heavy fuel oil and liquefied petroleum gases, are produced from crude oil. Many **useful materials** on which modern life depends are produced by the petrochemical industry, such as solvents, lubricants, polymers, detergents.
4.7.1.3 **Properties of hydrocarbons**	Some properties of hydrocarbons depend on the size of their molecules, including boiling point, viscosity and flammability. These properties influence how hydrocarbons are used as fuels. Boiling point and viscosity increase as the molecules get bigger and flammability decreases as molecules get bigger. The **combustion** (burning) of hydrocarbon fuels **releases energy**. During combustion, the carbon and hydrogen in the fuels are **oxidised**. The complete combustion of a hydrocarbon **produces carbon dioxide and water. Ethane + oxygen → carbon dioxide + water** $\mathbf{2C_2H_6 + 7O_2 \rightarrow 4CO_2 + 6H_2O}$
4.7.1.4 Cracking and alkenes 	Hydrocarbons can be **broken down (cracked)** to **produce smaller**, **more useful** molecules. Cracking can be done by various methods including **catalytic cracking** (need **high temperature** and a **catalyst**) and **steam cracking** (**mixed with steam** and heated to a **very high temperature**). e.g. decane → pentane + propene +ethene $C_{10}H_{22} \rightarrow C_5H_{12} + C_3H_6 + C_2H_4$ The products of cracking include alkanes and another type of hydrocarbon called alkenes. Alkenes are more reactive than alkanes and react with bromine water, which is used as a test for alkenes. **(bromine water** goes from **orange** to **colourless** with alkenes) There is a high demand for fuels with **small molecules** and so some

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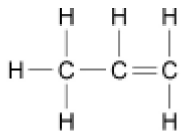
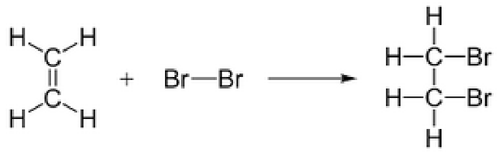
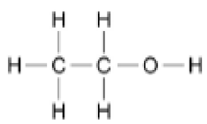
	of the products of cracking are useful as **fuels**. **Alkenes** are used to **produce polymers** and as starting materials for the production of many other chemicals.
4.7.2	Reactions of alkenes and alcohols (chemistry only)
4.7.2.1 Structure and formulae of alkenes C_3H_6 or 	**Alkenes** are **hydrocarbons** with a **double carbon-carbon bond**. The general formula for the homologous series of alkenes is C_nH_{2n} Alkene molecules are **unsaturated** because they contain two fewer hydrogen atoms than the alkane with the same number of carbon atoms. The first four members of the homologous series are ethane C_2H_4, propene C_3H_6, butane C_4H_8, pentene C_5H1_0
4.7.2.2 Reactions of alkenes	**Alkenes** are **hydrocarbons** with the **functional group C=C.** It is the generality of reactions of functional groups that determine the reactions of organic compounds. Alkenes **react** with **oxygen in combustion reactions** in the same way as other hydrocarbons, but they tend to burn in air with smoky flames because of **incomplete combustion**. **Alkenes react with hydrogen, water and the halogens**, by the **addition of atoms** across the **carbon-carbon double bond** so that the double bond becomes a single carbon-carbon bond. E.g. ethene + bromine 
4.7.2.3 Alcohols **e.g. ethanol** CH_3CH_2OH or 	Alcohols contain the **functional group –OH**. Methanol CH_3OH, ethanol C_2H_5OH, propanol C_3H_7OH and butanol C_4H_9OH are the first four members of a homologous series of alcohols. **Reaction with sodium** sodium + ethanol → sodium ethoxide + **hydrogen**, **combustion** (burn) in air, ethanol + oxygen → carbon dioxide + water **oxidation (**react with an oxidising agent) **produces carboxylic acids** ethanol + oxygen → ethanoic acid + water Alcohols are used for **fuels** and **solvents** Aqueous solutions of ethanol are produced when sugar solutions are fermented using yeast. Glucose → ethanol + carbon dioxide $C_6H_{12}O_6\ (aq) \rightarrow 2C_2H_5OH(aq) + 2CO_2\ (g)$ This needs warm conditions
4.7.2.4 Carboxylic acids e.g. ethanoic acid	Carboxylic acids have the functional group **–COOH.** The first four members of a homologous series of carboxylic acids are methanoic acid , ethanoic acid, propanoic acid and butanoic acid. **react with carbonates** to produce a salt, carbon dioxide and water,

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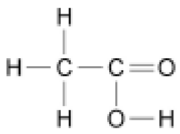
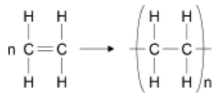
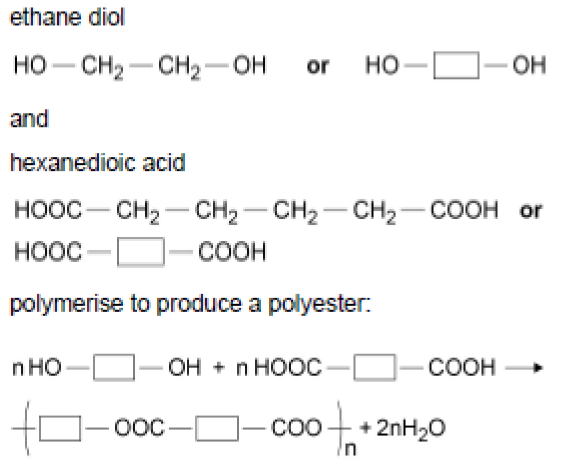
CH_3COOH or 	e.g. ethanoic acid + sodium carbonate → sodium ethanoate + carbon dioxide + water dissolve in water to make **acidic solutions** They only **partially ionise** to release **hydrogen ions** so are **weak acids** (have a higher pH) react with alcohols to produce **esters (e.g. ethyl ethanoate)** e.g. ethanoic acid + ethanol → ethyl ethanoate + water Need a **sulfuric acid catalyst** for this reaction
4.7.3	Synthetic and naturally occurring polymers (chemistry only)
4.7.3.1 Addition polymerisation For example:  	Alkenes can be used to make polymers such as poly(ethene) and poly(propene) by **addition polymerisation.** In addition polymerisation reactions, **many small molecules (monomers) join** together to form **very large molecules (polymers).** Monomers have a C=C bond
4.7.3.2 Condensation polymerisation (HT only)	**Condensation polymerisation** involves monomers with **two functional groups**. When these types of monomers react they join together, usually **losing small molecules such as water**, and so the reactions are called condensation reactions. The simplest polymers are produced from two different monomers with two of the same functional groups on each monomer.  This is a different molecule drawn in different wavs
4.7.3.3 Amino acids (HT only)	Amino acids have two different functional groups in a molecule. Amino acids react by **condensation polymerisation** to produce polypeptides. For example: glycine is H_2NCH_2COOH and polymerises to produce the polypeptide $(-HNCH_2COO-)n$ and n H_2O Different amino acids can be combined in the same chain to produce proteins.
4.7.3.4 DNA (deoxyribonuclei c acids) and other naturally occurring polymers	**DNA (deoxyribonucleic acid)** is a large molecule essential for life. DNA encodes **genetic instructions** for the development and functioning of living organisms and viruses. Most DNA molecules are two polymer chains, made from **four different monomers** called **nucleotides,** in the form of a **double helix.** Other naturally occurring polymers important for life include

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	Proteins (made from amino acids), starch (made from glucose monomers) and cellulose (made from glucose monomers).