Unit 2: Carbon Compounds

(a)Fuels

(i) Combustion

- A fuel is a chemical which is burned to produce energy.
- Combustion is another word for burning.
- When a substance burns it reacts with oxygen.
- The chemical compounds which are found in oil and natural gas are mainly hydrocarbons.
- A hydrocarbon is a compound which contains hydrogen and carbon only.
- Hydrocarbons burn in a plentiful supply of air to produce carbon dioxide and water.
- The test for carbon dioxide is that it turns lime water milky.
- Carbon, and carbon monoxide, a poisonous gas, are produced when the hydrocarbons burn in a supply of oxygen which is insufficient for complete combustion.
- Nitrogen and oxygen from the air react inside a petrol engine to form nitrogen oxides which are poisonous gases.
- The burning of some fuels releases sulphur dioxide, a poisonous gas, into the atmosphere.
- Soot particles produced by the incomplete combustion of diesel are harmful.
- Air pollution from the combustion of hydrocarbons can be reduced by the use of catalytic converters which speed up the conversion of pollutant gases to harmless gases.

(ii) Fractional distillation

- Crude oil is a mixture of chemical compounds, mainly hydrocarbons.
- Fractional distillation is the process used to separate crude oil into fractions according to the boiling points of the components of the fractions.
- A fraction is a group of hydrocarbons with boiling points within a given range.
- Ease of evaporation, viscosity, flammability and boiling point range of the fractions are properties related to molecular sizes of the molecules within the fractions.
- The uses of the fractions are related to the ease of evaporation, viscosity, flammability and boiling point range of the fractions.

b) Nomenclature and structural formulae

(i) Hydrocarbons

- The alkanes are a subset of the set of hydrocarbons.
- An alkane can be identified from the '-ane' ending.
- Straight-chain alkanes can be named from molecular formulae, shortened and full structural formulae (only C_1 to C_8).
- Molecular formulae can be written and shortened and full structural formulae can be drawn, given the names of straight-chain alkanes (only C_1 to C_8).
- Branched-chain alkanes can be systematically named from shortened and full structural formulae (only C_4 to C_8).
- Molecular formulae can be written and shortened and full structural formulae can be drawn, given the systematic names of branched-chain alkanes (only C_4 to C_8).
- The alkenes are a subset of the set of hydrocarbons.
- An alkene can be identified from the carbon to carbon double bond and the '-ene' ending.
- Straight-chain alkenes can be named, incorporating the position of the double bond, from shortened and full structural formulae (only C_2 to C_8).

- Molecular formulae can be written and shortened and full structural formulae can be drawn, given the names of alkenes (only C_2 to C_8).
- The cycloalkanes are a subset of the set of hydrocarbons.
- A cycloalkane can be identified from the name.
- Cycloalkanes can be named from molecular formulae, shortened and full structural formulae (only C_3 to C_8; isomers are not required, eg only cyclohexane is expected, not methylcyclopentane).
- Molecular formulae can be written and shortened and full structural formulae can be drawn, given the names of cycloalkanes (only C_3 to C_8).
- A homologous series is a set of compounds with the same general formula and similar chemical properties.

(ii) Isomers

- Isomers are compounds with the same molecular formulae but different structural formulae.
- Isomers can be drawn for given molecular formulae, shortened and full structural formulae.
- The alkenes are a subset of the set of hydrocarbons.
- An alkene can be identified from the carbon to carbon double bond and the '-ene' ending.
- Straight-chain alkenes can be named, incorporating the position of the double bond, from shortened and full structural formulae (only C_2 to C_8).
- Molecular formulae can be written and shortened and full structural formulae can be drawn, given the names of alkenes (only C_2 to C_8).
- The cycloalkanes are a subset of the set of hydrocarbons.
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- Isomers are compounds with the same molecular formulae but different structural formulae.
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c) Reactions of carbon compounds

(i) Addition reactions

- The alkanes and the cycloalkanes are saturated hydrocarbons.
- Saturated hydrocarbons contain only carbon to carbon single covalent bonds.
- The alkenes are unsaturated hydrocarbons.
- Unsaturated hydrocarbons contain at least one carbon to carbon double covalent bond.

- It is possible to distinguish an unsaturated hydrocarbon from a saturated hydrocarbon using bromine solution.
- An alkene reacts with hydrogen to form the corresponding alkane.
- The reactions of an alkene with bromine, hydrogen and water are addition reactions.

(ii) Cracking

- Fractional distillation of crude oil yields more long-chain hydrocarbons than are useful for present-day industrial purposes.
- Cracking is an industrial method for producing a mixture of smaller, more useful molecules, some of which are unsaturated.
- The catalyst allows the reaction to take place at a lower temperature.
- Cracking can be carried out in the laboratory using an aluminium oxide or silicate catalyst.

(iii) Ethanol

- Ethanol, for alcoholic drinks, can be made by fermentation of glucose derived from any fruit or vegetable.
- An enzyme in yeast acts as a catalyst for the reaction.
- There is a limit to the ethanol concentration of fermentation products.
- Distillation is a method of increasing the ethanol concentration of fermentation products in the manufacture of 'spirit' drinks.
- Alcoholic drinks, if taken in excess, can have damaging affects to health and mind.
- To meet market demand ethanol is made by means other than fermentation.
- Industrial ethanol is manufactured by the catalytic hydration of ethene.
- Ethanol can be converted to ethene by dehydration.
- Ethanol, mixed with petrol, can be used as a fuel for cars.
- The ethanol is obtained from sugar cane, a renewable source of energy.

(iv) Making and breaking esters

- Esters are formed by the condensation reaction between a carboxylic acid and an alcohol.
- In a condensation reaction, the molecules join together by the reaction of the functional groups to make water.
- The ester link is formed by the reaction of a hydroxyl group with a carboxyl group.
- The parent carboxylic acid and the parent alcohol can be obtained by hydrolysis of an ester.
- The formation and hydrolysis of an ester is a reversible reaction.

d) Plastics and synthetic fibres

(i) Uses

- Synthetic materials are made by the chemical industry.
- Most plastics and synthetic fibres are made from chemicals derived from oil.
- Examples of plastics include polythene, polystyrene, perspex, PVC, nylon, bakelite, formica and silicones.
- Kevlar, which is very strong, and poly(ethenol), which readily dissolves in water, are recently developed plastics.
- The everyday uses of plastics are related to their properties.

- Examples of synthetic fibres include polyesters, eg Terylene, and nylon.
- For some uses, synthetic materials have advantages over natural materials and vice versa.
- Biopol is a recently developed degradable plastic.
- Most plastics are not biodegradable and their low density and durability can cause environmental problems.
- Some plastics burn or smoulder to give off toxic fumes, including carbon monoxide.
- The toxic gases given off during burning or smouldering can be related to the elements present in the plastic.
- Plastics can be either thermoplastic or thermosetting.
- A thermoplastic is one which can be reshaped on heating.
- A thermosetting plastic cannot be reshaped by heating.

(ii) Addition polymerisation

- Plastics are made up of long chain molecules called polymers.
- Polymer molecules are made from many small molecules called monomers.
- Addition polymers are made from small unsaturated molecules produced by cracking by a process called addition polymerisation.
- The small unsaturated molecules join together by the opening of the carbon to carbon double bond.
- The name of the addition polymer is related to the name of the monomer.
- The repeating unit or the structure of an addition polymer can be drawn given the monomer structure and vice versa.

(iii) Condensation polymerisation

- Condensation polymers are made from monomers with two functional groups per molecule.
- The repeating unit or the structure of a condensation polymer can be drawn given the monomer structures and vice versa.
- Polyesters are examples of condensation polymers.
- An amine can be identified from the functional group.
- Polyamides are examples of condensation polymers.
- The amide link is formed by the reaction of an amine group with a carboxyl group.

e) Natural products

(i) Carbohydrates

- Carbohydrates form an important class of food made by plants.
- Carbohydrates supply the body with energy.
- Carbohydrates are compounds which contain carbon, hydrogen and oxygen with the hydrogen and oxygen in the ratio of two to one.
- Carbohydrates can be divided into sugars and starches.
- Examples of sugars include glucose, fructose, maltose and sucrose (table sugar).
- Most sugars can be detected by the Benedict's test; sucrose is an exception.
- Starch can be distinguished from other carbohydrates by the iodine test.
- Sugars are carbohydrates with small molecules.
- Starch is a natural condensation polymer made of many glucose molecules linked together.
- Plants convert the glucose into starch for storing energy.

- During digestion starch is hydrolysed to glucose which is carried by the blood stream to body cells.
- Starch can be hydrolysed by acid and by enzymes.
- Body enzymes function best at body temperature and are destroyed at higher temperature.

(ii) Proteins

- Proteins form an important class of food made by plants.
- Proteins are the major structural materials of animal tissue and are involved in the maintenance and regulation of life processes and include enzymes, many hormones, eg insulin and haemoglobin.
- Proteins are condensation polymers made of many amino acid molecules linked together.
- The structure of a section of protein is based on the constituent amino acids.
- Condensation of amino acids produces the peptide (amide) link.
- The peptide link is formed by the reaction of an amine group with a carboxyl group.
- Proteins specific to the body's needs are built up within the body.
- During digestion enzyme hydrolysis of dietary proteins produces amino acids.
- The structural formulae of amino acids obtained from the hydrolysis of proteins can be identified from the structure of a section of the protein.

(iii) Fats and oils

- Natural fats and oils can be classified according to their origin as animal, vegetable or marine.
- The lower melting points of oils compared to those of fats is related to the higher unsaturation of oil molecules.
- The conversion of oils into hardened fats involves the partial removal of unsaturation by addition of hydrogen.
- Fats and oils in the diet supply the body with energy and are a more concentrated source of energy than carbohydrates.
- Fats and oils are esters.
- The hydrolysis of fats and oils produces fatty acids and glycerol in the ratio of three moles of fatty acid to one mole of glycerol.
- Fatty acids are saturated or unsaturated straight chain carboxylic acids, usually with long chains of carbon atoms.