The Variety of Organic Chemicals

- Organic chemistry is the study of organic compounds: carbon compounds that originate in living things

Homologous series

Their similarities	Their differences
• The same general formula • The same functional group • Similar chemical properties	• Different chain lengths • Different physical properties

Homologous series	General formula	Functional group	Chemical properties
Alkanes	C_nH_{2n+2}		All are generally unreactive
Alkenes	C_nH_{2n}		All react with bromine
Alcohols	$C_nH_{2n+1}OH$		All react with sodium
Carboxylic acids	$C_nH_{2n}O_2$		All are acidic, neutralized by sodium hydroxide

Structural isomers

- Structural isomers are compounds with the same formula, but a different arrangement of atoms.

Alkanes

- Alkanes are hydrocarbons which only have a single covalent bonds in their structure.
- We call them saturated hydrocarbons because no more atoms can be added to their molecules

Physical properties of the alkanes

- All alkanes are colorless gases, liquids or solids
- The first four member of the alkane homologous series are gases at r.t.p.
- Alkanes with 5 to 17 carbon atoms in their chains are liquids
- Alkanes with more than 17 carbon atoms in their chains are solids
- The boiling points of the alkanes vary in a regular way
- You can see as the carbon chains get longer, the boiling points of the alkanes increase
- The difference in the boiling point from one alkane to the next also gets smaller as the number of carbon atoms increases

Chemical properties of the alkanes

- Alkanes are generally unreactive compounds
- They do not react with acids or alkalis
- They do burn and undergo a few reactions under special conditions
- Alkanes burn with a clean blue flame if there is plenty of oxygen or air present
- We describe this reaction as complete combustion
- Carbon dioxide and water are formed

They burn in air	
Type of Reaction	Combustion
Reactants	Alkane + plenty of oxygen for complete combustion
What else is required	Flame to ignite the fuel
What is produced	Carbon dioxide + water + plenty of heat

<u>The reactions of alkanes with chlorine</u>

- One chemical that alkanes will react with is chlorine-but only under certain conditions
- Alkanes do not react with chlorine in the dark
- However, if we mix chlorine with an alkane in a sealed tube and keep it in bright sunlight, the green color of chlorine disappears
- This is a photochemical reaction
- We call this type of reaction a substitution reaction
- You will notice that the acidic gas hydrogen chloride is produced. This turns damp blue litmus paper red
- If we use excess chlorine we can substitute more hydrogen atoms
- If enough chlorine is present all hydrogen atoms can be replaced by chlorine atoms
- We can carry out similar reactions with alkanes and other halogens

Reaction with chlorine	
Type of reaction	Substitution (one or more hydrogen atoms are replaced by chlorine)
Reactant	Alkane + chlorine gas
What else is required	UV light- this is a photochemical reaction
What is produced	Hydrogen chloride + chloroalkanes

<u>Cracking alkanes</u>

- Cracking is the thermal decomposition of alkanes
- Alkenes are obtained from alkanes by a process called cracking
- Cracking involves heating vaporized alkanes in the presence of a catalyst
- Cracking breaks down molecules into smaller ones
- Cracking always produces some molecules with double bonds: alkenes
- Longer chained alkanes are cracked to form a mixture of shorter-chained alkanes and alkenes

<u>Cracking petroleum fractions on a large scale</u>

- Cracking is often carried out on a large scale using a catalyst
- The huge tank where this takes place is called a catalytic (cat) cracker
- The vapor from the gas-oil or kerosene fractions is passed through a catalyst of silicon (IV) oxide and aluminum oxide at 400-500°C
- The catalyst is a fine powder which has to be continuously recycles to the cat cracker through a regenerator tank
- This frees the catalyst from any carbon deposited on its surface

The longer-chained alkanes in the gas-oil or kerosene fractions which are less useful are broken down to shorter chained hydrocarbons:

- The shorter-chained alkanes are used for petrol and very small alkanes are used for fuel
- The alkenes can be used to make a wide variety of chemicals, including plastics
- Hydrogen may also be formed which can be used for making ammonia or as a fuel

Catalytic cracking is not the only type of cracking.

- Long chained alkanes can be cracked at a high temperature without a catalyst
- A temperature between 450°C and 800°C is used
- This type of cracking produces a greater percentage if alkenes

<u>Alkenes</u>

- Alkenes are a homologous series of hydrocarbons whose names end in –ene
- We call them unsaturated hydrocarbons because they have a double carbon bond
- They do not have the maximum number of hydrogen atoms around each carbon atom
- More atoms can be added to their molecules
- We can test to see if a hydrocarbon is unsaturated by using aqueous bromine
- Bromine water is a yellow/orange color
- If the bromine water is decolorized, the hydrocarbon in unsaturated
- All alkenes decolorize bromine water
- If the bromine water remains the same yellow/orange color, the hydrocarbon is saturated

<u>Chemical properties of the alkenes</u>

<u>Combustion</u>

- The complete combustion of alkenes produces carbon dioxide and water

<u>Addition reactions</u>

- Many of the reactions of alkenes are called addition reactions
- In an addition reaction, two reactants add together to form only one product

Hydrogen reacts with alkenes to form alkanes

- This addition reaction is also called a hydrogenation reaction
- It can also be classed as a reduction reaction
- The reaction is carried out at 60°C with nickel as a catalyst
- This type of reaction is used to male margarine from unsaturated vegetable oils
- Only some of the double bonds in the vegetable oil are changed to single bonds
- This is enough to harden the oil and make it into solid margarine

Steam reacts with alkenes to form alcohols

- A high temperature 300°C, and high pressure 700 atms is needed for these reactions
- The steam is passed over a catalyst of phosphoric acid
- This method gives a good yield of alcohol
- Ethanol of high purity is made by this method

Alcohols

- Alcohols are a homologous series having –OH as the functional group
- Their names all end with –ol
- Ethanol is a colorless liquid that boils at about 78°C
- It is miscible with water
- Ethanol can by manufactured from:

Fermentation of glucose

- During fermentation, the enzymes in living yeast cells catalyze the breakdown of glucose into ethanol and carbon dioxide
- Fermentation is an exothermic reaction- heat is released
- The ethanol is separated from the mixture by fractional distillation
- Fermentation is used to make ethanol from corn, wine and grapes. When the % of ethanol reaches a certain level, or if the liquid gets too warm, the yeast stops working

By hydration of ethene-the chemical way

- The reaction is called a hydration because water molecules adds on to the ethene
- There is no other product- so this is an addition reaction
- A catalyst is needed, to speed up the reaction
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- It is a reversible reaction, and high pressure improves the yield of ethanol
- The hydration is exothermic- heat is released
- A low temperature will improve the yield, but the reaction will be too slow- so 570°C is chosen as a compromise

Uses of ethanol

- As a solvent: ethanol is used in perfumes and other cosmetics, in printing inks and glues
- As a fuel: ethanol can be mixed with petrol or used alone as a fuel for cars. It is less polluting than petrol and reduces the reliance on petrol and diesel
- It is used to male other chemicals such as esters which are used in food flavorings and in many cosmetics
- In some cultures the ethanol produced by fermentation is used for making alcoholic drinks

Ethanol to ethanoic acid

Oxidation/Fermentation in the air:

- Acetobacter is a group of bacteria that causes wine to go sour
- These bacteria are naturally present in air and the surfaces around us
- When we leave a solution of ethanol exposed to the air, enzymes from the bacterium speed up the conversion of ethanol to ethanoic acid
- The reaction does not take place in the absence of oxygen
- This reaction makes vinegar
- Vinegar is a solution of ethanoic acid

Acidified potassium manganate (VII)

- Potassium manganate (VII) is a good oxidant, especially when sulfuric acid is added
- We heat the ethanol with potassium manganate (VII) and sulfuric acid
- We do this in a flask with a condenser in an upright position
- We call this refluxing
- This prevents alcohol which is very volatile from escaping
- Other alcohols can be oxidized in the same way
- The manganate (VII) ions are reduced, which produces a color change

Potassium dichromate (VI)

- Ethanol is oxidized by potassium dichromate (VI) another powerful oxidizing agent
- There is a color change when the chromate (VI) ions are reduced
- Potassium dichromate is used in one type of breathalyzer
- It oxidizes any alcohol on a person's breath and it itself reduced, changing color from orange to green

Carboxylic acids

- The carboxylic acids are a homologous series with –COOH as the functional group
- Their names all end in –ioc acid

Chemical properties of carboxylic acid

- Carboxylic acids are typical weak acids
- They are only partly ionized in water
- The hydrogen of the –COOH group is the only one that is responsible for the acidity of carboxylic acids
- Salts of ethanoic acid are named by changing the –oic to the –oate
- They react with metals to form a salt and hydrogen
- They react with alkalis to form a salt and water
- They react with metal carbonates to form a salt, water and carbon dioxide

Esters

- Ethanoic acid reacts with alcohols to form compound called esters
- The functional group is circled. It is called the ester linkage
- Many esters have distinctive tastes and smells so they are used as artificial flavorings and fragrances