GCE 'O' Level Chemistry Revision

Chapter 1 – Kinetic Particle Theory

Gases

Gases are easily compressed as the volume of gas particles is negligible compared to the volume occupied by the gas.

Chapter 2 – Measurement and Experimental Techniques

Apparatuses for Measurement

The accuracies of apparatuses used for measurement in ascending order are beaker, graduated measuring cylinder, burette then pipette.

Collection of Gases

The collection of poisonous gases (e.g. chlorine) when carrying out downward delivery should be carried out in a fume cupboard.

Method	Suitability	Examples
	• Incoluble or clightly	Hydrogen
Displacement of water		Carbon dioxide
		Oxygen
Downward dolivory	Soluble in water	Hydrogen chloride
Downward delivery	Denser than air	Chlorine
Lloward dolivory	Soluble in water	• Ammonia
	Less dense than air	

Drying of Gases

We can dry a gas by passing it through a drying agent. Using conc. sulfuric acid to dry ammonia is unsuitable as the sulfuric acid will react with the ammonia to produce ammonium sulfate.

Drying agent	Suitability and examples
Conc. sulfuric acid	 Most gases
Quicklime	Ammonia
Calcium chloride	Most gases

Chapter 3 – Separation and Purification

Desert Survival Kit

The desert survival kit question makes use of distillation.



Chapter 6 – Ionic Bonding

lonic bonding is between metallic and non-metallic elements and it refers to the transfer of electrons from one element to another. Ionic compounds are solids at room temperature.

Melting and Boiling Points

lonic compounds have high melting and boiling points. Strong electrostatic forces between the positive and negative ions which are arranged in a giant crystal lattice. It requires much energy in order to separate the ions.



Electrical Conductivity

Solid ionic compounds do not conduct electricity since the ions are held firmly in place, indicating the absence of free-moving ions to conduct electricity.

lonic compounds only conduct electricity when dissolved in a solution or in the molten state. When an ionic compound melts or when it's dissolved in a solution, the charged ions are free to move. When an electric current passes through, solutions of ionic compounds can be decomposed into their individual elements.

Chapter 7 – Covalent and Metallic Bonding

Covalent Bonding

Covalent bonding is between non-metallic and non-metallic elements and it refers to the sharing of electrons between elements. Covalent compounds are usually gaseous or liquids at room temperature.

Diamond – Melting and Boiling Points

Diamond has high melting and boiling points. 1 carbon atom is bonded to 4 other carbon atoms, making it having a tetrahedral structure. Much energy is required in order to separate the atoms which are connected by strong covalent bonds. Since diamond contains many covalent bonds, it has a high melting and boiling point.



Diamond – Electrical Conductivity

Diamond does not conduct electricity. Since all the electrons in carbon are used up in bonding, there is no presence of free-moving ions to conduct electricity.

Silicon(IV) Dioxide

Silicon(IV) dioxide has a structure similar to diamond.

Graphite – Melting and Boiling Points

Graphite has high melting and boiling points. 1 carbon atom is bonded to 3 other carbon atoms, making it having a hexagonal structure. Like diamond, graphite has strong covalent bonds connected between the atoms and since there are many bonds, much energy is required to separate the atoms.



Graphite can conduct electricity since 1 carbon atom is bonded to 3 other carbon atoms, graphite has delocalised electrons which carry the charges from place to place and allowing it to conduct electricity.



Graphite – Being Slippery

Graphite contains layers of carbon atoms and these layers are held by weak intermolecular forces. The layers slide over each other very easily, making graphite slippery.

Metallic Bonding

Metallic bonding is between metallic and metallic elements. Metals have free-moving electrons in their outer shells which form a sea of delocalised electrons around the closely-packed positive ions. These electrons carry electric charges, which explains why metals can conduct electricity. When an electric current passes through a metal, the metal will not decompose.



Metallic Bonding – Melting and Boiling Points

Compounds which consist of metallic bonds have high melting and boiling points. There are strong electrostatic forces between the positive and negative ions holding the particles together. It requires much energy to separate the particles. When electricity is passed through a compound consisting of metallic bonds, the electrons will be disrupted and will return to their original positions.

Chapter 11 – Acids and Bases

Types of Oxides

Most oxides can be grouped into four types: acidic oxides, basic oxides, amphoteric oxides and neutral oxides.

	Acidic oxides	Basic oxides	Amphoteric oxides	Neutral oxides
React with acid?	No	Yes	Yes	No
React with alkali?	Yes	No	103	
Examples	CO ₂ , SiO ₂	Na ₂ O, K ₂ O	Al ₂ O ₃ , PbO	CO, H2O

When passed through powdered calcium carbonate, carbon monoxide will not be removed. However, oxides such as sulfur dioxide are removed. The reason is that calcium carbonate is basic and it reacts with acidic gases. Since carbon monoxide is a neutral gas, it will not react with calcium carbonate.

Chapter 12 – Salts

Preparation of Salts

We can prepare salts 3 ways.

- Reaction of an acid with a metal, insoluble base or carbonate
- Titration
- Precipitation

	Reaction of an acid with a metal, insoluble base or carbonate	Titration	Precipitation
Example of salt	Copper(II) sulfate	Sodium chloride	Barium sulfate
Starting materials (i.e.)	Copper(II) oxide, sulfuric acid	Sodium hydroxide, hydrochloric acid	Barium nitrate, sodium sulfate
Steps	 Filter the mixture. Collect the filtrate. Crystallise the filtrate. Filter to obtain the salt crystals. 	 Crystallise the salt solution. Filter to obtain the salt crystals. 	 Filter the mixture.

Preparation of Copper(II) Sulfate

Fill a beaker with dilute sulfuric acid. Stir and add excess copper(II) oxide powder until no more reaction occurs with the acid. Filter to remove the excess copper(II) oxide powder. Collect the filtrate. This is the copper(II) sulfate solution. Heat till the filtrate becomes saturated. Allow the saturated solution to cool so that the salt can crystallise. Filter to collect the crystals. Wash the crystals with a little cold water to remove any impurities. Dry the crystals between 2 sheets of filter paper.

Preparation of Sodium Chloride

Fill a burette with dilute hydrochloric acid. Note the initial burette reading (V₁ cm³). Pipette 25.0cm³ of sodium hydroxide solution into a conical flask. Add 1 or 2 drops of methyl orange indicator to the sodium hydroxide solution. The solution turns yellow. Swirl the conical flask while adding hydrochloric acid from the burette slowly until the solution turns orange permanently. This is the end-point. Record the final burette reading (V₂ – V₁ cm³).

To obtain a pure sample of sodium chloride, pipette 25.0 cm³ of sodium hydroxide solution into a conical flask. Dispense V₂ – V₁ cm³ of hydrochloric acid from the burette. Do not add the indicator as it will make the salt impure. Heat the solution until it is saturated. Allow the saturated solution to cool so that the salt can crystallise. Filter to collect the crystals. Wash the crystals with a little cold water to remove any impurities. Dry the crystals between 2 sheets of filter paper.

The substances in the conical flask and the burette can be swapped (i.e. you can fill the burette with sodium hydroxide and the conical flask with hydrochloric acid).

Methyl Orange Colour Change

Acidic	Neutral	Alkaline
Yellow	Orange	Red

Preparing Barium Sulfate

Pour barium nitrate solution into a small beaker. Add excess sodium sulfate solution and stir until no more precipitate forms. Filter to collect the precipitate. Wash the precipitate with distilled water to remove impurities. Allow the precipitate to dry on a piece of filter paper.

Nitrate Salts

Nitrate salts cannot be used in a reaction to prepare another salt since all nitrates are soluble.

Qualitative Analysis

Concepts are test for cations, test for anions and test for gases.

Identifying Cations

The tests for lead and aluminium ions result in the same observations. We do not carry out tests for lead in the laboratory since lead is a toxic substance.

	Aq. sodium hydroxide		Aq. ammonia	
	Few drops	Excess	Few drops	Excess
		Precipitate dissolves		Precipitate dissolves
Zinc	White ppt.	in excess, forms	White ppt.	in excess, forms
		colourless solution		colourless solution
Aluminium	White ppt	Insoluble in excess	White ppt	Insoluble in excess
Lead	white ppt.		white ppt.	

Identifying Anions

The solubility rules for salts are very important in the test for anions. When asked for the purpose of adding dilute nitric acid in the tests for sulfates, chlorides and iodides, the reason is to remove any carbonate in the solution to prevent false results.

As barium sulfate and silver halides are insoluble, it accounts for the reason that precipitates are formed in the test for sulfates, chlorides and iodides.

Anion	Test		Observations and inference
	Add dilute acid. Deep the		Effervescence is observed.
Carbonate	as given off into	•	Gas given off forms a white ppt. in limewater.
Carbonate	limewater		Ppt. is soluble in excess.
		•	Carbon dioxide gas is liberated.
	Add aq. sodium hydroxide,		
	then a piece of aluminium	•	Effervescence is observed.
Nitrate	foil. Warm the mixture.	•	The moist red litmus paper turns blue.
	Test the gas with a piece	•	Gas is ammonia.
	of damp red litmus paper.		
Sulfate	Add dilute nitric acid, then	•	White ppt, formed (barium sulfate)
Ounate	barium nitrate solution.	•	White ppt. formed (bandin suitate)
Chloride	Add dilute nitric acid, then	•	White ppt. formed (silver chloride)
lodide	silver nitrate solution.	•	Yellow ppt. formed (silver iodide)

Chapter 13 – Oxidation and Reduction

Redox Reactions and Disproportionation Reactions

A redox reaction is a type of chemical reaction that involves a transfer of electrons between two substances. All neutralisation reactions are redox reactions.

When the same element is both oxidised and reduced, the reaction is known as a disproportionation reaction.

Oxidising and Reducing Agents

An oxidising agent is a substance that causes another substance to be oxidised. A reducing agent is a substance that causes another substance to be reduced. Potassium iodide is a reducing agent and KMnO₄ is an oxidising agent.

Test for an Oxidising Agent

Test	Observation
Add KI (aq.)	Brown solution formed.
Dip a piece of starch-iodide paper	Starch-iodide paper turns from white to blue.

Test for a Reducing Agent

Test	Observation
Add acidified KMnO ₄	Colour of the KMnO ₄ solution changes from purple to colourless.

Chapter 14 – Metals

Pure Metals

Pure metals are not widely used in industries as they are soft. In a pure metal, the atoms are packed regularly in layers. The layers of atoms can slide over one another easily when a force is applied. Moreover, pure metals may react with air and water and wear away or corrode easily.

Alloys

An alloy is a mixture of a metal with one or a few other elements. Alloys are stronger and harder than their constituent metals because in an alloy, the atoms of the different metals or elements have different sizes. The regular arrangement of atoms in the pure metal is disrupted. The atoms of different sizes cannot slide over one another easily when a force is applied.

Malleability and Ductility

Metals are both malleable and ductile. This means that they can be hammered into different shapes (malleable) and drawn into wires without breaking (ductile). When a force is applied to a metal, the layers of metal atoms can slide over one another through the sea of electrons. The metallic bonding is undisrupted.



Reactivity Series

In the experiment shown above, steam is passed over a heated metal sample. Hydrogen gas is collected. Reactive metals react with cold water or steam to produce hydrogen gas. A possible option for the metal sample is zinc as it is moderately reactive. It reacts with steam to form zinc oxide and hydrogen.

To obtain the most vigorous reaction from a metal and metal oxide reaction, one must react a very reactive metal with an unreactive metal oxide.

Summary of Reactions

In this section, we will study the reactions of metals with cold water, steam, dilute hydrochloric acid and metallic oxides. Some metal oxides can also be reduced by carbon and hydrogen. Heat can decompose the metal carbonate as well.

Cold Water and Steam

Zinc and iron cannot react with cold water. However, hot zinc reacts readily with steam to produce zinc oxide and hydrogen gas. Red-hot iron reacts slowly with steam to form iron oxide (Fe_3O_4) and hydrogen gas.

Hydrochloric Acid

No reaction takes place for lead, copper and silver. Lead does not appear to react with hydrochloric acid since it forms an insoluble layer of lead(II) chloride.

Carbon, Hydrogen and Carbonate

The more reactive a metal is, the more difficult it is to reduce its oxide to the metal by carbon/hydrogen/decompose its carbonate by heat.

The oxides of reactive metals are very thermally stable, they do not decompose easily.

Extracting Metals

There are 3 main stages involved in obtaining metals from their ores:

- **Concentrating the metal ore:** Earth and rock are removed before the metal is extracted from the ore. This results in a metal ore that contains little waste materials.
- **Extracting crude metal from the ore:** Depending on the position of the metal in the reactivity series, the metal is extracted by reduction with carbon or using electricity.
- **Refining crude metal:** Generally, electrolysis is used.

The Blast Furnace – Extracting Iron from Haematite

Haematite contains iron(III) oxide mixed with impurities like sand and clay. Iron is extracted from haematite in a blast furnace. Haematite (iron(III) oxide), coke (carbon) and limestone (calcium carbonate) are added at the top of the blast furnace. Blasts of hot air are blown into the furnace near the bottom.



The following reactions take place in sequence:

Carbon dioxide is produced.

The carbon in coke burns in a blast of hot air to produce carbon dioxide. This reaction is highly exothermic.

Carbon + oxygen \rightarrow carbon dioxide

Carbon monoxide is produced.

As the carbon dioxide rises up the furnace, it reacts with coke to produce carbon monoxide. This reaction is also highly exothermic.

Carbon + carbon dioxide \rightarrow carbon monoxide

Haematite is reduced to iron.

The carbon monoxide formed acts as a reducing agent as iron(III) oxide gets reduced to iron. The product iron is molten and it runs to the bottom of the furnace.

Iron(III) oxide + carbon monoxide \rightarrow carbon dioxide + iron

Impurities are removed.

Limestone is decomposed by heat to produce carbon dioxide and quicklime. This process is known as thermal decomposition.

Calcium carbonate \rightarrow carbon dioxide + calcium oxide

Some lime compounds are listed below.

Chemical name	Lime type
Calcium carbonate	Limestone, chalk
Calcium hydroxide	Slaked lime
Calcium oxide	Quicklime

10

As calcium oxide is a basic oxide, it reacts with silicon dioxide which is acidic and other impurities in haematite to form molten slag. The molten slag runs to the bottom of the furnace. It floats on top of the molten iron. Silicon dioxide is also known as silica. Calcium oxide + silicon dioxide \rightarrow calcium silicate

Hot waste gases like carbon monoxide, carbon dioxide and nitrogen escape through the top of the furnace. The only gases which react with the reactants in the blast furnace are carbon monoxide, carbon dioxide and oxygen. Nitrogen is not involved in any reaction.

Steel

Mild steel is hard, strong and malleable as its composition of carbon is little. However, when the composition of carbon increases, it becomes high-carbon steel. High-carbon steel is strong but brittle.

Chemical name	Alternative name
Iron(III) oxide	Haematite
Silicon dioxide	Silica
Calcium silicate	Slag

Chapter 15 – Electrolysis

A useful acronym is **AOCR (anode oxidation, cathode reduction)**. Recall that oxidation is the loss of electrons and reduction is the gain of electrons. Inert electrodes consist of carbon/graphite and platinum whereas reactive electrodes consist of copper.

Electrolysis of Molten Compounds

A binary compound consists of only 2 elements, usually a metal cation and a non-metal anion. We will conduct a case study of the electrolysis of molten sodium chloride in the next section.

Electrolysis of Molten Sodium Chloride In the electrolysis of molten sodium chloride, the only ions present are Na⁺ and Cl⁻.

The state symbol is (*l*) since we are referring to molten sodium chloride.

Anode	Cathode
Chlorine gas	Molten sodium



Electrolysis of Aqueous Solutions of Compounds

We will investigate how the reactivity series affects the selective discharge of cations and anions, as well as how concentration affects the selective discharge of anions.

Electrolysis of Dilute Sodium Chloride Solution The ions present in this solution are sodium, Oxygen chloride, hydrogen and hydroxide.

The ratio of the volume of hydrogen gas to oxygen gas collected is 2:1. They are gases so the molar volume is the same.

Since oxygen is soluble, some oxygen dissolves into the solution so less oxygen gas is collected. The ratio of hydrogen to oxygen gas collected increases. However, after the electrolysis has been running some time, the



solution becomes saturated with dissolved oxygen. The oxygen gas can no longer dissolve in the solution and is collected as a gas.

This process is known as they electrolysis of water. Water is gradually removed from the solution and the concentration of sodium chloride solution gradually increases.

Anode	Cathode	
Oxygen gas, water	Hydrogen gas	

Electrolysis of Concentrated Sodium Chloride Solution

The ions present in this solution are sodium, chloride, hydrogen and hydroxide.

Anode	Cathode	Remaining solution
Chlorine gas	Hydrogen gas	Sodium hydroxide

Electrolysis of Copper(II) Sulfate Solution using Inert Electrodes



The ions present are copper, sulfate, hydrogen and hydroxide.

Anode	Cathode	Remaining solution
Oxygen gas, water	Copper metal	Sulfuric acid

Electrolytic Purification of Copper

Electrolysis of Copper(II) Sulfate using Copper Electrodes

Copper electrodes are reactive electrodes. The ions present in the solution are copper, sulfate, hydrogen and hydroxide. The cathode increases in mass, the anode decreases in mass. The decrease in mass of the anode = the increase in mass of the cathode.

Anode	Cathode	Conc. of CuSO ₄ solution
Copper dissolves to form Cu ²⁺ ions	Copper metal is formed	Unchanged

Refining Copper by Electrolysis

Similar. The impure copper at the anode slowly dissolves and decreases in mass. It falls to the bottom of the trough containing the electrolyte as anode sludge. A pure layer of copper is deposited on the cathode.

Electroplating

Electroplating is an application of electrolysis. The following are some reasons why we electroplate:

- To make a metal object look more expensive/give a decorative finish
- To prevent rusting



At the cathode, we place the object which we want to

electroplate. The anode will be the pure metal electrode. Electrons travel from the negative to the positive terminal. The silver anode undergoes reduction and the silver ions are deposited into the electrolyte. The travel to the wire and silver metal is deposited onto the surface of the teapot.

Simple Cells

A simple cell is a device which converts chemical energy to electrical energy. The further apart the 2 metals are in the reactivity series, the greater the voltage produced in the cell.

Zinc-Copper Cell with Copper(II) Sulfate Solution

Zinc is more reactive than copper. Electrons will flow through the wire from the zinc electrode to the copper electrode. The direction of conventional current is in the opposite. At the zinc electrode, the zinc atoms give up electrons to form zinc ions. At the copper electrode, copper(II) ions receive electrons from the solution to form copper.

Chapter 16 – The Periodic Table

Group I Elements – Alkali Metals

Down the group, the:

- Melting and boiling points decrease
- Reactivity increases
- Densities increases

Group VII Elements – Halogens

Down the group, the:

- Melting and boiling points increase
- Reactivity decreases
- Appearance of the elements becomes darker

Displacement of Halogens from its Aqueous Solution

A more reactive halogen will displace a less reactive halogen from its halide solution. This only applies to aqueous compounds. It will not work on solids. For example, when aqueous chlorine is added to sodium bromide (aq.), sodium chloride (aq.) and aqueous bromine are formed.

Transition Metals

Transition metals have the following properties:

- High melting and boiling points and high densities
- Have variable oxidation states
- Form coloured compounds

For example, manganese, a transition metal, can have variable oxidation states. In manganese(IV) oxide, the oxidation state of it is +4 but in potassium permanganate, the oxidation of it is +7.

It is good to know the colours of some coloured compounds. As such, here's a table for reference.

Name	Colour	Remarks
Copper(II) oxide	Black	
Copper(I) oxide	Red	
Copper(II) hydroxide/sulfate/nitrate	Blue	Copper(II) sulfate is white when anhydrous.
Copper(II) carbonate	Green	
Iron(II) sulfate	Oreen	
Iron(III) chloride	Yellow	
Potassium dichromate(VI)	Orange	
Potassium permanganate	Purple	
Potassium dichromate	Orange, green when reduced	
Zinc oxide	White when cooled, yellow when heated	

Chapter 17 – Energy Changes

Summary of Endothermic and Exothermic Changes

	Endothermic changes		Exothermic changes
•	Heat taken in from surroundings	٠	Heat given out to surroundings
•	Enthalpy change is positive	•	Enthalpy change is negative
•	Energy content of reactants is higher than	•	Energy content of reactants is higher than
	that of the products		that of the products

Activation Energy

Activation energy is the minimum amount of energy that reactant particles must possess in order for a chemical reaction to occur. Catalysts are used to lower the activation energy to speed up the reaction.

Combustion of Fuels

Most fuels contain carbon and hydrogen. When these fuels burn, carbon dioxide, water vapour and heat energy are produced. Combustion equations can be represented by hydrocarbon/fuel + oxygen \rightarrow carbon dioxide + water vapour. The state symbol for the water vapour is (g).

If a limited supply of air is used, carbon particles (in the form of soot) and carbon monoxide are produced. This is known as incomplete combustion. As all combustion reactions give off heat energy, combustion is an exothermic process.

When Bunsen burners emit a yellowish-orange flame, it implies that the air hole is closed, limiting the oxygen supply for burning. As such, soot is produced. Opening the air hole allows more oxygen to enter, ensuring that complete combustion takes place.

Fuel Cells

A chemical cell in which reactants are continuously supplied to produce electricity directly is called a fuel cell. There are advantages and disadvantages of using hydrogen as a fuel.

	Advantages	Disadvantages
•	 Hydrogen does not cause pollution. In the combustion of hydrogen, only water is produced. Hydrogen is a renewable source of energy as it can be obtained by electrolysis through the decomposition of water. Hydrogen is an efficient source of energy. When it burns, it releases much more energy compared to other fuels. 	 It is not cheap to obtain hydrogen. One can either obtain it by cracking of petroleum or electrolysis. Hydrogen is extremely flammable and explosive. Hydrogen cannot be stored and used as easily as liquid fuels since it has a low boiling point.

Chapter 18 – Speed of Reaction

Factors affecting the Speed of Reaction

There are different factors which affect the speed of a chemical reaction which are namely:

- Concentration of the reactants
- Pressure (for gaseous reactants)
- Surface area (for solid reactants)
- Temperature
- Presence of a catalyst

Concentration

When the concentration of the reactant is increased, the speed of the reaction increases. This is because at a higher concentration, there are more reactant particles per unit volume. More particles are available to collide with one another, meaning that the collisions become more frequent. As such, the frequency of effective collisions increases.

Pressure

When the pressure of a gaseous reactant is increased, the speed of reaction increases. At a higher pressure, the particles of the gaseous reactants are closer together. The collisions between the particles become more frequent. As a result, the frequency of effective collisions increases and the speed of reaction is higher. Moreover, the concentration of the gaseous reactants will increase.

Surface Area

When the surface area of a solid reactant is increased, the speed of the reaction increased. When a solid reactant is broken up into smaller pieces, its total surface area is increased. The exposed surface area to volume ratio increases, resulting in the collisions between the reacting particles to become more frequent. This increases the frequency of effective collisions, speeding up the reaction.

Temperature

When the temperature of a reactant is increased, the speed of the reaction increases. At higher temperatures, the reactant particles possess more kinetic energy equal to or greater than the activation energy, move faster and collide with one another more often. It results in a higher frequency of effective collisions, speeding up the reaction.

Catalyst

A catalyst is a substance which is used to speed up a chemical reaction but remains chemically unchanged at the end of the reaction. The characteristics are as follows:

- It lowers the activation energy by providing an alternative pathway for the reaction to proceed.
- The physical appearance of a catalyst may change at the end of the reaction (i.e. from a lump of solid to fine particles) but its chemical properties remain unchanged.
- A catalyst is selective in its action.
- Participates in the chemical reaction.

Enzymes are biological catalysts as they catalyse the chemical reactions in plants and animals.

Chapter 19 – Ammonia

When ammonia is converted to nitrogen gas, it undergoes oxidation.

Manufacturing Ammonia by the Haber process

Ammonia is manufactured industrially by the Haber process. The raw materials are nitrogen and hydrogen which are mixed in the ration of 1:3. This ratio is chosen since the percentages by volume match the ratio of the number of moles of gases in the balanced equation to manufacture ammonia from nitrogen and hydrogen. Nitrogen is obtained from the fractional distillation of liquid air and hydrogen is produced from the cracking of petroleum.

Conditions required for the Haber process

Optimal conditions are a temperature of 450°C, a pressure of 250atm and the presence of an iron catalyst.

The higher the pressure, the higher the yield of ammonia. However, maintaining high pressure is costly as expensive equipment is required. The lower the temperature, the higher the yield of ammonia. However, a lower temperature results in a slower speed of reaction. An iron catalyst is used to speed up the reaction.

Displacement of Ammonia from its Salts

The equation is ammonium salt + alkali \rightarrow ammonia + water + salt. For example, when ammonium chloride reacts with sodium hydroxide, the products are ammonia, water and sodium chloride.

Neutralising Acidity in Soils

Calcium hydroxide and quicklime are widely used to neutralise acidity in soil. However, both compounds will react with nitrogenous fertilisers to form ammonia which escapes into the atmosphere. This causes the loss of nitrogen from fertilisers already added to the soil by farmers. Nitrogenous fertilisers and lime should not be added to the soil at the same time.

Chapter 20 – The Atmosphere and Environment

Composition of Air

Air is a mixture of several gases. It contains nitrogen (78%), oxygen (21%) and other gases (1%) which include argon and carbon dioxide. To separate air into its constituent gases, the air is cooled and compressed until liquid air is obtained. The gases are distilled by fractional distillation.

Air Pollution

There are a variety of air pollutants. It is important to understand the **sources** and **effects** of these air pollutants.

	Sources	Properties	Effects
Carbon monoxide	 Incomplete combustion of petrol in car engines. 	Colourless, odourless.	 Talk about carboxyhaemoglobin.
Sulfur dioxide	Fossil fuels, natural gas.Volcanic eruptions.	 Kill bacteria in the preservation of dried fruit. 	Breathing difficulties.Acid rain.
Oxides of nitrogen	 High temperatures in car engines/ factories. Lightning. 		 Similar to sulfur dioxide.
Unburnt hydrocarbons	Car exhaust fumes.		Carcinogenic.
Methane	 Rubbish in landfills. Animal matter decay, cows. 	Colourless, odourless.	Global warming
Ozone	 Unburnt hydrocarbons + nitrogen dioxide under sunlight. 		 Irritates the eyes and lungs. Breathing difficulties.

Case Study of Helium

Helium is an inert gas as it can be found in Group 0 of the periodic table. Since it has a very low density (0.17g/dm³), it can easily rise into the upper atmospheres and escape into outer space. It is extremely low in concentration so this makes it difficult to be recovered.

Some people think that the use of helium to fill party balloons should be discouraged. This will cause more helium to be lost to the atmosphere. As helium cannot be easily recovered, the finite resource of helium will be depleted.

Acid Rain

Sources of acid rain are sulfur dioxide, oxides of nitrogen and carbon monoxide. Sulfur dioxide dissolves in water to form sulfurous acid, which is then oxidised to sulfuric acid. In the presence of oxygen and water, oxides of nitrogen form nitric acid. Carbon dioxide reacts with water to form carbonic acid.

Acid rain reacts with metals and carbonates like marble and limestone. Metal bridges and stone buildings are damaged. It also lowers the pH values of water bodies.

20

Reducing Air Pollution

It is possible to reduce air pollution via 2 means. They are by using catalytic converters and flue gas desulfurisation.

Catalytic converters are made of ceramic-coated with rhodium and platinum catalysts to speed up the reaction. Carbon monoxide is oxidised to carbon dioxide, oxides of nitrogen are reduced to nitrogen and unburnt hydrocarbons are oxidised to carbon dioxide and water.

Flue gas desulfursation (FGD) minimises the effects of sulfur dioxide pollution. In FGD, calcium carbonate plays an important role in reducing the effect of acid rain.

Depletion of the Ozone Layer

Ozone is an allotrope of oxygen. It is a pale blue gas with a pungent odour. Ozone filters out some of the harmful UV radiation from the Sun. However, the ozone layer around the Earth is disappearing quickly mainly due to chlorofluorocarbons (CFCs).

Propellants in aerosols and coolants in refrigerators and air-conditioners release CFCs into the atmosphere. In the presence of UV radiation, CFCs decompose to form chlorine atoms. These chlorine atoms react with ozone molecules in the atmosphere to form chlorine oxide and oxygen, destroying the ozone layer. As a result, harmful UV radiation reaches the Earth via holes in the ozone layer.

Chapter 21 – An Introduction to Organic Chemistry

In summary, here are the list of reactions and their respective conditions.

Homologous Series	Reaction	Conditions
	Combustion	Oxygen
	Substitution	UV light
Alkanes		High temperature
	Catalytic cracking	Aluminium oxide and silicon dioxide
		catalysts
	Combustion	Oxygen
	Hydrogenation	• 200°C
	riyurogenation	Nickel catalyst
	Hydration	• 300°C
Alkenes		• 60atm
		 Phosphoric(V) acid catalyst
	Bromination	Aqueous bromine
	AP	High temperature
		Catalyst
Alcohols	Combustion	Oxygen
Alcohola	Oxidation	Oxygen from oxidising agent
	Reactive metal	
	Carbonate	
Carboxylic acids	Base	
	Enterification (anapial)	Concentrated sulfuric acid catalyst
		High temperature

Petroleum and Natural Gas

Natural gas and petroleum are sources of energy. Petroleum is a naturally occurring mixture of hydrocarbons. Hydrocarbons consist of only carbon and hydrogen. Petroleum must be separated into fractions before it can be useful. It is separated by fractional distillation.

Fractional Distillation of Crude Oil



The process is as follows:

- Heat petroleum \rightarrow vaporisation.
- Vapour passes through fractionating column.
- Vapour cools and condenses.
- Lighter fractions, which have lower BP are collected at the top as gases.
- Heavier fractions, which have higher BP are collected at the bottom.

As the molecular size of the hydrocarbon increases, the following changes take place:

- The flammability of the substance decreases.
- The viscosity of the substance increases.
- The melting and boiling points of the substance increases.

The uses of the different fractions are as follows:

Fraction	Use(s)
Petroleum gas	Fuel for cooking
Petrol/gasoline	Fuel for motorcars
Naptha	Feedstock for making petrochemicals (e.g. plastics)
Kerosene/paraffin	Fuel for aircraft engines
Diesel oil	Fuel for diesel engines in buses, lorries and trains
Lubricating oil	Lubricating machines, making waxes and polishes
Bitumen	Road surfaces, roofing

Chapter 22 – Alkanes and Alkenes

Alkanes

Alkanes are saturated hydrocarbons. As you go down the series, their melting and boiling points increase, they become more viscous and they become less flammable. Alkanes are generally unreactive.

Melting and Boiling Points

As the molecular sizes increase, the melting and boiling points of the alkanes increase. This is because as the sizes of the alkane molecules increase, the forces of attraction between the molecules become stronger.

Viscosity

Alkanes become more viscous as their molecular size increase. This is due to the stronger forces of attraction between the molecules.

Alkanes - Flammability

Alkanes are flammable. As the sizes of the alkane molecules increase, the percentage of carbon in the alkane molecule also increases. They become less flammable.

Alkenes

They go through combustion and addition reactions.

Hydrogenation

At 200°C in the presence of a nickel catalyst, alkenes react with hydrogen to form alkanes. When alkenes undergo hydrogenation, the C=C bond is broken.

Hydration

Alkenes react with steam to produce alcohols. The conditions required are a temperature of 300°C and a pressure of 60atm. The reaction also requires a phosphoric(V) acid catalyst.

Bromination

Bromination is an irreversible reaction.

Catalytic Cracking

We can produce alkenes by catalytic cracking. Cracking refers to the break-down of long-chain hydrocarbons into smaller molecules. During catalytic cracking, the long-chain alkanes produce a mixture of short-chain alkenes and a mixture of short-chain alkanes or hydrogen gas.

Cracking is important. Alkenes are used as starting materials for making ethanol and plastics. It is also used to produce hydrogen. It is an important starting material in the manufacture of ammonia in the Haber process. Cracking is used to produce petrol. Hydrocarbons of higher molecular mass are converted into smaller molecules which are ideal for petrol and refinery gas (high demand).

Importances of cracking:

- Produce short-chain alkenes
- Produce hydrogen
- Produce petrol

Fats and Oils

Some fats and oils are polyunsaturated. This is because their hydrocarbon chains contain more than 1 C=C double bond. Fats are solids at room temperature and pressure. They contain mainly saturated fat molecules. Oils are liquids at room temperature and pressure. They contain a higher percentage of unsaturated fat molecules.

Production of Margarine

Hydrogen is added to vegetable oil. A temperature of 200°C and a nickel catalyst are used. The greater the amount of hydrogen used, the more solid the margarine becomes.

The difference between unsaturated and polyunsaturated is that saturated substances only have 1 C=C bond but polyunsaturated substances have many C=C bonds.

Chapter 23 – Alcohols and Carboxylic Acids

Alcohols

As the molecular size of the alcohol increases, the solubility decreases. The boiling point increases as well. The boiling point increases as the size of the alcohol molecules increase and the forces of attraction between the molecules also increase.

Oxidation

Alcohols can undergo oxidation when heated with an oxidising agent like potassium permanganate. A carboxylic acid and water are formed.

Case Study – Ethanol

Ethanol can be prepared via 2 methods – from ethene or by fermentation.

Producing Ethanol from Ethene

Ethene undergoes hydration and in doing so produces ethanol. Steam is added to ethene. The reaction is carried out at 300°C, 60atm with the addition of a phosphoric(V) acid catalyst.

Ethanol is used in alcoholic drinks, as a solvent in deodorants etc. and as a fuel in cars and in cooking.

Producing Ethanol by Fermentation

The reaction in the fermentation process is as follows: glucose solution in the presence of yeast \rightarrow ethanol + carbon dioxide. Glucose solution is mixed with yeast and the mixture is kept at a temperature of around 37°C. Its purpose is because enzymes in yeast work best at around 37°C. If the temperature is raised beyond 37°C, then the enzymes will be denatured and are unable to catalyse, stopping the reaction.

Think about it this way: ethanol is obtained from glucose which is widely available in sugary drinks. Through fermentation, ethanol is produced. The profit margin is very large as sugar is cheap but ethanol, an expensive liquor, is produced.

Carboxylic Acids

Producing Carboxylic Acids

To produce a carboxylic acid, an alcohol must be oxidised. It can be oxidised by either two methods – by acidified potassium manganate(VII) or atmospheric oxygen.

Special reaction to distinguish a normal acid from a carboxylic acid is that only carboxylic acids undergo esterification.

Reactive Metal

When a carboxylic acid reacts with a reactive metal, the reactive metal displaces the hydrogen from the O-H bond.

Esterification

When ethanoic acid is warmed with ethanol in the presence of a few drops of concentrated sulfuric acid, water and an ester called ethyl ethanoate are produced. Concentrated sulfuric acid acts as a catalyst for the reaction. Esters are colourless liquids which are insoluble in water. To separate a mixture of ethyl ethanoate (an ester) and water, a separating funnel must be used since they are immiscible liquids. Esterification is a reversible reaction.

During esterification, the ester produced will have a boiling point lower than its constituent alcohol and carboxylic acid.

Esters are used in the preparation of artificial food flavourings and solvents for perfumes etc.

Isomerism



Isomers are compounds with the same molecular formula but different structural formula. Now, suppose you have two compounds, **A** on the left and **B** on the right. Are **A** and **B** isomers of each other? No, they are not. The structural formulae are the same.

Chapter 24 – Macromolecules

Addition Polymerisation

Addition polymerisation occurs when unsaturated monomers join together without losing any molecules or atoms. The polymer formed is called an addition polymer.

Formation of Polyethene

At high temperature and pressure and in the presence of a catalyst, the C=C double bonds of the ethene molecules break. Each monomer forms single bonds with 2 other monomers and eventually, they join to form polyethene.

Condensation Polymerisation

Condensation polymerisation occurs when monomers combine to form a polymer with the removal of a small molecule such as water. There are 2 main groups of condensation polymers: the polyamides and polyesters.

Differences between Addition Polymerisation and Condensation Polymerisation

	-
Addition polymerisation	Condensation polymerisation
Does not involve the removal of small molecules	Involves the removal of small molecules
Products are non-biodegradable	Products are biodegradable
Monomers are unsaturated	Monomers are saturated
Involvos C-C bonds	Involves other bonds like -OH, -COOH
involves C=C bonds	and -NH2
Lisos: plastic bags toys buckets cling film	Uses: clothes, curtains, parachutes,
Uses. plastic bags, toys, buckets, cling him	fishing lines, plastic bags



Diacid + Diamine ⇒ Polyamide

Nylon – A Synthetic Polyamide

Nylon is made from a dicarboxylic acid and a diamine. Recall that the functional group for carboxylic acids is -COOH and for amines, it is $-NH_2$.

Nylon is a polyamide as it contains many amide linkages. The amide linkage is as shown.

Terylene – A Synthetic Polyester

Terylene is made from a dicarboxylic acid and a diol. Recall that the functional group for carboxylic acids is –COOH. Diol means an alcohol with 2 –OH functional groups.

Terlyene is a polyester as it contains many ester linkages. The ester linkage is as shown.

On the combustion of Terylene, CO_2 , CO and H_2O are formed.

Diacid + Diol \Rightarrow Polyester + $\begin{pmatrix} 0 \\ HO \end{pmatrix}$ $C \longrightarrow C \end{pmatrix}$ $\begin{pmatrix} 0 \\ HO \end{pmatrix}$ $\begin{pmatrix}$

Polyester (e.g. Terylene)

	Nylon		Terylene
•	Made from a dicarboxylic acid and diamine.	•	Made from a dicarboxylic acid and diol.
•	Contains amide linkages.	•	Contains ester linkages.
•	On combustion, nitrogen dioxide, carbon	•	On combustion, carbon dioxide, carbon
	dioxide and water vapour are formed.		monoxide and water vapour are formed.