MOJZA

O Levels & IGCSE

CHEMISTRY NOTES

5070 & 0620

BY TEAM MOJZA

MOJZA

CONTENTS

UNIT 1: PARTICULATE NATURE OF MATTER

Kinetic Particle Theory

- Solids

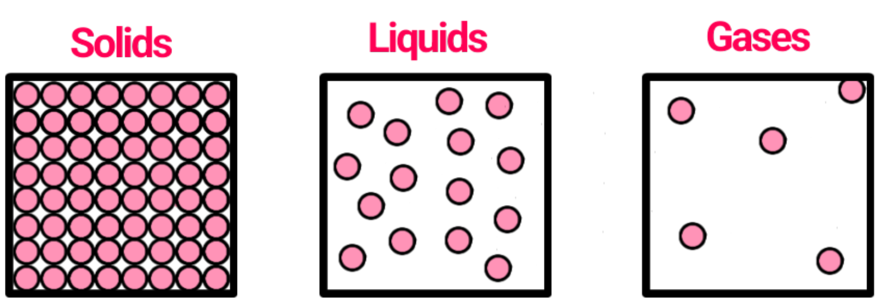
➜ Strong forces of attraction between particles
➜ Particles are arranged in an orderly manner
➜ Particles vibrate in their fixed position
➜ Fixed volume, shape, and mass
➜ High density and incompressible
➜ Can't be compressed as they are tightly packed
➜ Fixed volume, as particles are close together and can not be compressed

- Liquids

➜ Weaker forces of attraction than solids
➜ Particles are a little further apart with an irregular pattern
➜ Particles are free to move and adapt to the shape of the container
➜ Fixed volume but no fixed shape

- Gases

➜ Barely any forces of attraction
➜ Particles are far apart, irregular pattern
➜ Particles move randomly according to Brownian motion
➜ Brownian motion is the movement of particles in fluids due to a large number of collisions with other smaller, fast-moving particles.
➜ No fixed shape, but fixed mass
➜ Volume can be changed with pressure
➜ Volume of gas increases as the temperature increases
➜ Because the frequency of collisions with the container walls increases as the number of gas particles increases, causing the pressure of the gas to rise



State Changes

- Melting

➜ Solid changes into liquid state
➜ Occurs at a fixed temperature known as the 'melting point', at which a pure substance melts
➜ Energy breaks up the forces of attraction between particles to allow them to move more freely

- Freezing

➜ Liquid changes into solid state
➜ This is the opposite of melting
➜ Occurs at the same fixed temperature as melting does
➜ The melting and freezing points of a substance are the same

- Boiling

➜ Liquid changes into gaseous state
➜ Occurs at a fixed temperature known as 'Boiling point'
➜ Bubbles are formed at the bottom of the liquid and escape through the surface
➜ Occurs throughout the liquid

- Condensation

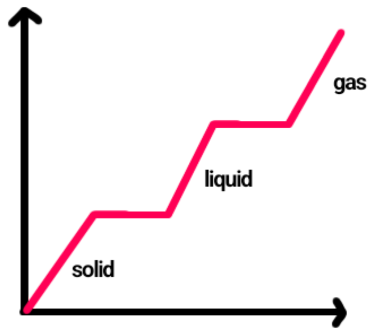
➜ Gas changes into liquid state
➜ This is the opposite of boiling
➜ Particles lose energy upon cooling, which causes them to settle down in closer positions to each other
➜ Can occur at a range of temperatures

- Evaporation

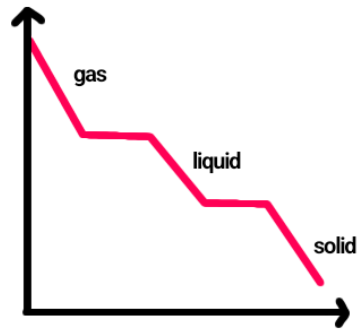
➜ Liquid changes into gaseous state
➜ Only occurs at the surface of a liquid
➜ Particles with high kinetic energy escape the surface
➜ The overall energy of the remaining liquid is reduced
➜ Can occur at a range of temperatures below the boiling point
➜ The rate of evaporation increases with the surface area and temperature

- Sublimation

➜ Solid to gas; direct state change
➜ Only occurs in a few solids, like iodine
➜ Occurs at a fixed temperature
➜ The reverse process is known as deposition



Heating Curve



Cooling Curve

- Diffusion

➜ Movement of atoms and molecules from areas of high concentration to those of low concentration
➜ It's the process by which a gas diffuses through space and is caused by random motion
➜ Gas particles change direction whenever they collide
➜ The bigger the molecule and the larger its molecular weight, the slower its rate of diffusion
➜ The higher the temperature, the greater the rate of diffusion

- Pure & Impure Substances

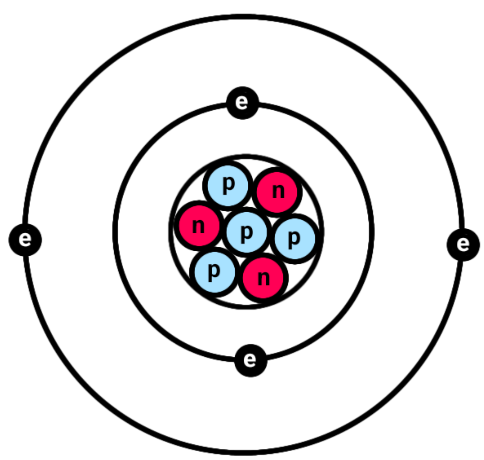
➜ Pure substances have a fixed melting point, and boiling point; any change in melting or boiling points indicates impurities
➜ Impurities in liquids increase the boiling point
➜ Impurities in solids decrease the the melting point

UNIT 2: ATOMS, ELEMENTS & COMPOUNDS

➜ An element is a pure substance that cannot be split into anything simpler; it contains atoms of the same proton number
➜ Compound is a pure substance made from two or more elements chemically combined in a fixed ratio by mass
➜ A mixture is a combination of two or more substances that are not chemically combined and can be separated through physical means

- Atoms and the Periodic Table

➜ An atom is the smallest particle of a chemical element that can exist independently
➜ The mass of atoms is measured using relative atomic mass
➜ One unit of relative atomic mass is 1/12 of the mass of a carbon-12 atom
➜ Atoms are made of protons, neutrons, and electrons
➜ Protons have a +1 charge, and mass 1
➜ Neutrons have 0 charge, and mass 1
➜ Electrons have a -1 charge, and mass 1/1840 (negligible)
➜ The atomic number/proton number is the number of protons in the nucleus of an atom
➜ The atomic number determines the position of an element in the Periodic table
➜ The nucleon number is the total number of protons and neutrons in the nucleus of an atom
➜ Nucleon number - Proton number = Neutron number
➜ Electrons orbit the nucleus in paths called ‘shells’
➜ Elements in the Periodic table are arranged in ascending order of atomic number
➜ The group number of an element represents the number of electrons in its outermost shell
➜ The period number of an element represents the number of shells of that element



- Isotopes

➜ Isotopes are atoms of the same element with the same proton numbers but different neutron numbers
➜ Isotopes have similar chemical properties because they have the same number of electrons/same electronic configuration
➜ They have different physical properties because their nucleon number is different

- Electron Structure

➜ The first electron shell of an atom can have 2 electrons, and the second and third can have 8
➜ Electrons fill the shells starting from the first shell
➜ After one shell is filled up, they start filling up the next
➜ The outermost shell is known as the valence shell; atoms with completely filled outer shells are stable
➜ The period of an element represents the number of shells it has
➜ Elements in the same group have the same number of valence electrons
➜ Electronic configuration can be represented by the number of electrons an atom has in each shell
➜ Elements with full outer electron shells are unreactive and are known as noble gases
➜ Group 8/0 of the periodic table has noble gases, all the elements have 8 electrons except helium, which has 2, but its outer shell is full
➜ All elements try to reach the electronic configuration of noble gases

The electronic configuration of the first twenty elements

Element	Number of Electrons	Electronic Configuration
Hydrogen	1	1
Helium	2	2
Lithium	3	2,1
Beryllium	4	2,2
Boron	5	2,3
Carbon	6	2,4
Nitrogen	7	2,5
Oxygen	8	2,6
Fluorine	9	2,7
Neon	10	2,8

Elements	Number of Electrons	Electronic Configuration
Sodium	11	2,8,1
Magnesium	12	2,8,2
Aluminium	13	2,8,3
Silicon	14	2,8,4
Phosphorus	15	2,8,5
Sulphur	16	2,8,6
Chlorine	17	2,8,7
Argon	18	2,8,8
Potassium	19	2,8,8,1
Calcium	20	2,8,8,2

MOJZA

- Metals and Non-Metals

➜ Elements can be either be metal or non-metals, a few elements show properties of both
➜ Metals are elements which have the ability to lose electrons and form positive ions
➜ Non-metals are elements which have the ability to gain electrons and form negative ions
➜ The metallic character of elements decreases from left to right in the Periodic table

- Properties of Metals

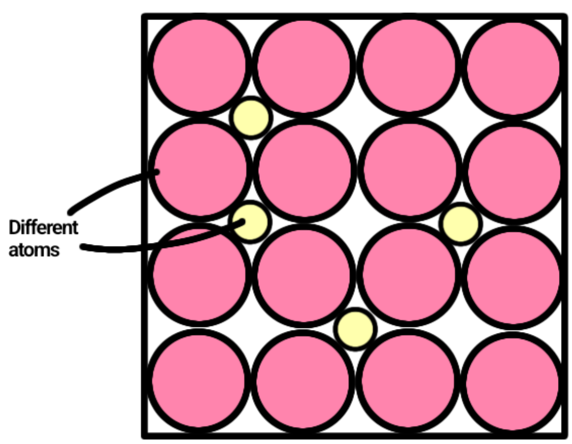
➜ Conduct heat and electricity
➜ Are malleable
➜ Are ductile
➜ Have high density and high melting & boiling points (mostly)
➜ Form positively charged ions by losing electrons
➜ Form basic oxides

- Properties of Non-Metals

➜ Poor conductors of heat and electricity
➜ Are brittle
➜ Low density and low melting & boiling points
➜ Form negative ions through the gain of electron
➜ Form acidic oxides

- Alloys

➔ Alloys are mixtures of two or more metals or a metal and a non-metal
➔ The substances are not chemically combined
➔ Alloys can have very different properties from their components
➔ They can have higher strength, hardness, or resistance to corrosion
➔ They contain atoms of different sizes; the layers cant slide over each other easily



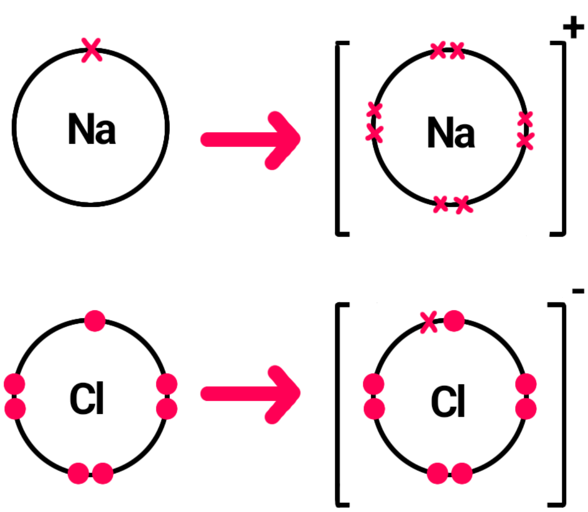
Ions and Ionic bonds

- Ions

➔ An ion is an atom that has a charge
➔ Ions are formed by the gain or loss of electrons
➔ Atoms lose or gain electrons to obtain a full outer shell
➔ Ions have the electronic configuration of noble gases
➔ All metals lose electrons to form positively charged ions
➔ It is easier for metals to complete their shell by losing one or two electrons than by gaining 6 or 7 electrons
➔ All non-metals gain electrons to form negatively charged ions
➔ It is easier for non-metals to gain one or two electrons to complete their shell than to lose electrons
➔ Positive ions are known as cations
➔ Negative ions are known as anions
➔ An ionic bond is a strong electrostatic attraction between positively and negatively charged ions
➔ The metals transfer electrons from their outermost shell to the non-metals to complete the shells of both elements
➔ The electrons have to be in such a ratio that the number of electrons lost by the metal is equal to the number of electrons gained by the non-metal

- Ionic Bonding: Group I and Group VII

➔ Group I metals have one electron in their outermost shell and can complete their shell by losing one electron to form an ion with a +1 charge
➔ Group VII have seven electrons in their outermost shell and can complete their shell by gaining one electron to form an ion with a -1 charge
➔ The Group I metal will transfer one electron to the Group 7 non metal to complete both atoms' shells
➔ This will make an ionic compound



MOJZA

- Ionic bonding: Group II and Group VI

➜ Group II metals have two electrons in their outermost shell and can complete their shell by losing two electrons to form an ion with a +2 charge
➜ Group VI have six electrons in their outermost shell and can complete their shell by gaining two electrons to form an ion with a -2 charge
➜ The Group II metal will transfer two electrons to the Group 6 non-metal to complete both atoms' shells
➜ This will make an ionic compound

- Calculating an element's relative atomic mass from relative masses and abundances of its isotopes

➜ The relative atomic mass (Ar) of an element is the average mass of its isotopes
➜ The Ar can be calculated by using the relative abundance value (which is usually given)
➜ The formula is as following:

Ar = (relative abundance (of the first isotope) x mass (of the first isotope)) + (relative abundance (second isotope) x mass (second isotope)) etc. divided by 100

Covalent Bonds

- Covalent Bonding

➜ The sharing of electrons is known as covalent bonding
➜ Covalent bonding only takes place between non-metals
➜ If two atoms need one electron each to complete their outermost shell, they will share one pair of electron
➜ In this manner, different elements of non-metals can share electrons with each other in different ratios to complete their outermost shell

- Ionic Compounds vs Covalent Compounds

➜ Ionic compounds have high melting and boiling points; are mostly solid at room temperature
➜ Covalent compounds have low melting and boiling points; are mostly liquid or gas at room temperature
➜ Strong electrostatic forces between molecules in an ionic lattice
➜ Weak intermolecular forces are present in covalent compounds
➜ Ionic compounds are mostly soluble in water
➜ Covalent compounds are usually insoluble in water
➜ Ionic compounds conduct electricity only in molten or aqueous states
➜ Covalent compounds cannot conduct electricity due to the unavailability of free electrons or ions

- Metallic Bonding

➜ Electrostatic attraction between positive ions in a giant metallic lattice and a 'sea' of negatively charged delocalised electrons
➜ Metals are great electrical conductors, as electrons are free to move and carry a charge
➜ Metals are malleable and ductile as the layers of atoms simply slide over each other when force is applied, without breaking the metallic bonds
➜ Due to the metallic lattice structure which allows for the movement and sliding of layers of atoms, allowing the metal to be shaped and bent without breaking

Macromolecules

➜ Diamond and graphite are giant covalent structures that are allotropes of carbon
➜ They contain many carbon-carbon covalent bonds in a giant lattice structure
➜ They have high melting and boiling points due to a large number of bonds
➜ Very high amounts of energy are required to break these bonds

- Diamond

➜ Each carbon atom covalently bonds with four other carbon atoms
➜ All the bonds are strong and there are no weak intermolecular forces
➜ This causes diamonds to have a high melting point and high density
➜ Diamond can not conduct electricity; free electrons are unavailable
➜ It is used for cutting hard substances and in jewellery

- Graphite

➜ Each carbon atom is covalently bonded to three other carbon atoms
➜ The carbon atoms form layers of hexagonal-shaped structures
➜ There is one free electron per carbon atom
➜ The free electrons allow graphite to conduct electricity
➜ The covalent bonds are strong; however, the intermolecular forces between the hexagonal layers are weak
➜ The layers can slide over each other, allowing graphite to be slippery and smooth
➜ It has a high melting point
➜ It has a lower density than diamond
➜ Used in pencils, industrial lubricants, electrodes for electrolysis

- Silicon dioxide

➜ SiO_2 or sand is a macromolecule
➜ It has a structure similar to diamond
➜ It has similar properties to diamond
➜ It is hard, has a high melting point and does not conduct electricity

UNIT 3: STOICHIOMETRY

The Mole

➜ One mole of any substance contains 6.02×10^{23} particles
➜ One mole of any gas has $24dm^3$ or $24000cm^3$ volume at room temperature
➜ The ratio of moles between substances in a reaction is always the same

- Calculations

➜ To find the number of moles of any gas when the volume is given, divide the volume by $24\ dm^3$
➜ To calculate the volume of any gas when the moles are given, multiply the moles by $24\ dm^3$
➜ To find the moles of a substance when the mass is given, or to find the mass when the moles are given, use the formula moles = mass/Mr (the Mr can be calculated using the Periodic table)
➜ To calculate the percentage by mass of a substance in a compound, use the formula mass of substance/mass of compound x 100
➜ The concentration, volume, or moles of a solution can be found using the formula concentration = moles/volume when two of the three are given
➜ To find the mass of a reactant or product when the moles of some other substance in the reaction is given, find the ratio of moles between the two to find the moles of the substance of which we need to find the mass and use the formula mole=mass/Mr

- Limiting reactant

➜ The limiting reactant is the reactant that runs out when the other reactant(s) still remain
➜ When the limiting reactant finishes, the reaction can not carry on
➜ The rest of the reactants will remain with the product after the reaction
➜ To find the limiting reactant, find the ratio of moles in which the reactants react
➜ Find the required volume of each reactant using the ratios and see which is less than required
➜ If the ratio of moles for reactant X to reactant Y is 1:2, the amount of volume of Y required for the reaction is twice the volume given of X, if the volume is lesser than required Y is the limiting reactant. The amount of volume of X required is half that of Y; if it is less than half, X is the limiting reactant

- Empirical Formula

➜ To find the empirical formula when the mass or percentage of elements is given;
➜ Divide the mass of each element by its atomic mass to get the number of moles
➜ Simplify the moles' ratio by dividing all of the moles' values by the smallest one
➜ The final ratio represents the number of atoms of each element

- Molecular formula

➜ To find the molecular formula, you first need to have the empirical formula
➜ Divide the Mr of one of the elements in the substance by its mass in the substance
➜ Multiply this result with the ratio of atoms in the empirical formula

- Percentage Yield

➜ To find how much yield was obtained compared to the expected yield, use the formula actual yield/expect yield x 100
➜ You may have to calculate the yields using some other method such as moles=mass/Mr or using the molar ratio

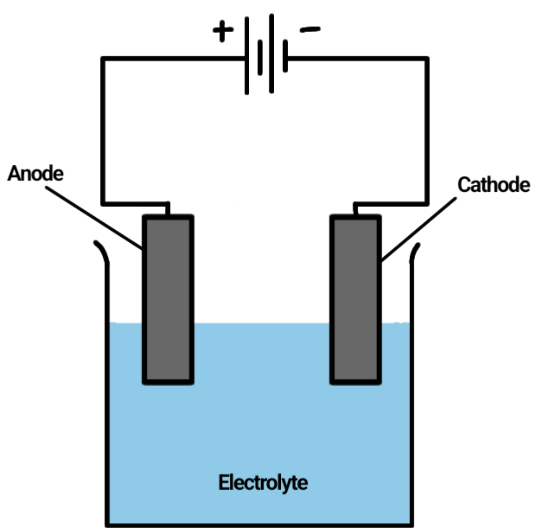
- Percentage Purity

➜ Mass of pure substance / Total Mass x 100

UNIT 4: ELECTRICAL CHEMISTRY

Electrolysis

➜ Electrolysis is a process through which an ionic compound in aqueous or molten state is broken down into its constituent elements by passing electricity through it
➜ Only substances that can conduct electricity can be electrolysed
➜ The molten or aqueous compound to be electrolysed is known as an electrolyte
➜ An electrode is a rod through which electricity is conducted in an electrolyte
➜ Anode is the positive electrode; Cathode is the negative electrode
➜ Mnemonic: PANIC; **P**ositive is **A**node, **N**egative **I**s **C**athode
➜ Anion is a negatively charged ion; it is attracted to the anode
➜ Cation is a positively charged ion; it is attracted to the cathode
➜ Reduction takes place at the cathode; oxidation takes place at the anode
➜ Mnemonic: **R**ed **C**at, **A**n **O**x



- Electrolysis of Molten Compounds

➜ In molten binary compounds, as there are only two ions in the electrolyte, both the components will be produced at the electrodes
➜ The anions will go to the anode where they will lose electrons to form a gas
➜ The cations will go to the cathode, where they will gain the electrons that were lost at the anode and produce a metal

- Electrolysis of Dilute Aqueous Solutions

➜ Aqueous solutions mean the compound is dissolved in water; this means there will also be H^+ and OH^- ions in the solution
➜ In dilute solutions, Oxygen gas will always be produced at the anode
➜ The OH- ions will go to the anode and be reduced to form Oxygen; the other negative ion will remain in the solution
➜ The equation for the reaction at the anode in a dilute solution will always be
$4OH^- \rightarrow O_2 + 2H_2O + 4e^-$
➜ At the cathode, the ion lower in position in the reactivity series will be produced

- Electrolysis of Concentrated Aqueous Solutions

➜ The concentration of the solution does not impact the product at the cathode, it will still be either hydrogen or the metal ion, based on which is less reactive
➜ At the anode, the gas produced will be decided by the reactivity
➜ If the solution contains sulphate or nitrate ions, they will never be discharged and oxygen will always be produced
➜ If the solution contains a high concentration of chloride, bromide, or iodide ions, they will lose electrons and their respective diatomic compound will be produced

- Nature of electrodes

➜ Electrodes are classified into two categories : 1. Inert, 2. Reactive
➜ Inert electrodes don't affect the electrode reactions due to their chemical nature e.g. graphite or platinum
➜ Reactive electrodes affect the electrode reactions due to their chemical nature
➜ Effects of electrodes apply to metals below hydrogen in the reactivity series
➜ If the anode's metal and metal ion in the electrolyte are same, then the anode dissolves (oxidises) into the electrolyte
➜ Anode dissolves to compensate deficiency of metal ion in the electrolyte caused due to cathode reaction
➜ No change with respect to chemical reactions will occur at the cathode

Hydrogen-Oxygen Fuel Cell

➜ Type of electrochemical cell, which converts chemical energy (fuel) into electrical energy,
➜ Produces water, as hydrogen and oxygen combine together

- Advantages

➜ Hydrogen is a renewable source of energy as it can be obtained by the electrolysis of water
➜ Releases more energy per mole than other fuels
➜ Does not produce any harmful gases that lead to pollution
➜ Efficient process - less steps in converting chemical energy to electrical energy
➜ Doesn't need to be recharged

- Disadvantages

➜ There are no cheap sources to obtain hydrogen
➜ Electrolysis of water is an expensive process
➜ Obtaining hydrogen from catalytic cracking involves the use of fossil fuels, which are non-renewable resources
➜ Hydrogen is extremely flammable and explosive when it comes in contact with air. Extra caution has to be taken for storage and transportation

- Electroplating

➜ Electrolysis can be used to coat a layer of a metal on an object
➜ The metal that is being used to coat should be less reactive than the object's metal
➜ The anode is made of the pure metal that is to coat the object
➜ The object to be coated is taken at the cathode
➜ The electrolyte is a soluble salt containing the metal ion that is to coat the object
➜ The pure metal loses electrons at the anode; ions go into the solution, the ions gain electrons at the cathode and form a layer over the object
➜ Electroplating is used to make objects more resistant to corrosion or to make them shinier and improve their appearance

MOJZA

UNIT 5: CHEMICAL ENERGETICS

Enthalpy

➜ Every substance has some kind of energy, called its internal energy/enthalpy
➜ Change in internal energy is called change in enthalpy

- Endothermic Reactions

➜ Endothermic reactions take in heat from the surroundings and as a result the surrounding / reaction mixture feels cooler
➜ More energy is absorbed than given out
➜ The products have greater energy than the reactants
➜ They take in heat and feel cold
➜ Examples include photosynthesis, lightning and decomposition reactions

- Exothermic Reactions

➜ Exothermic reactions transfer heat to the surroundings, leading to an increase in the temperature of the surroundings
➜ More energy is given out than absorbed
➜ The products of the chemical reaction have lesser energy than the reactants
➜ They give off heat
➜ The enthalpy change (ΔH) is negative
➜ Examples include respiration, combustion and neutralisation reactions

- Bond Breaking & Making

➜ Bond breaking and making is observed when a reaction takes place
➜ Bond breaking is an endothermic process
➜ Heat is absorbed in breaking the bonds in reactants
➜ Bond making is an exothermic process
➜ Heat is released in making new bonds in the products
➜ Mnemonic : **MEXO** and **BENDO**
➜ MEXO: **M**aking of bonds is **EXO**thermic
➜ BENDO : **B**reaking of bonds is **ENDO**thermic

- Determining the type of reaction

➜ Amount of heat energy absorbed or released during a reaction determines the type of reaction
➜ If heat released > heat absorbed then the reaction is exothermic
➜ If heat absorbed > heat released then the reaction is endothermic

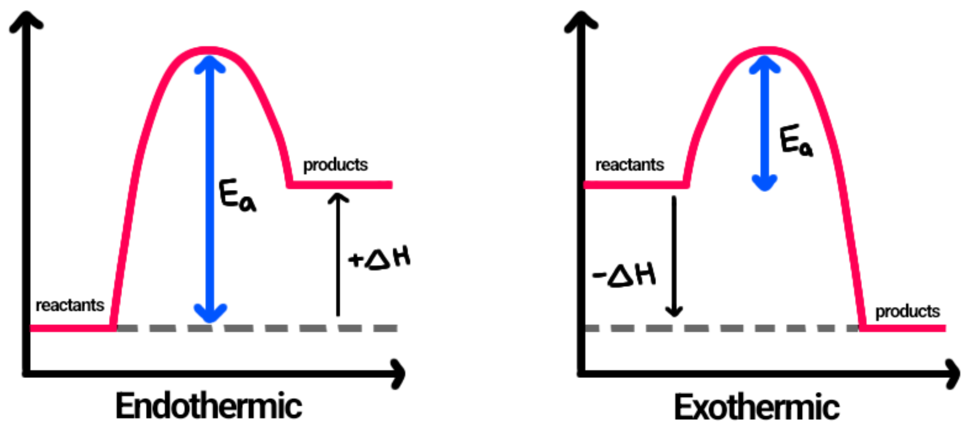
- Calculating Energy of a Reaction

➜ You may be given the energy of specific bonds and be asked to calculate the total energy of a reaction
➜ Multiply the the bond energies with the number of times it is present and add the energies of both sides individually to get the energy input and energy output
➜ Energy change = Energy input - Energy output
➜ If the change in energy is positive, the reaction is endothermic
➜ If the change in energy is negative, the reaction is exothermic

- Enthalpy Change

➜ Enthalpy Change (ΔH) = Energy absorbed to break bonds (Endothermic) - Energy released to make bonds (Exothermic)
➜ For an endothermic reaction, the energy absorbed to break bonds is higher than the energy released to make bonds
➜ For an exothermic reaction, the energy released to make bonds is higher than the energy absorbed to break the bonds

- Reaction Pathway Diagrams



➜ An upward arrow for ΔH shows the energy that is required, while a downward arrow shows the energy that is released
➜ In the reaction pathway diagram for an exothermic reaction, always remember that reactants would be higher than the products i.e: the reactants would have more energy than the products
➜ In the reaction pathway diagram for an endothermic reaction, always remember that products would be higher than the reactants i.e: the products would have more energy than the reactants
➜ Activation Energy (Ea) is the minimum amount of energy required to start a chemical reaction
➜ The reactants' particles must possess the energy equal to or greater than the activation energy in order to react with other particles
➜ The arrow representing activation energy always faces upwards as it is the energy taken to start a chemical reaction

UNIT 6: CHEMICAL REACTIONS

- Physical and Chemical Changes

➜ Physical changes produce no new substances
➜ Usually related to a change of state
➜ Usually easy to reverse
➜ Examples: Melting ice, dissolving a solute in a solvent, etc.
➜ Chemical changes result in the formation of new substances
➜ Newly formed substances have very different properties from those which they have formed from
➜ Such reactions are usually difficult to reverse
➜ Energy changes also occur
➜ Examples: Cooking, rusting, burning wood etc.

- Rate of Reaction

➜ Rate of reaction is the speed with which reactants turn into products

- Concentration

➜ Increasing concentration increases the rate of reaction
➜ There will be more particles closer to each other at higher concentrations causing a greater number of collisions
➜ The frequency of successful collisions increases

- **Surface Area**

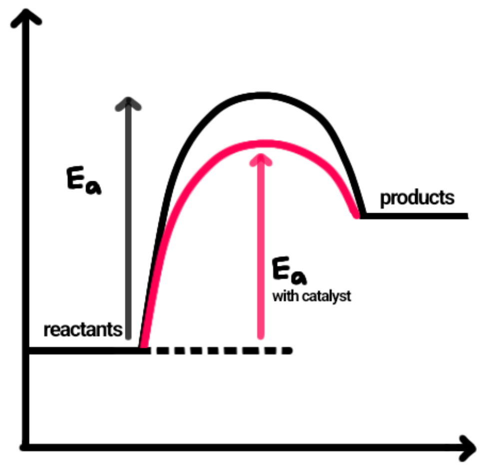
➜ Increasing the surface area of a solid increases the rate of reaction
➜ More solid particles are exposed to the other reactants due to the greater surface area, causing more collisions
➜ The frequency of successful collisions increases

- Temperature

➜ The rate of reaction increases by increasing the temperature
➜ Increasing temperature increases the kinetic energy of particles
➜ Particles move faster and collide more frequently
➜ More successful and frequent collisions per second

- Catalyst

➜ A catalyst speeds up the rate of reaction by lowering the activation energy required
➜ Catalyst doesn't effect the yield of a reaction



- Pressure

➜ Increasing the pressure increases the rate of reaction by pushing the particles closer to each other, resulting in more frequent collisions

- Measuring the rate of reaction

➜ When the volume or mass of a product is plotted against the time, at a higher the rate of reaction the curve of the graph will be steeper and rise to same volume or mass in a shorter time
➜ To measure the speed of reaction in which a gas is produced, add the reactants to a sealed conical flask attached to a gas syringe and measure the volume after a fixed time

- Reversible Reactions

➜ Reversible reactions (as shown by the symbol ⇌) are those in which the products can produce the reactants again
➜ The reaction can occur in both directions
➜ The formation of the products is known as the forward reaction
➜ The formation of the reactants is known as the backward reaction

- Dynamic Equilibrium

➜ When the rate of the forward reaction is equal to the rate of the backward direction, the reaction is at equilibrium
➜ It can only occur in a closed system where none of the reactants or products can escape from the reacting apparatus
➜ A change in the temperature, pressure, concentration, or amount of reactants and products can change the position of equilibrium
➜ If the position of equilibrium shifts towards the forward reaction, the products' concentration is higher and the rate of the forward reaction is greater
➜ If the position of equilibrium shifts towards the backward reaction, the reactants' concentration and rate of backward reaction is higher

- Le Chatelier's principle and position of equilibrium

➜ The addition of a catalyst does not impact the position of the equilibrium
A catalyst only lowers the activation energy and speeds up the rate of reaction equally for both the forward and backward reaction, maintaining the equilibrium
➜ An increase in temperature will increase the rate of the endothermic reaction and decrease the rate of the exothermic reaction, causing the position of equilibrium to shift towards the endothermic reaction
➜ Decreasing the temperature will increase the rate of the exothermic reaction and reduce the rate of the endothermic reaction, causing the position of equilibrium to shift towards the exothermic reaction
➜ Increasing the pressure will increase the rate of reaction and cause the position of equilibrium to shift to the side with the lesser number of moles of gas
➜ Decreasing pressure will cause the position of equilibrium to shift towards the side with larger number of moles
➜ Increasing the concentration of the reactants causes the position of equilibrium to shift towards the forward reaction
➜ Increasing concentration of products causes the position of equilibrium to shift towards the backward reaction
➜ Decreasing concentration of the reactants causes the position of equilibrium to shift towards the backward reaction
➜ Decreasing the concentration of the products causes the position of equilibrium to shift towards the forward reaction
➜ Concentration is increased or decreased by adding or removing some of the reactants or products
➜ Adding a catalyst has no effect on the position of the equilibrium
➜ The position of equilibrium is related to the yield while the catalyst only affects the rate
➜ Adding a catalyst would allow dynamic equilibrium to be reached more quickly

- Redox Reactions

➜ Reduction and oxidation both take place simultaneously in redox reactions
➜ Reduction is the gain of electrons
➜ Reduction is the loss of oxygen or decrease in oxidation state
➜ Oxidation is loss of the electrons
➜ Oxidation is the gain of oxygen or increase in oxidation state
➜ The oxidation state is the number given to an element or ion that shows its degree of reduction or oxidation
➜ It shows the movement of electrons in a redox reaction
➜ The oxidation state of a compound is always 0
➜ Redox reactions are identified by a change in the oxidation states

- Oxidising and Reducing Agents

➜ Oxidising agents are substances that oxidises another substance while reducing itself
➜ Reducing agents are substances that reduce other substances while oxidising itself
➜ Potassium manganate (VII) $KMnO_4$ is an oxidising agent used to test for reducing agents; it turns from purple to colourless in the presence of a reducing agent
➜ Potassium iodide is a reducing agent used to test for oxidising agents. The solution turns brown when it is added to an oxidising agent

- Use of Roman numerals to represent the oxidation states

➜ Roman numerals are used to represent oxidation states when the elements exist in more than one oxidation state. An example are the Transition elements (located in between the Group II and Group III elements of the Periodic table)
For example:
- Iron (III) Oxide, Fe_2O_3
- Copper (II) Oxide, CuO

In each of the examples above, the roman numeral written in the bracket indicates the oxidation state of the element

Sulfuric Acid & Contact Process

- Contact Process

➜ Raw materials: Sulfur, Water, Conc. sulfuric acid
➜ Sulfur is first burnt in oxygen; Sulfur dioxide is formed
➜ SO_2 & air go through the process of electrostatic dust precipitation for purification
➜ Sulfur dioxide is oxidised to sulfur trioxide under the following conditions:

- Temperature: 450 °C
- Pressure: 2 atm
- Catalyst: Vanadium pentoxide, V_2O_5

➜ Oleum ($H_2S_2O_4$) is prepared by adding sulfuric acid to sulfur trioxide
➜ Sulfuric acid is finally prepared by adding water to oleum

- Uses of Sulfuric acid

➜ Used in preparation of fertilisers
➜ Used as an electrolyte in car batteries
➜ Used to prepare detergents

- Uses of Sulfur dioxide

➜ Used to sterilise babys' bottles
➜ Used as preservative in jams and jellies
➜ Used to bleach wood pulp

Haber Process

➜ Ammonia is manufactured by the Haber process
➜ Nitrogen is obtained from the fractional distillation of liquid air and hydrogen is obtained from the catalytic cracking of hydrocarbons

Conditions:
Temperature: 450°C
Pressure: 200 atm
Catalyst: Iron
➜ Unreacted H_2 and N_2 are put back into the process

$N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g)$

➜ At a higher temperature, the backward reaction would be favoured and the yield will decrease
➜ At a lower temperature, the yield would be higher
➜ Temperature is kept at 450°C, as decreasing it would reduce the rate too much
➜ At 450°C, there is a balance between the rate of reaction and the yield
➜ A higher pressure would increase the yield as the forward reaction has lesser number of moles
➜ Pressure is not increased and kept at 200 atm, because a higher pressure would be dangerous and expensive

UNIT 7: ACIDS, BASES & SALTS

- Acids

➜ Acids are defined as H^+ ion (proton) donors
➜ Acids have a pH below 7
➜ They have a sour taste and are corrosive
➜ They turn blue litmus paper red
➜ Methyl orange changes turns red in presence of acid
➜ Acids react with bases to neutralise them, forming a salt and water - known as a neutralisation reaction
➜ Ionic equation for neutralisation reaction:
$H^+_{(aq)} + OH^-_{(aq)} \rightarrow H_2O_{(l)}$
➜ Only metals above hydrogen in the reactivity series can react with acids
➜ Metal + Acid → Metal Salt + Hydrogen
➜ Metal Oxide + Acid → Metal Salt + Water
➜ Metal Hydroxide + Acid → Metal Salt + Water
➜ Metal Carbonate + Acid → Metal Salt + Carbon Dioxide + Water

- Bases

➜ Bases are H^+ ion (proton) acceptors
➜ Bases have a pH above 7
➜ Bases are metal oxides or metal hydroxides
➜ Soluble bases are known as alkalis
➜ The presence of hydroxide ions makes a solution alkaline
➜ Acid + Base → Salt + Water
➜ Ammonium Salt + Alkali → Alkali Metal Salt + Water + Ammonia

- pH and Indicators

➜ pH scale is used to see how acidic or basic a substance is
➜ The lower the pH, the more acidic the solution
➜ The higher the pH, the more basic the solution
➜ pH 7 is neutral
➜ Indicators, such as universal indicator, are used to test pH
➜ A few drops of the indicator are add to solution which gives a colour change
➜ The colour is matched with a chart of known pH values to find the pH
➜ Litmus is red in acids and blue in bases
➜ Methyl orange is red in acids and yellow in bases
➜ Thymolphthalein is colourless in acids and blue in bases
➜ Acid rain may cause soil to become acidic
➜ Limestone, lime, or slaked lime is used to neutralise acidity in soil; these are calcium carbonate, calcium oxide and calcium hydroxide

MOJZA

- Weak and Strong Acids

➜ Strong acids ionise completely in water
➜ They have very low pH values
➜ Weak acids have higher pH values and ionise partially in water
➜ HCl, HNO_3 and H_2SO_4 are examples of strong acids
➜ Carboxylic acids are weak acids
➜ The ionisation of weak acids is reversible

- Oxides

➜ Non-metal oxides are acidic
➜ Acidic oxides react with bases to form salt and water
➜ They produce acidic solutions with low pH when dissolved in water
➜ Metal oxides are basic
➜ They react with acids to form salt and water
➜ They make a basic solution with a high pH when dissolved in water
➜ Neutral oxides do not react with either acids or bases
➜ Examples of neutral oxides are NO, H_2O and CO
➜ Amphoteric oxides react with both acids and bases
➜ Examples are zinc oxide ZnO and aluminium oxide Al_2O_3

- Salts

➜ Salts are compounds formed by the displacement of hydrogen in acids by a more reactive metal
➜ Salt solubility:
➜ All Group I salts are soluble
➜ All ammonium salts are soluble
➜ All nitrates are soluble
➜ All chlorides are soluble, except lead chloride and silver chloride
➜ All sulfates are soluble except barium sulfate, calcium sulfate, and lead sulfate
➜ All carbonates are insoluble, except its Group I and ammonium salts

Preparation of Salts

- Titration

➜ Titration is used to produce Group I and ammonium salts only
➜ Reactants: Acid + Alkali
➜ Titrate reactant A against reactant B until the indicator changes colour
➜ Repeat the titration without the indicator
➜ Evaporate the solution to dryness (for pure, dry sample)
➜ Heat the solution till saturation point, let it cool and crystallise, filter to collect the crystals, and then dry in an oven (for crystals)

- Excessive Reagent Method

➜ It is used for the formation of soluble salts which do not belong to Group 1 or are ammonium salts
➜ Reactants: Acid + Metal/Insoluble Base/Metal Carbonate
➜ Add excess metal/insoluble base/metal carbonate to acid, until the excess starts to settle at the bottom
➜ Filter the mixture to collect the filtrate
➜ Evaporate the solution to dryness (for pure, dry sample)
➜ Heat the solution till saturation point, let it cool and crystallise, filter to collect the crystals, and then dry in an oven (for crystals)

- Ionic Precipitation

➜ It is used to form all insoluble salts
➜ Reactants: Soluble compounds
➜ Add excess reactant A to reactant B until no more precipitates form
➜ Filter the mixture to collect the residue
➜ Wash the residue with distilled water
➜ Dry in an oven

- Water of Crystallisation

➜ Water molecules present in hydrated crystals
➜ e.g. In $CuSO_4.5H_2O$ - $5H_2O$ is the water of crystallisation
➜ e.g.In $CoCl_2.6H_2O$ - $6H_2O$ is the water of crystallisation
➜ Hydrated Substance: substance chemically bonded with water
➜ Anhydrous Substance substance containing no water

- Performing a flame test

➜ Flame tests can be performed in two ways:
- Use a clean wire that has a solid sample
- Dipping a splint into the concentrated solution of the sample

➜ Sample used is of the metal that needs to be tested
➜ Wire or splint is brought near to the hot flame or bunsen burner
➜ Colour of the flame is recorded
➜ Colour of the flame identifies the metal that is being tested

MOJZA

- Identification of Ions and Gases

(Very Important to memorise)

Tests for anions

anion	test	test result
carbonate, CO_3^{2-}	add dilute acid then test for carbon dioxide gas	effervescence, carbon dioxide produced
chloride, Cl^- [in solution]	acidify with dilute nitric acid, then add aqueous silver nitrate	white ppt.
bromide, Br^- [in solution]	acidify with dilute nitric acid, then add aqueous silver nitrate	cream ppt.
iodide, I^- [in solution]	acidify with dilute nitric acid, then add aqueous silver nitrate	yellow ppt.
nitrate, NO_3^- [in solution]	add aqueous sodium hydroxide, then aluminium foil; warm carefully	ammonia produced
sulfate, SO_4^{2-} [in solution]	acidify with dilute nitric acid, then add aqueous barium nitrate	white ppt.
sulfite, SO_3^{2-}	add a small volume of acidified aqueous potassium manganate(VII)	the acidified aqueous potassium manganate(VII) changes colour from purple to colourless

Tests for aqueous cations

cation	effect of aqueous sodium hydroxide	effect of aqueous ammonia
aluminium, Al^{3+}	white ppt., soluble in excess, giving a colourless solution	white ppt., insoluble in excess
ammonium, NH_4^+	ammonia produced on warming	—
calcium, Ca^{2+}	white ppt., insoluble in excess	no ppt. or very slight white ppt.
chromium(III), Cr^{3+}	green ppt., soluble in excess	green ppt., insoluble in excess
copper(II), Cu^{2+}	light blue ppt., insoluble in excess	light blue ppt., soluble in excess, giving a dark blue solution
iron(II), Fe^{2+}	green ppt., insoluble in excess, ppt. turns brown near surface on standing	green ppt., insoluble in excess, ppt. turns brown near surface on standing
iron(III), Fe^{3+}	red-brown ppt., insoluble in excess	red-brown ppt., insoluble in excess
zinc, Zn^{2+}	white ppt., soluble in excess, giving a colourless solution	white ppt., soluble in excess, giving a colourless solution

MOJZA

Flame tests for metal ions

metal ion	flame colour
lithium, Li^+	red
sodium, Na^+	yellow
potassium, K^+	lilac
calcium, Ca^{2+}	orange-red
barium, Ba^{2+}	light green
copper(II), Cu^{2+}	blue-green

Tests for gases

gas	test and test result
ammonia, NH_3	turns damp red litmus paper blue
carbon dioxide, CO_2	turns limewater milky
chlorine, Cl_2	bleaches damp litmus paper
hydrogen, H_2	'pops' with a lighted splint
oxygen, O_2	relights a glowing splint
sulfur dioxide, SO_2	turns acidified aqueous potassium manganate(VII) from purple to colourless

UNIT 8: THE PERIODIC TABLE

➜ The Periodic table is arranged according to increasing proton number/atomic number of protons
➜ Vertical columns are known as groups
➜ Group number represents the number of electrons in the outermost shell of an atom
➜ Horizontal rows are known as periods
➜ Periods represent the number of occupied electron shells of an atom
➜ The metallic character of elements decreases from left to right
➜ Elements in the same group have similar chemical properties

- Group I: Alkali Metals

➜ Group I metals are known as alkali metals, and they all have 1 electron in their outermost shell
➜ Alkali metals are soft, have low densities, and are easy to cut
➜ Alkali metals conduct heat and electricity
➜ They all have low melting points which decrease down the group
➜ Their density increases down the group
➜ Their reactivity increases down the group
➜ They react readily with oxygen and water vapour
➜ Kept in oil to prevent from reacting
➜ React vigorously with water to produce Metal Hydroxide + Hydrogen (always)

- Group VII: Halogens

➜ Group VII non metals are known as halogens and are poisonous
➜ They all have 7 electrons in their outermost shell
➜ Halogens are diatomic; they will always exist in pairs
➜ The melting points and boiling points increase down the group
➜ Their reactivity decreases down the group
➜ Their density increases down the group
➜ At room temperature, fluorine and chlorine are pale yellow-green gases, bromine is a red-brown liquid, iodine is a grey-black solid, and astatine is a black solid
➜ The colour of the halogens gets darker down the group
➜ More reactive halogens can displace less reactive halogens

- Transition Elements

➜ They are hard and strong metals
➜ They are good conductors of heat and electricity
➜ They have high melting points and high densities
➜ They form coloured compounds
➜ They have variable oxidation states
➜ Their compounds are often used as catalysts

MOJZA

- Similarities in chemical properties of elements in the same group of the Table (electronic configuration)

➜ Similar electronic configurations of elements in the same group of the Periodic table
➜ Similar number of valence electrons result in similar tendencies to gain or lose electrons in chemical reactions
➜ They have similar reactivity patterns, chemical reactions and form similar types of compounds

- Noble Gases

➜ Group VIII elements
➜ Unreactive, owing to their valence/outermost shell being fully occupied by electrons

MOJZA

UNIT 9: METALS

- Properties of Metals

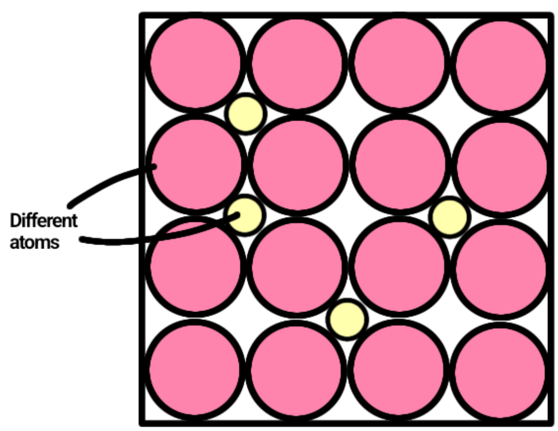
➜ Metals have high melting and boiling points
➜ Metals have strong metallic bonds which require large amounts of energy to overcome
➜ They are good conductors of heat and electricity
➜ They have a ‘sea’ of delocalised electrons that are free to move around, which allows them to conduct electricity
➜ They are malleable and ductile
➜ The layers of positive ions can slide over each other easily
➜ The metallic bonds are not broken by the sliding, so they can be shaped without breaking

- Reactions of Metals

➜ Metals produce the constituent metal hydroxide and hydrogen gas upon reaction with cold water
➜ Reaction with steam produces the constituent metal oxide and hydrogen gas
➜ Reaction with air/oxygen produces the constituent metal oxide
➜ Metals above hydrogen in the reactivity series can react with acids

- Alloys

➜ Alloy is a mixture of a metal with other elements, including: brass as a mixture of copper and zinc; stainless steel as a mixture of iron and other elements such as chromium, nickel, and carbon



(Note: Must be able identify alloys)

➜ They have properties different from their components
➜ They have greater strength, hardness, and resistivity to corrosion

➜ The differently-sized atoms make it difficult for them to slide over each other
➜ Brass is an alloy of copper and zinc
➜ Aluminium alloy is used for aeroplanes, because it is harder and has a low density
➜ Aluminium is used in the manufacture of overhead electrical cables because of its low density and good electrical conductivity
➜ Alloys are not chemically combined; they are mixtures, not compounds

- Reactivity Series

Reactivity decreases down the reactivity series
Must memorise

Elements	**Mnemonic**
Potassium	**P**lease
Sodium	**S**top
Calcium	**Call**ing
Magnesium	**M**e
Aluminium	**A**
(**Car**bon)	**Car**eless
Zinc	**Z**ebra
Iron	**I**nstead
Tin	**T**ry
Lead	**L**earning
(**H**ydrogen)	**H**ow
Copper	**Copper**
Silver	**S**aves
Gold	**Gold**

➜ The reactivity decreases down the series
➜ More reactive metals can displace less reactive metals
➜ More reactive metals lose electrons and forms ions more readily
➜ Aluminium metal is not very reactive, despite being high in the series, because it has a layer of unreactive aluminium oxide over it which prevents it from coming into contact with the reactant, making it unreactive and resistant to corrosion
➜ Because it is resistant to corrosion, aluminium can be used in food containers

- Extraction of Metals

➜ Metals are found as ores and need to be extracted
➜ The more reactive a metal is, the harder its is to extract it

➜ The highly reactive metals are extracted by electrolysis or displacement by a more reactive metal. These include metals from potassium to aluminium in the reactivity series. During electrolysis, the carbon anodes need to be regularly replaced since the carbon reacts with oxygen to form carbon dioxide
➜ Medium reactivity metals are extracted in blast furnaces by reducing them using carbon or carbon monoxide. These include metals from zinc to tin in the reactivity series
➜ Low reactivity metals are extracted by heating. These include metals from lead to mercury in the reactivity series
➜ Unreactive metals are found uncombined as they do not react with other materials. These include silver and gold

- Extraction of Aluminium

➜ Electrolysis is used to extract aluminium from its ore bauxite
➜ Bauxite is first purified to obtain aluminium oxide (Al_2O_3)
➜ Aluminium oxide is dissolved in molten cryolite to lower its melting point, improve conductivity and reduce costs
➜ The aluminium oxide and cryolite solution is taken as the electrolyte and heated tot a temperature of 1000°C
➜ Graphite electrodes are used
➜ The oxygen ions go to anode and lose electrons to produce oxygen gas
➜ Some of the oxygen reacts with the graphite electrodes to produce carbon dioxide, causing the electrodes to be used up
➜ Aluminum ions gain electrons at the cathode and molten aluminium is produced
➜Reaction at cathode : $Al^{3+} + 3e^- \rightarrow Al$
➜Reaction at anode : $2O^{2-} \rightarrow O_2 + 4e^-$
➜Overall Equation : $4Al + 3O_2 \rightarrow 2Al_2O_3$
➜ The molten aluminium is taken out and more aluminium oxide is added
➜ The electrodes need to be constantly replaced due to being burned away

- Extraction of Iron

➜ Iron has to be extracted from its ore hematite
➜ It is extracted in the blast furnace
➜ Iron ore (Fe_2O_3), coke (carbon) and limestone ($CaCO_3$) are added at the top of the blast furnace as raw materials
➜ Limited supply of air or oxygen is provided
➜ The oxygen reacts with the coke (carbon) and oxidises it to carbon dioxide
➜ $C (s) + O_2 (g) \rightarrow CO_2 (g)$
➜ Excess coke reacts with the carbon dioxide to produce carbon monoxide
➜ $CO_2 (g) + C (s) \rightarrow 2CO (g)$
➜ Carbon monoxide acts as a reducing agent and reacts with Fe_2O_3, reducing it to iron
➜ $Fe_2O_3 (s) + 3CO (g) \rightarrow 2Fe (l) + 3CO_2 (g)$
➜ The molten iron oxide contains impurities such as sand (SiO_2), for which limestone was added
➜ $CaCO_3$ first decomposes in the heat to formed calcium oxide and carbon dioxide
➜ $CaCO_3 (s) \rightarrow CaO (s) + CO_2 (g)$
➜ Calcium oxide reacts with sand to produce calcium silicate (Ca_2SiO_4)

➜ $CaO (s) + SiO2 (s) \rightarrow CaSiO3 (l)$
➜ The calcium silicate melts and floats over the molten iron as slag
molten iron settles at the bottom of the furnace from where it is tapped off

- Rusting

➜ Corrosion of Iron, as a result of which hydrated iron oxide is produced
➜ Rusting occurs in the presence of oxygen and moisture

- Sacrificial Protection

➜ A process in which a more reactive metal is is chemically attached to a less reactive metal in order to protect the less reactive metal from corrosion
➜The sacrificial metal being more reactive than the one to be protected, reacts with oxygen and moisture instead of the less reactive metal, sacrificing itself to protect the other metal
➜The sacrificial metal loses electrons in preference to the less reactive metal, preventing it from reacting and hence corroding
➜Example: Magnesium is chemically attached to iron to prevent it from rusting by sacrificing itself.
➜ Similarly coating a layer of Zinc specifically, as a means of sacrificial protection is called galvanising.
➜ Very reactive metals such as Sodium and Potassium are not used in the process of sacrificial protection, because they will be quickly used up in violent and explosive reactions and need to be replace very often.

- Steel

➜ Molten Iron is brittle so it is converted into steel to strengthen it
➜ Molten Iron contains impurities such as carbon, phosphorus and silicon
➜ The molten iron is transferred to a tilting furnace
➜ Oxygen and powdered calcium oxide are added
➜ The oxygen reduces the impurities to their oxides
➜ CO_2 and SO_2 escape as gases
➜ The acidic silicon and phosphorus oxides react with calcium oxide to form slag, mainly calcium silicate
➜ Slag floats on the iron and the molten iron is removed
➜ Ease of obtaining metals from their ores is related to their position in the reactivity series
- The method of extracting a metal depends upon its position in the reactivity series
- Metals placed higher up on the series i.e above carbon, are to be extracted using electrolysis while metals in the lower half can be extracted by heating with carbon

- Uses of Metals

➜ Aluminium is used in the manufacture of overhead electrical cables because of its low density and good electrical conductivity
➜ Copper in electrical wiring because of its good electrical conductivity and ductility

UNIT 10: CHEMISTRY OF ENVIRONMENT

- Water

➜ Water can be chemically tested by adding it to anhydrous cobalt (II) chloride which turns from blue to pink in presence of water, and copper (II) sulfate turns from white to blue
➜ Pure water can also also tested by using its melting and boiling points
➜ Untreated water has different soluble and insoluble impurities
➜ Water from natural resources may contain substances including dissolved oxygen, metal compounds, plastics, sewage, harmful microbes, nitrates and phosphates from fertilisers, and detergents
➜ This is why distilled water is used in practical chemistry; it contains fewer chemical impurities
➜ Large insoluble particles are removed by filtration by passing water through layers of sand and gravel filters
➜ Chlorine is passed through water to kill bacteria by chlorination
➜ Carbon is used to remove odours and tastes from water
➜ Algae, and other larger plants, release oxygen directly into the water where it is used by fishes and other aquatic organisms
➜ Dissolved oxygen is also considered a measure of water quality, as when it becomes too low, aquatic life cannot survive
➜ Some metal compounds, including mercury, lead, chromium, cadmium, and arsenic, are toxic, and long exposure to such can cause harm to humans
➜ In the ocean, plastic debris injures and kills fish, seabirds, and marine mammals
➜ Sewage contains microbes that can cause intestinal, lung, and other infections
➜ Elevated levels of phosphate and nitrates can result in an increased growth of algae and other aquatic plants, reducing dissolved oxygen levels, which can be very harmful for aquatic life

Air & Atmosphere

➜ The composition of air is 78% nitrogen, 21% oxygen, 0.9% argon and others

- Air Pollution

➜ Carbon monoxide: produced by incomplete combustion, it is poisonous and combines with blood and prevents oxygen from being carried by the blood
➜ Sulfur dioxide: produced by combustion of fuels and volcanos, causes acid rain
➜ Oxides of nitrogen: produced in car exhausts or furnaces, cause acid rain
➜ Methane: produced by decay of organic matter, increase greenhouse effect
➜ Carbon dioxide: produced from the complete combustion of carbon-containing fuels

- Effects of air pollutants

➜ Carbon monoxide: toxic gas
➜ Particulates: increased risk of respiratory problems and cancer
➜ Oxides of nitrogen: acid rain, photochemical smog and respiratory problems
➜ Sulfur dioxide: acid rain

- Photosynthesis

➜ Carbon Dioxide + Water → Glucose + Oxygen
➜ $6CO_2 + 6H_2O \rightarrow C_6H_{12}O_6 + 6O_2$

- Catalytic Converters

➜ Car engines produce air pollutants like oxides of nitrogen and carbon monoxide
➜ Catalytic converters are used to make the gases harmless
➜ Platinum and rhodium are used as catalysts to speed up reactions
➜ The catalysts force the harmful gases to react with oxygen to produce harmless gases
➜ The oxides of nitrogen produce nitrogen gas N_2, and carbon monoxide and hydrocarbons form CO_2

- Fertilisers

➜ Fertilisers contain nitrogen, phosphorus and potassium
➜ These promote plant growth and are used to increase crop yield
➜ Alkali substances can displace ammonia from its salts
➜ Farmers add calcium hydroxide to soil to decrease acidity
➜ If too much is added, ammonia will be displaced from fertiliser, making the fertiliser ineffective

- Greenhouse gases

➜ Greenhouse gases like carbon dioxide and methane trap radiation in the environment
➜ The Sun radiates heat to the Earth and the Earth reflects it. However, these gases trap it, causing greenhouse effect, resulting in global warming
➜ Carbon dioxide is produced by the combustion of wood and fuels, respiration, and reactions between acids and carbonates
➜ Methane is produced by digestive processes, decay of vegetable matter and bacterial action in swamps
➜ It causes climate change which has many consequences, such as extinction of species due to loss of natural habitats

UNIT 11: ORGANIC CHEMISTRY

➜ Organic compounds are those which contain carbon
➜ Metal carbonates, carbon dioxide, and carbon monoxide are not organic
➜ Hydrocarbons are compounds that contain carbon and hydrogen only
➜ General formula is a formula that tells the ratio of elements in a compound of a homologous series
➜ Structural formula is an unambiguous description of way the atoms in a molecule are arranged
➜ Hydrocarbons can undergo combustion in the presence of oxygen
➜ In complete combustion, when oxygen is in excess, carbon dioxide and water is produced
➜ In incomplete combustion, when oxygen is limited, carbon monoxide and water are produced

- Fractional Distillation of Crude Oil

➜ A fuel is a substance that releases energy when burnt, which can then be used to create electricity
➜ Petroleum or crude oil is a mixture of hydrocarbons
➜ Petroleum itself isn't very useful but its fractions have many uses and can be separated by fractional distillation
➜ The boiling point and viscosity of each fraction increases along with the length of its carbon chain
➜ The distillation is carried out in a fractionating column which is hot at the bottom and cool at the top
➜ Crude oil enters the column and is heated; vapours rise up the column
➜ Fractions with high boiling points will condense immediately and settle at the bottom of the column
➜ Fractions with lower boiling points will rise to the top of the column before condensing
➜ The different fractions condense at different heights according to their boiling points and are tapped off accordingly

- Fractions and their uses in increasing order of boiling point

➜ Refinery gas: heating and cooking
➜ Gasoline/Petrol: fuel for cars
➜ Naphtha: raw product for producing chemicals
➜ Kerosene/Paraffin: jet fuel
➜ Diesel: fuel for diesel engines
➜ Fuel oil: fuel for ships and for home heating systems
➜ Lubricating oil: for lubricants, polishes, waxes
➜ Bitumen: for surfacing roads

Homologous Series

➜ A homologous series is a family of organic compounds that have similar features and chemical properties due to sharing the same functional group
➜ All members of a homologous series have the same general formula, same functional group, similar chemical properties, a graduation in physical properties, and differ from one member to the next by a $-CH_2-$ unit

- Name Prefixes

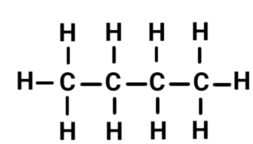
➜ The initial name of an organic compound is decided by the number of carbon atoms it has

Name Prefix	Number of Carbon Atoms
Meth-	1
Eth-	2
Prop-	3
But-	4
Pent-	5
Hex-	6
Hept-	7
Oct-	8
Non-	9
Dec-	10

- Alkanes

➜ Alkanes are a series of hydrocarbons which have only carbon-carbon single bonds
➜ There are no C-C double bonds
➜ They are saturated hydrocarbons as all the bonds are single bonds
➜ The general formula of alkanes is C_nH_{2n+2}
➜ They are mostly colourless and unreactive
➜ They can undergo combustion in the presence of oxygen
➜ They can undergo cracking to form an alkene and an alkane or alkenes and hydrogen gas
➜ They react with halogens in presence of light; the halogen displaces hydrogen atoms in a substitution reaction

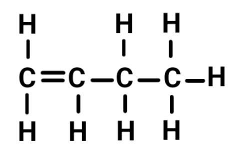
Example of Butane:



- Alkenes

➜ A homologous series of compounds which contain a carbon-carbon double bond
➜ They have the general formula C_nH_{2n}
➜ They are unsaturated hydrocarbons and decolourise bromine water
➜ The carbon-carbon double bond is the functional group of alkenes
➜ Alkenes can be produced by the catalytic cracking of molecules with larger carbon chains
➜ Alkenes can form additional polymers like poly(ethene)
➜ Alkenes undergo addition reactions where simple molecules are added across the C-C double bond
➜ Alkenes can undergo hydrogenation, which is the addition of hydrogen at a temperature of 150°C with nickel as a catalyst
➜ Hydrogenation is used to make margarine from vegetable oils
➜ Alkenes can also undergo hydration, in which an alkene reacts with water to produce an alcohol; it occurs at 330°C, a pressure of 60-70 atm, and the use of phosphoric acid as a catalyst

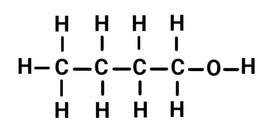
Example of Butene:



- Alcohols

➜ Alcohols are a homologous series with the functional group -OH
➜ Alcohols can undergo combustion in excess oxygen
➜ Alcohols can be produced by the hydration of alkenes
➜ They can also be produced by the fermentation of glucose

Example of Butanol:



- Fermentation

➜ Sugar/starch solution is added to yeast
➜ The mixture is left in the absence of oxygen for a few days at 25-35°C
➜ Yeast breaks down the sugar or starch into glucose
➜ At very low temperatures, the rate of reaction will be too slow
➜ At very high temperatures, the enzymes will be denatured
➜ The yeast respires anaerobically
➜ The yeast dies when alcohol reaches a high concentration. Hence, it is done in a batch process, which reduces efficiency

- Carboxylic Acids

➜ Homologous series with the functional group -COOH
➜ They are colourless liquids and weak acids
➜ The carboxylic acids partially ionise in water, and release hydrogen ions in a reversible reaction
➜ They can react with high reactivity metals, metal carbonates and metal hydroxides
➜ They react in the same way as acids do to produce salts

- Esters

➜ Alcohols and carboxylic acids react to form esters
➜ Esters have the functional group -COOH
➜ They are sweet smelling liquids used for flavouring and perfumes
➜ When an alcohol is added to a carboxylic acid, the alcohol loses a hydrogen H^+ ion and the carboxylic acid loses a hydroxide OH^- ion, which form water
➜ The place where the H^+ and OH^- ions breaks off join together to form an ester
➜ The carbon from the carboxyl group of the carboxylic acid will bond with the oxygen in the alcohol's hydroxyl group
➜ The ester is named according to the alcohol and carboxylic acid it was made from
➜ (prefix for number of carbon atoms in alcohol)-yl (prefix for the number of carbon atoms in the acid)-anoate

- Isomers

➜ Isomers are compounds with the same molecular formula but different structural formulae
➜ This could either be because of the carbon chain or the position of the functional group
➜ If a compound has more than 3 carbon atoms, the carbon chain can be rearranged so that all the carbons atoms are not connect directly, but rather, with branches
➜ For example, in butane, the fourth carbon atom may be attached to the second carbon atom instead of the third
➜ The name of these isomers will be (prefix for the number carbon atoms in the smaller chain)-yl (name of the longer straight chain)
➜ If the functional group is attached to some carbon atom in the middle instead of a straight chain, that is also an isomer and is named by putting the number of the carbon atom to which the group is attached before the name or before the group such as 1-butanol or butan-1-ol

Polymers

➜ Polymers are large molecules made by linking smaller molecules called monomers
➜ Each repeating unit is connected to the next by a covalent bond
➜ There are two types of polymers: natural and synthetic.
➜ Synthetic polymers are man made and have many uses
➜ Polymers can be recycled but it is difficult and expensive

- Addition Polymerisation

➜ Addition polymers are made by joining many identical monomers
➜ For additional polymerisation, the monomers must have C=C double bonds, like alkenes do
➜ The double bond breaks into a single bond, and a new bond is formed with the adjacent monomer
➜ The name of the polymer is written as poly(monomer's name)
➜ In additional polymerisation, no other products are formed

- Condensation Polymerisation

➜ In condensation polymerisation, a small molecule is removed from the monomer during the reaction, which is usually water
➜ It involves two different monomers with a functional group at each end
➜ Hydrolysing a condensation polymer can return it to its monomers

- Deducing polymers and monomers

➜ Repeating units are used to display the formula
➜ Convert the double bond into a single bond in the repeating unit
➜ Put it in brackets and draw an extended line at each end to show extension bonds
➜ Write a small n at the bottom right to show an n number of units
➜ To draw the polymer, connect multiple repeating units with each other, joining the extension bonds with each other
➜ To deduce the monomer from the polymer, change the single bond into a double bond after identifying the repeating unit and remove the adjacent bonds

- Plastics:

➜ They are synthetic polymers
➜ Examples: nylon, terylene, PVC, etc
➜ Nylon is used for clothing, ropes and fabrics
➜ Terylene is mixed with cotton for clothing
➜ Synthetic polymerisation also includes plastics
➜ Polyethene is used for plastic bags and bottles
➜ Polypropene is used for food packaging, ropes and carpets
➜ Poly chloroethene/PVC is used for plastic sheets, pipes and insulation
➜ They are non-biodegradable: cannot be broken down by the action of microorganisms
➜ They are sturdy and strong substances

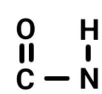
- Issues related to Plastics:

➜ Plastics often end up being washed away or dumped into oceans where they accumulate and harm marine life
➜ They fill up space in landfills and microorganisms can not break them down
➜ On burning they produce carbon dioxide which is greenhouse gas
➜ They produce carbon monoxide by incomplete combustion which is poisonous

- Nylon

➜ Nylon is a polyamide polymer
➜ It is made from the monomers dicarboxylic acid (-COOH) and diamine (-NH_2)
➜ The functional group must be on both ends of the monomer
➜ COOH loses its OH
➜ NH_2 loses one of its H

Nylon

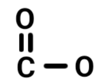


➜ The OH and H form water and an amide linkage is formed between the COO and NH

- Terylene

➜ Terylene is a polyester, which is also called PET (polyethylene terephthalate)
➜ It is made from the monomers dicarboxylic acid (-COOH) and diol (-OH)
➜ The functional group must be on both ends
➜ COOH loses its OH
➜ OH loses its H
➜ OH and H form water and ester linkage is formed between CO and O

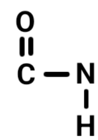
Terylene



- Proteins

➜ Proteins are the building blocks of cells and are essential for growth
➜ They are a natural condensation polymer
➜ They are formed by amino acid monomers
➜ They have peptide linkages, which is similar to nylon
➜ Amino acids contain NH_2 and COOH functional groups
➜ Most proteins contain more than 20 different amino acids
➜ COOH loses OH, NH_2 loses H, and water is formed
➜ CO bonds with NH to form peptide linkage

Proteins



UNIT 12: EXPERIMENTAL TECHNIQUES

Measurements

- Temperature

➜ Temperature can be measured using a thermometer
➜ Digital thermometers are more accurate than liquid-in-glass thermometers
➜ Temperature is measured in degrees Celsius ℃

- Time

➜ A stopwatch can be used to measure time
➜ Time is measured in seconds and/or minutes
➜ There are 60 seconds in 1 minute

- Mass

➜ A digital balance is used to measure mass
➜ Mass is measured in grams (g) and/or kilograms (kg)
➜ 1kg = 1000g

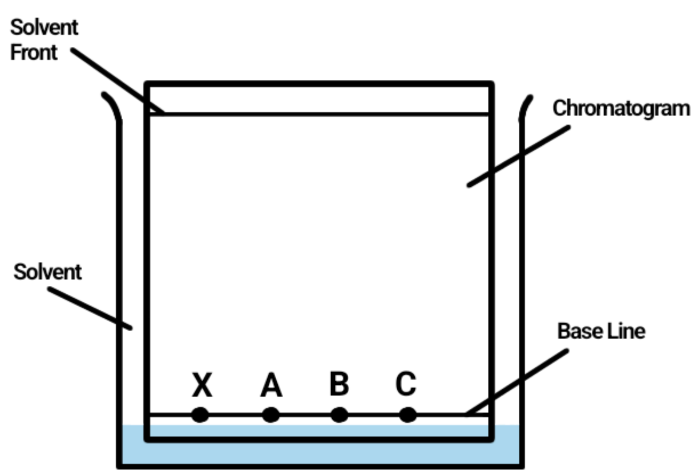
- Volume

➜ Different instruments can be used for a different level of accuracy
➜ Measuring cylinders/graduated cylinders are used when accuracy is not important
➜ For very accurate measurements, a pipette or burette can be used
➜ Pipettes can accurately measure $10cm^3$ or $25cm^3$ of a liquid
➜ Burettes can accurately measure a changing volume of liquid between 0 to $50cm^3$
➜ A gas syringe is commonly used to measure the volume of a gas➜ Insoluble gases can be measured with a graduated flask in water

Purity Checking and Separation Techniques

- Paper Chromatography

➜ Chromatography is used to separate substances with different solubilities
➜ A baseline is drawn on a chromatogram using a pencil
➜ Drops of the mixture to be tested and known samples are placed on the line
➜ The paper is then lowered into a solvent up until the solvent front
➜ The solvent moves up the paper and takes some of the dissolved substances with it
➜ The substances will travel different distances according to their solubilities
➜ More soluble substances will travel further
➜ The solvent will leave spots on the chromatogram
➜ If two spots travel the same distance on the chromatogram, it means they are the same substance
➜ If a known substance matches with one in the mixture, the known substance is present in the mixture
➜ Pure substances will have only one spot
➜ The Retention Factor / Rf value of a substance is calculated by dividing the distance travelled by the substance by the distance travelled by the solvent
➜ Rf values are compared to see what substances a mixture includes
➜ If the Rf values match for two spots, they are the same substance
➜ Some spots are colourless; a locating agent is sprayed to see the spot
➜ All substances must be soluble for chromatography



- Filtration

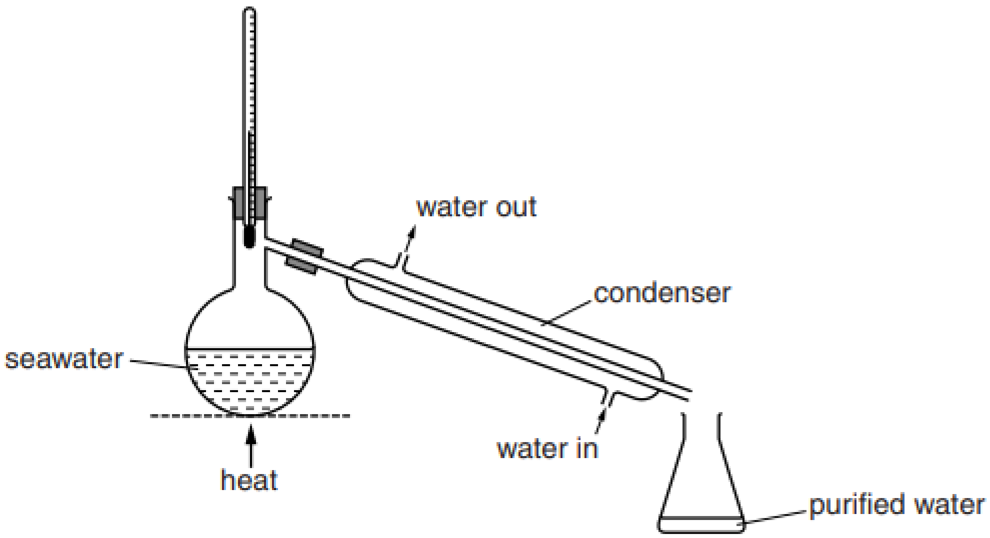
➜ Filtration is used to separate an insoluble substance from a soluble substance
➜ A solvent is added to the mixture and stirred so that all of the soluble substance is dissolved
➜ The solvent is passed through a filter paper in a filter funnel above a container e.g. a beaker
➜ The insoluble solid can not pass through the filter paper, and will be left as residue
➜ The solution will pass through the paper into the container as the filtrate

- **Crystallisation**

➜ It is used to obtain a solid dissolved in a solution
➜ The solution is heated; some of the solvent evaporates and the solution becomes saturated when the amount of solute and solvent in the solution become the same
➜ It is heated till the saturation point is reached
➜ To test for saturation, a glass rod is dipped in the solution; if crystals form on it, the solution is saturated
➜ The saturated solution is then left to cool
➜ The solubility will decrease and the solid will crystallise
➜ Filter the crystals, wash with distilled water to remove impurities, and dry

- **Simple Distillation**

➜ It is used to separate a liquid and a soluble solid from a solution
➜ The solution is heated to the boiling point
➜ The liquid evaporates and rises up the flask
➜ The vapours then pass through a condenser, where they are condensed into a liquid, which is collected is collected in a flask
➜ The solid remains in the original flask after all the liquid is evaporated
➜ In crystallisation the liquid is lost; in distillation, both the solid and liquid are collected



- **Fractional Distillation**

➜ Used to separate a mixture of different liquids of different boiling points
➜ The solution is heated to the lowest boiling point of one of the liquids
➜ The substance will evaporate and rise
➜ The vapours will be passed through a condenser and the fraction will be separated in a flask
➜ The temperature will not increase until that fraction is fully separated
➜ When the temperature begins to rise past the boiling point of the liquid with the highest boiling point, heating should be stopped

A Note from Mojza

These notes for Chemistry (5070/0620) have been prepared by Team Mojza, covering the content for GCE O levels and IGCSE 2023-25 syllabus. The content of these notes has been prepared with utmost care. We apologise for any issues overlooked; factual, grammatical or otherwise. We hope that you benefit from these and find them useful towards achieving your goals for your Cambridge examinations.

If you find any issues within these notes or have any feedback, please contact us at support@mojza.org.

Acknowledgements

Authors:
Hussain Ahmed Moghal
Syed Muhammad Shaheer Ali
Fatimah tuz Zehra
Aroush Amir Ali

Proof-readers:
Hadiya Farrukh
Aroosham Mujahid
Ali Irfan
Zoella Ahmad
Fasiha Raza

Designers:
Mussarat Fatima
Hussain Ahmed Moghal