MODULE: 045

DIVERSITY AND INTERACTIONS OF SUBSTANCES

SUBSTANCES

Elements

Metals

They lose their valence electrons from the outermost energy level to form positively charged ions (Cations). Eg; sodium, Potassium, Calcium, Magnesium and Aluminium {Except hydrogen}

Non-metals

They gain electrons in their outermost energy level to form negatively charged ions (Anions). Eg. Chlorine, Oxygen and Nitrogen.

Properties of Metals

- They have shiny surfaces.
- They conduct heat.
- They conduct electricity.
- They can be malleable and ductile, allowing them to be shaped into sheets and wires.
- They have a high density.

Properties of Non-metals

- They are generally lighter than metals.
- Low Melting & Boiling Points – Many non-metals exist as gases or liquids at room temperature.
- Non-Sonorous – They do not produce a ringing sound when struck.
- They do not conduct heat or electricity well (except graphite).

Compounds

Covalent compounds

They are formed by equal sharing of electrons between non-metal atoms to form a covalent bond. Eg; Carbon dioxide, Hydrogen chloride and Dihydrogen oxide (water)

Ionic compounds

They are formed by transfer of valence electron(s) from a metal atom to a non-metal atom to form an ionic bond between them. Eg; Sodium chloride, Calcium oxide, Iron (III) oxide and Sodium oxide

Properties of Covalent compounds

- Low Melting & Boiling Points.
- They do not conduct electricity well, as they lack free-moving ions.
- Many covalent compounds form soft or brittle solids rather than hard crystalline structures.
- Most covalent compounds do not dissolve in water unless they are polar. But more soluble in organic solvent.

Properties of Ionic compounds

- Have High Melting & Boiling Points.
- Crystalline Structure – Ionic compounds form well-organized crystal lattices.
- They do not conduct electricity in solid form but become good conductors when dissolved in water or melted.
- Many ionic compounds dissolve in water

Materials

Packaging Materials

Natural Packaging Materials

They exist on their own without man's influence. Eg. Cellulose in wood used to make paper bags.

Artificial Packaging Materials

They are synthesized by man. Eg polyethene bags, aluminum tins, Plastic and Glass bottles.

Building Materials

Natural Building Materials

They exist on their own without man's influence. Eg. Rocks (Gravel), Water, Wood (Timber), Sand, .

Artificial Building Materials

They are synthesized by man. Eg Iron bars, Paint, Poly vinyl Chloride pipes (PVC Pipes), Cement, Dump proof polyethene sheet, Glass, Nylon ropes

Clothing Materials

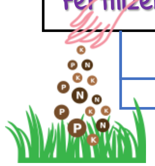
Natural Clothing Materials

They exist on their own without man's influence. Eg. Natural cotton wool, silk wool, Animal-based wool (from sheep). Linen (from the fibers of the flax plant.)

Artificial Clothing Materials

They are synthesized by man. Eg polyester, nylon, acrylic, and PVC.

Fertilizers



Synthetic Fertilizers

They are synthesized by man in the laboratory. Eg. Urea, NPK, Ammonium phosphate

Organic Fertilizers

They are made from plant and animal wastes Eg. Animal Manure

Environmental Impacts of paper bags

- When paper bags are burnt as rubbish, they release acidic gases like Carbon dioxide gas, when highly concentrated in the atmosphere react with rain water to form acid rain which alters the soil pH on reaching the ground, making the pH acidic, this affects plant growth.. This can be mitigated by recycling paper bags after use.
- Massive production of paper bags leads to increased rate of deforestation, this leads to desertification, due to the reduction of convection rainfall. This can be mitigated by practicing afforestation and reforestation.

Environmental Impacts of polyethene bags

- When polyethene bags are disposed in soil they block water from infiltrating the soil layers, this lowers the soil drainage capacity hence affecting plant growth. This can be mitigated by recycling and re-using the polyethene bags after use.
- Polyethene bags once disposed in water bodies release toxic substances and microplastics. These chemicals can be absorbed by aquatic organisms, hence affecting their life. This can be mitigated by using environmental friendly packaging materials like paper bags

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MODULE: O41

NATURAL RESOURCES

- Rocks and minerals.
- Water
- Air
- Fossil fuels.
- Plants (vegetation/forests)

NATURAL RESOURCES

RENEWABLE NATURAL RESOURCES. Eg trees, water and Air.

They **can be replaced** once used-up by natural processes in a short period of time within man's life-time.

- **Trees** are composed of carbohydrates like: **cellulose** and **starch**, which are compounds of carbon, hydrogen and oxygen.
- **Water** is a compound of elements such as **Hydrogen** and **Oxygen**.
- **Air** is a mixture of gases such as; Oxygen, carbon dioxide, nitrogen, and rare gases.

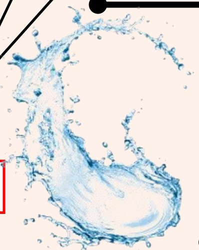
NON-RENEWABLE NATURAL RESOURCES. Eg Rocks and minerals, fossil fuels

They **can not be replaced** once used-up by natural processes in a short period of time within man's life-time.

- **Rocks are composed of minerals:**

Sedimentary rocks such as limestone are composed of **calcite**, a carbonate mineral containing Calcium carbonate, a compound of elements like Calcium, Carbon and Oxygen.
Metamorphic rocks such as Quartzite are composed of minerals like **Quartz** which contains Silicon (iv) oxide.
Igneous rocks such as Granite is composed of minerals like **Quartz**, **feldspar** and **mica**.

Crude oil is a fossil fuel composed of **hydrocarbons**, the **Alkanes** known to contain Hydrogen and Carbon only. And other Organic compounds which may contain nitrogen, Oxygen and Sulphur.
Coal is a fossil fuel composed of largely **Carbon** and other compounds containing Oxygen, Nitrogen and Sulphur.
Natural gas is a fossil fuel primarily composed of **methane**, but also includes smaller amounts of other hydrocarbons like **ethane**, **propane**, **butane** and **pentane**, known to contain carbon and hydrogen.

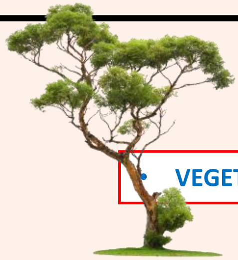


• WATER:

Industrialization, industries release harmful wastes in the water body, resulting into water pollution, affecting its quality (smell and appearance) leading to the death of aquatic animals (loss of biodiversity).. This can be mitigated by treating waste water from industries before being discharged.

Establishing agricultural plantations near water bodies, promotes runoff of inorganic fertilizers (Nitrates and Phosphates) into water bodies in case of rainfall. This leads to the rapid growth of algae in water, which lowers water quality.

Washing near water bodies promotes water pollution, since some of the washing agents are non-biodegradable, and contains chemical substances that can alter water pH. (making the pH high since soap solution is alkaline). This can be mitigated by establishing strict laws against washing along the shorelines of the water bodies.



• VEGETATION/TREES:

Deforestation, clearing of vegetation brings about drought and desertification which occurs when the amount of water vapour contributing to rain formation is reduced; mitigated by plant more trees, vegetation. (practicing agroforestry).

Bush burning during land preparation in agricultural plantations leads to global warming which occurs when green house gases like carbon dioxide are leased and accumulate in the atmosphere, mitigated by slashing/digging the bush during land preparation instead of burning.

Charcoal burning, involves burning of wood to make charcoal to be used as fuel, this leads to emission of acidic gases like carbon dioxide into atmosphere, which when highly concentrated in the atmosphere leads to acid rain, as if falls on ground it can alter soil pH making it acidic hence affecting plant growth (or when it falls in water bodies it laters water pH, thus affecting aquatic life). This can be mitigated by using environmental friendly source of energy, such as hydro electric power.

• FOSSIL FUEL:

Transportation using fuel powered vehicles leads to burning of fossil fuels in vehicle engines, releasing carbon dioxide which can result into acid rain that interferes with the soil pH, hence affecting plant growth, also leads to global warming. This Mitigated by increased afforestation such that the trees absorb carbon dioxide.

Oil spills by oil transporting ships into the water bodies in case of accidents, can cut off oxygen supply causing suffocation of aquatic animals, and deterioration of water quality.
Mitigated by doing regular inspection and maintenance on the oil transporting ships.

• AIR:

Industrialization leads to pollution of the air which occurs as a result of releasing waste gases from the industries into the atmosphere, this can lead to acid rain since some of the waste gases are acidic such as Sulphur dioxide and carbon dioxide. This can be mitigated by fitting catalytic converters in industrial chimneys transforms harmful gases into harmless.

Transportation using fuel powered vehicles, this involves release of exhaust fumes into atmosphere containing gases like carbon dioxide which leads to global warming caused as a result releasing greenhouse gases from burning carbon based fuels in vehicle engines; mitigated by using vehicles that run on renewable sources of energy eg electric cars.

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MODULE: 046

MANUFACTURING PROCESSES

ALUMINIUM

Materials

- Bauxite (the Ore).
- Sodium hydroxide.
- Cryolite

Process of extraction.

•Bauxite is ground into powder and heated in a steel container to convert any Iron (II) oxide impurity present into Iron (III) oxide and also to remove water of crystallization.

•The powder is then boiled with hot concentrated Sodium hydroxide solution that dissolves the amphoteric Aluminium oxide and acidic Silicon dioxide in the Ore forming Sodium aluminate and Sodium silicate in a container.

$$Al_2O_{3(s)} + 2NaOH_{(aq)} \rightarrow 2NaAlO_{2(aq)} + H2O_{(l)}$$
$$SiO_{2(s)} + 3NaOH_{(aq)} \rightarrow Na2SiO_{3(aq)} + H2O_{(l)}$$

•The undissolved basic Iron (III) oxide is filtered off.

•Carbon dioxide is bubbled through the filtrate to precipitate Aluminium hydroxide leaving silicate ions in the solution.

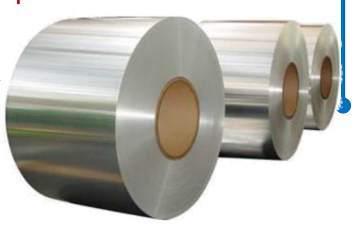
•Aluminium hydroxide is washed, dried and strongly heated to produce Aluminium oxide.

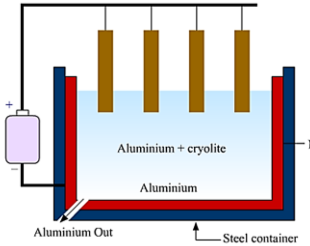
Electrolysis of Aluminium Oxide.

- Aluminium oxide is placed in the electrolytic cell and heated with cryolite.
- Cryolite is used in the electrolysis of aluminium oxide for two main reasons: to lower the melting point of the mixture and to increase its conductivity.
- Molten aluminium oxide, Using graphite electrodes in an Iron bath lined with Graphite.

At the cathode; $Al^{3+}{}_{(l)} + 3e^- \rightarrow Al_{(l)}$

At the Anode; $2O^{2-}{}_{(l)} \rightarrow O_2{}_{(g)} + 4e^-$





Extraction of aluminium

IRON

Materials:

- Iron ore (Heamatite)
- Coke.
- Limestone (calcium carbonate).

Process of extraction:

- Iron ore, coke and limestone are fed into the blast furnace from the top.
- Hot air is fed into the furnace from the bottom at about 1000 ºC.
- Carbon (coke) is oxidized by hot air to carbon dioxide gas:

$$C_{(s)} + O_{2(g)} \rightarrow CO_{2(g)}$$

- Carbon dioxide gas produced is reacted with excess or unreacted coke producing carbon monoxide gas.

$$CO_{2(g)} + C_{(s)} \rightarrow 2CO_{(g)}$$

- The carbon monoxide produced reduces the Haematite to iron.

$$Fe_2O_{3(s)} + 3CO_{(g)} \rightarrow 2Fe_{(s)} + 3CO_{2(g)}$$

- Limestone decomposes to calcium oxide and carbon dioxide gas.

$$CaCO_{3(s)} \rightarrow CaO_{(s)} + CO_{2(g)}$$

- The Calcium oxide combines with silica (Silicon dioxide) impurity to form slag (calcium silicate).
- The slag sinks to the bottom and floats on iron, protecting the iron from being re-oxidized hot air.
- **Purification:** Pure iron is obtained by passing air through molten iron to remove non-metal impurities.
- NOTE: Lime stone is used in the removal of impurities. E.g silicon dioxide (silica).

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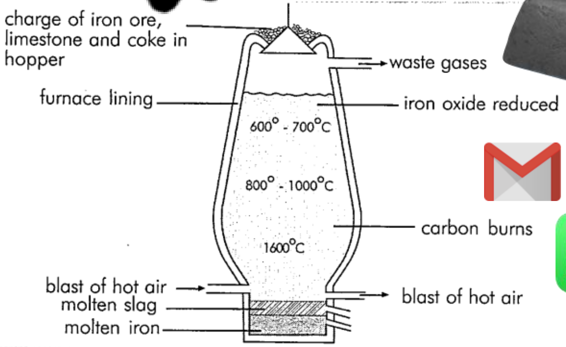

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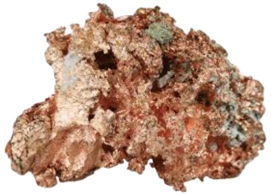
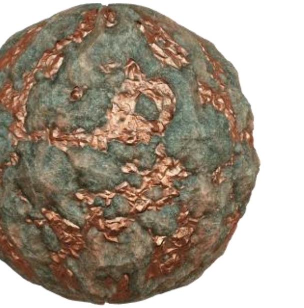
Copper

Materials

- Copper pyrites
- Silicon dioxide
- Oil
- Acidified copper(II) sulphate solution.





Process of extraction

a) **Concentration of the ore:**

The ore is crushed and ground to fine powder, mixed with oil and water in a steel tank to remove impurities.

- Compressed air is blown through the mixture in the tank a process known as froth flotation, to agitate the mixture.
- Oil coated particles of the ore float on top of the tank and are skimmed off and dried.

b) Reduction or roasting of the ore:

- Copper pyrites are roasted in a furnace to form copper(I) suphide, iron(II) oxide and Sulphur dioxide gas.

$$2CuFeS_{2(s)} + O_{2(g)} \rightarrow Cu_2S_{(s)} + 2FeO_{(s)} + 3SO_{2(g)}$$

- Silicon dioxide is added to the furnace. Where it reacts with iron(II) oxide to form iron(II) silicate, slag leaving behind the copper(I) sulphide.

The copper(I) sulphide is heated strongly in a furnace with limited supply of oxygen to form impure copper and Sulphur dioxide gas

c) Purification:

The impure copper is purified by electrolysis using impure copper as anode and pure copper as cathode in an electrolyte cell containing acidified copper(II) sulphate solution as electrolyte.

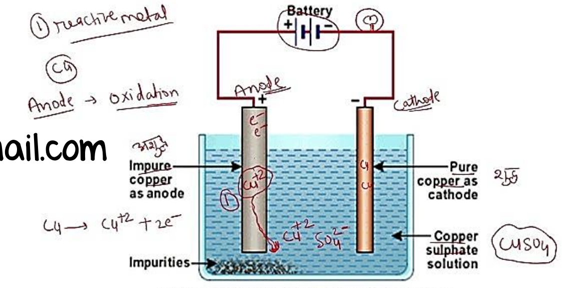
- Impure copper dissolves to form copper(II) ions and pure copper is deposited at the cathode.

At the cathode, copper(II) ions are deposited as copper.

$$Cu^{2+}{}_{(aq)} + 2e^- \rightarrow Cu_{(s)}$$

At the anode, copper goes into solution as copper(II) ions.

$$Cu_{(s)} \rightarrow Cu^{2+}{}_{(aq)} + 2e^-$$



Experimental set up for the electrolytic refining of copper.

CEMENT

Materials
- Limestone
- Clay, shale
- Silica
- Iron oxide

Process Of Production
- The raw materials are run through a crusher and milled into fine powder.
- The powders are blended and pre-heated to around 900°C in a rotary kiln using hot gases. The pre-heating burns off impurities.
- The material is burnt in a large rotary kiln at 1500 °C.
- The rotary kiln continuously mixes the ingredients and distributes heat uniformly on limestone to decompose it to Calcium oxide so that carbon dioxide is driven off, forming clinker.

$CaCO_{3\,(s)} \rightarrow CaO_{(s)} + CO_{2(g)}$

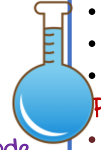
- The clinker is then cooled and ground to a fine powder in a rotating drum filled with steel balls of different sizes – depending on the desired fineness of the cement, that crush and grind the clinker.
- Gypsum is added during the grinding process to moderate or control the 'setting' of the cement.
- The cement is then bagged ready for sale, transportation and use.

CHLORINE GAS

Raw material
Concentrated sodium hydroxide solution (brine).
Graphite.
Mercury.

Process Of Production
- Brine is electrolyzed in an electrolytic cell having graphite anode and mercury cathode.
- During the electrolysis, chloride and hydroxide ions migrate to the anode.
- Chloride ions are preferentially discharged by electron loss to form chlorine gas due to their high concentration.
- At the Anode: $2Cl^-_{(aq)} \rightarrow Cl_{2\,(g)} + 2e$
- The chlorine formed is dried, liquefied and stored in tightly closed tanks.

SODIUM HYDROXIDE

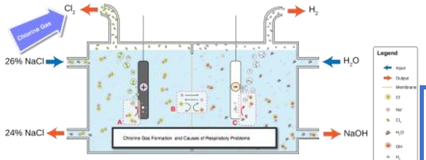


Materials
- Concentrated sodium hydroxide solution (brine).
- Graphite.
- Mercury.

Process Of Production
- Brine is electrolyzed in an electrolytic cell having graphite anode and mercury cathode.
- During the electrolysis, Sodium ions and hydrogen ions migrate to the cathode.
- Due to high concentration of sodium hydroxide, sodium ions are discharged in preference to hydrogen ions by electron gain to form sodium metal.
- Cathode (negative electrode): mercury flowing along bottom of cell

$Na^+_{(aq)} + e^- \rightarrow Na_{(s)}$

- The sodium metal dissolves (combines with) in mercury to form sodium amalgam which is reacted (dissolved in) with water to form sodium hydroxide solution, hydrogen and mercury. Mercury is fed back into the cell for re-use as the cathode.
- The sodium hydroxide solution is evaporated to dryness to molten sodium hydroxide and cooled to form solid sodium hydroxide.



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SULPHURIC ACID

Raw materials
- Sulphur.
- Oxygen.
- Vanadium(v) oxide.
- Water.

Process of production.
- Sulphur is heated strongly or roasted in a closed cylinder to produce Sulphur dioxide gas.
  - $S_{(s)} + O_{2(g)} \rightarrow SO_{2(g)}$
- Sulphur dioxide is further reacted with excess oxygen in presence of vanadium(v) oxide catalyst at 400 °C– 500 °C and 1-2 atmospheres in a closed cylinder to produced sulphur trioxide gas.
  - $2SO_{2(g)} + O_{2(g)} \rightarrow 2SO_{3(g)}$
- Sulphur trioxide gas is bubbled in a tank containing concentrated sulphuric acid to form oleum.
- Oleum is diluted with appropriate volume of water to produce sulphuric acid which is stored in storage tanks.

$2SO_{3(g)} + H_2SO_{4(aq)} \rightarrow H_2S_2O_{7(l)}$

$H_2S_2O_{7(l)} + H_2O_{(l)} \rightarrow H_2SO_{4(l)}$

- The sulphuric acid is then stored in the storage tanks.

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LIME
- Limestone is grounded into fine particles, then fed into a kiln, heated at about 900°C to form quick lime.
- $CaCO_{3(s)} \rightarrow CaO(s) + CO_{2(g)}$
- The quick lime (calcium oxide) formed is then cooled, added to water forming slake lime (Calcium hydroxide) in a sealed reactor tank.
- $CaO_{(s)} + H_2O_{(l)} \rightarrow Ca(OH)_{2(aq)}$
- The slake lime formed is passed through the purifiers to remove any impurities and water, concentrated and packed.

OXYGEN

Materials
- Air.
- Silica gel.
- Concentrated sodium hydroxide solution.

Process of production
- Air is passed through filters to remove smoke particles and dust particles.
- Air is passed through concentrated sodium hydroxide solution to absorb/ remove carbon dioxide, which is acidic.
  - $2NaOH_{(aq)} + CO_{2\,(g)} \rightarrow Na_2CO_{3\,(aq)} + H_2O_{(l)}$
- Air is free from Carbon dioxide is now passed through Silicon(IV) oxide (silica gel) to absorb water vapour.
- Carbon dioxide and water vapour are removed from air before it is liquefied because they solidify and block the apparatus.
- The air is now compressed at 200 atmospheres and allowed to cool by making it escape into a large space through a jet.
- The process of cooling is repeated several times to obtain liquid air at about –200°C.
- The liquid air is fractionally distilled using a fractionating column.
- Nitrogen boils off first because it has a lower boiling point (–196°C) leaving behind oxygen with a higher boiling point (–183°C).
- Both nitrogen and oxygen collected obtained contain traces of noble gases.
- Pure oxygen is then stored under pressure in steel cylinders.

FERTILIZERS

AMMONIA

Raw materials.
- Nitrogen gas
- Hydrogen gas.

Process of production
- Nitrogen gas from fractional distillation of liquid air is reacted with hydrogen gas from natural gas in a ratio of 1:3 respectively. This is done in a closed cylinder, at temperature (450 – 500 °C), and pressure of 200 atmospheres, with a finely divided Iron Catalyst.

$$N_{2(g)} + 3H_{2(g)} \rightleftharpoons 2NH_{3(g)}$$

Anhydrous ammonia is stored as a liquid under pressure for ease handling in cyliders.

Bio Gas

- Biogas can be made from agricultural waste, manure, sewage, food scraps, and plant material.
- The waste is crushed and mixed with water to form a slurry.
- The slurry is placed in an anaerobic digester, a sealed container where bacteria break down the organic matter..
- The bacteria produce methane (CH_4) and carbon dioxide (CO_2) as the main gases.Other gases like hydrogen sulfide (H_2S) may also be present.
- The biogas is collected in a gas storage chamber.
- Impurities like water vapor and hydrogen sulfide are removed to improve quality.
- The purified biogas can be used for cooking, heating, electricity generation, or even as vehicle fuel.The leftover material (digestate) is used as organic fertilizer.

AMMONIUM NITRATE

- Ammonium nitrate fertilizer is obtained from nitric acid and ammonia gas.
- During Haber process:
- Nitrogen obtained from air reacts with hydrogen from natural gas in a sealed container at 450°C and 200 atmospheres to form ammonia gas.
- The gas is then purified, liquefied and refrigerated.
  - $N_{2(g)} + 3H_{2(g)} \rightarrow 2NH_{3(g)}$
- During Catalytic Oxidation of ammonia: ammonia gas is oxidized to nitric oxide gas in a sealed container in the presence of platinum – rhodium catalyst.
- The nitric oxide gas then reacts with water to form Nitric acid.
  - $3NO_{2(g)} + H_2O_{(l)}\ 2HNO_{3(aq)} + NO_{(g)}$
- Both nitric acid and ammonia gas are heated in a neutralizer reactor tank to form ammonium nitrate as fertilizer, purified, concentrated and packed.
  - $NH_{3(g)} + HNO_{3(aq)} \rightarrow NH_4NO_{3(s)}$

UREA FERTILIZER

- Urea fertilizer is obtained from ammonia and carbon dioxide gas.
- During Haber process: nitrogen obtained from air with hydrogen from natural gas in a sealed container at temperatures of 450°C and pressure of 200 atmospheres to form ammonia gas.
- Ammonia gas is then purified, liquefied and refrigerated.

$$N_{2(g)} + 3H_{2(g)} \rightarrow 2NH_{3(g)}$$

- Both ammonia gas and carbon dioxide gas react in a sealed reactor tank to form Urea as fertilizer, purified, concentrated and packed.
- $2NH_{3(g)} + CO_{2(g)} \rightarrow H2NCONH_{2(s)} + H2O_{(l)}$

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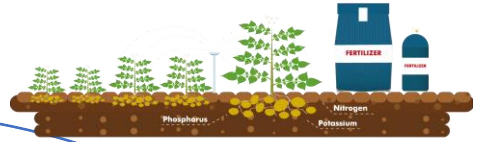
AMMONIUM SULPHATE FERTILIZER



- Ammonium sulphate fertilizer is obtained from Sulphuric acid and ammonia gas.
- During Haber process:
- Ammonia is produced by reacting nitrogen obtained from air with hydrogen from natural gas in a sealed container at temperatures of 450°C and pressure of 200 atmospheres forming dry ammonia gas.
- The gas is then compressed into liquid and refrigerated.

$$N_{2(g)} + 3H_{2(g)}\ 2NH_{3(g)}$$

- During Contact process: Sulphuric acid is produced by reacting sulphur in air to form sulphur dioxide gas; followed by catalytic oxidation of sulphur dioxide to form sulphur trioxide gas in a sealed reactor tank.

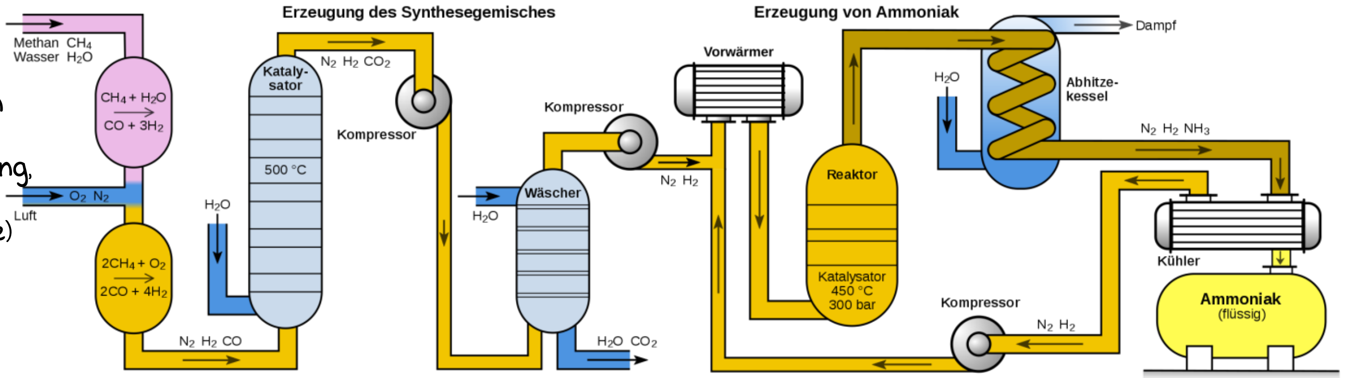
$$S_{(s)} + O_{2(g)} \rightarrow SO_{2(g)}$$
$$SO_{2(g)} + O_{2(g)} \rightarrow SO_{3(g)}$$

- The sulphur trioxide gas formed is then reacted in a sealed reactor tank containing concentrated Sulphuric acid to form Oleum, which is dissolved in water to form pure Sulphuric acid.

$$SO_{3(g)} + H_2SO_{4(L)} \rightarrow H_2S_2O_{7(L)}\ (Oleum)$$
$$H_2S_2O_{7(L)} + H_2O_{(l)} \rightarrow 2H_2SO_{4(aq)}$$

- Both Sulphuric acid and ammonia gas are heated in a sealed reactor tank to form ammonium sulphate as fertilizer, purified, concentrated and packed.

$$2NH_{3(g)} + H_2SO_{4(aq)} \rightarrow (NH_4)_2SO_{4(s)}$$



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ETHANOL

From Bananas

Raw material: bananas, sorghum, water

Process of production

- The bananas are covered after harvesting for about a week to ripen. (During Ripening, enzyme diastase convert the starch in banana to maltose).

$$\text{Starch} + H_2O_{(l)} \rightarrow C_{12}H_{22}O_{11(aq)}$$

- The ripe bananas are put in a wooden trough and then squeezed between spear grass to extract the juice from them while adding water.
- The mixture is filtered to obtain juice.
- Sorghum which has been roasted is added to the filtered juice and the mixture is stored.

- The mixture is then covered in a warm place to cut off oxygen supply to allow fermentation to occur.
- Yeast from fermented sorghum provides maltase enzyme which catalyses hydrolysis of maltose to glucose.

$$C_{12}H_{22}O_{11(aq)} + H_2O_{(l)} \rightarrow 2C_6H_{12}O_{6(aq)}$$

- Zymase enzyme from yeast catalyses the hydrolysis of glucose to ethanol which is crude

$$C_6H_{12}O_{6(aq)} \rightarrow 2C_2H_5OH_{(l)} + 2CO_{2(g)} + \text{Heat}$$

- The crude ethanol is purified by fractional distillation to obtain pure ethanol.

From Cassava

- Cassava is ground in a mortar and mixed with water to form starch solution in a steel container.
- Malt is added to starch solution, and diastase enzyme in malt hydrolyses starch to maltose.

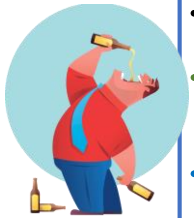
$$\text{Starch} + H_2O_{(l)} \rightarrow C_{12}H_{22}O_{11(aq)}$$

- Yeast is then added to the mixture.
- Yeast contains two enzymes, maltase and zymase.
- Maltase catalyses the hydrolysis of maltose to glucose as below.

$$C_{12}H_{22}O_{11(aq)} + H_2O_{(l)} \rightarrow 2C_6H_{12}O_{6(aq)}$$

- Zymase catalyses the breakdown of glucose into ethanol, carbon dioxide, producing heat in the process.

$$C_6H_{12}O_{6(aq)} \rightarrow 2C_2H_5OH_{(l)} + 2CO_{2(g)} + \text{Heat}$$



From Sorghum or Millet

- Sorghum is ground in a mortar and mixed with little water to form a paste.
- The sorghum paste is buried underground and left for a week to ferment to form yeast.
- Fermented sorghum is removed from underground and sun dried.
- And them mixed with ground Germinating sorghum (containing maltose) in a plastic drum with warm water.
- The plastic drum is covered with air tight lid, and left to stand for about 3 to 5 days.
- Maltase enzyme in yeast catalyse the hydrolysis of Maltose to glucose.

$$C_{12}H_{22}O_{11(aq)} + H_2O_{(l)} \rightarrow 2C_6H_{12}O_{6(aq)}$$

- Then another enzyme from yeast called Zymase catalyses the hydrolysis of glucose to ethanol which is crude ethanol.

$$C_6H_{12}O_{6(aq)} \rightarrow 2C_2H_5OH_{(l)} + 2CO_{2(g)} + \text{Heat}$$

- Pure ethanol can be purified by fractional distillation of crude ethanol.

Soapless Detergents

Benzene is reacted with a long chain alkene in presence of an acid to form alkylbenzene.

The alkylbenzene is heated with concentrated sulphuric acid to form alkylbenzene sulphonic acid, which is then neutralised by heating it with concentrated sodium hydroxide to form Sodium alkyl benzene sulphonate, the soapless detergent.

Alkyl benzene sulphonic acid + NaOH → Sodium alkyl benzene sulphonate + H_2O

Examples of soapless detergents include;

- Sodium Lauryl Sulphate,
- Sodium Laureth Sulphate,
- Ammonium Lauryl sulphate,
- Linear alkylbenzene sulphonate.

Soapy Detergents

MATERIALS:

✓Vegetable oil
✓Sodium hydroxide solution
✓Concentrated sodium chloride solution

Process of production

- Vegetable oil is first bleached with animal charcoal.
- Vegetable oil is boiled with sodium hydroxide solution for sometime until frothing stops.
- The mixture is left to cool.

(The ester in the vegetable oil breaks down releasing the organic acid and an alcohol, a process called saponification.
The organic acid is immediately neutralized by sodium hydroxide solution to form a sodium salt of the organic acid, which is the soap.)

- The soap is precipitated by addition of concentrated sodium chloride solution, a process called 'salting out'.
- Sodium chloride lowers the solubility of soap and causes precipitation of soap which floats on top of the solution.
- The solid soap is then removed and compressed into a continuous block which is cut into bars.

Examples of soapy detergent. Sodium stearate, Potassium stearate, Sodium oleate, Potassium oleate, Sodium palmitate, Potassium palmitate

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MODULE: 042

CHEMICALS FOR COMSUMERS

FOOD ADDITIVES

Food preservatives

Mode of action.

Slow down or inhibit the growth of microorganisms(bacteria, moulds among others), and so increase or extend the shelf life of food.
Food preservatives introduce conditions that interfere with metabolism of microorganisms.

Examples of natural preservatives include; table salt,

- *Sugar,*
- *Vinegar,*
- *Ascorbic acid,*
- *Benzoic acid.*

Examples of artificial preservatives include;

- *Sodium benzoate,*
- *Sodium nitrite,*
- *Sulphur dioxide,*
- *Calcium propionate.*

- Common salt and Sugar: Draws water from cells of microorganisms.Retards the growth of microorganisms.
- Vinegar: Lowers pH to inhibit growth of microorganisms.
- Calcium propionate: Inhibit growth of moulds and bacteria in baked products.
- Sodium benzoate / benzoic acid: Slows down growth of microorganisms

Antioxidants

Mode of action.

Prevents oxidation of fats and oils, and so prevents deterioration of fats and oils, and fruits from becoming brown.
Oxidation of oil in food causes the food to become rancid, changes colour and taste and may be toxic.
Processed foods like cakes, biscuits, margarine, deep fried food, and vegetable oils contain antioxidants.

Natural antioxidants include;

- Ascorbic acid (vitamin C),
- Tocopherols (vitamin E),
- Flavonoids, catechin etc.

Synthetic antioxidants include;

- Sodium citrate,
- Butylated hydroxyanisole (BHA),
- Butylated hydroxytoluene (BHT),
- Tert-butylhydroquinone (TBHQ).

- Vitamin E (Tocopherols): Prevent oil from getting rancid. Can be used in Palm oil, sun flower oil.
- Ascorbic acid (vitamin C): Prevent cut fruits from going brown, preserves juice colour. Can be used in Fruit juice, cut fresh fruits, frozen fish.
- Sodium citrate: Prevents fat from turning rancid. Can be used in Cured meat, ice cream.
- Butylated hydroxyanisole(BHA: Retards rancidity in fats, oils, and oil containing foods.
- Butylated hydoxytoluene(BHT)

Food colourings/ dyes

Mode of action.

Add or restore colour of food, making it attractive to the consumer.
NB. Food processing and packaging leads to loss of natural food colouring.

Curcumin (natural) obtained from turmeric plant roots. (Orange-yellow) can be used in Beverages, dairy products, cereals, baked goods.
Beta-carotene (natural) from carrots, tomatoes, oranges. (Orange, yellow, red). Can be used in Juice, baked foods, snack foods, beverages, dairy products.
Anthocyanin (natural), from red grape, red cabbages, potoes, tomatoes. (Red, purple, blue). Can be used in Ice cream, sweets, fruit juices, baked goods.
Azo compounds (artificial). Red, orange, yellow. Can be applied in Drinks, sweets, dairy products, processed meat.
Paprika (natural) from sweet peppers. (Red), Dessert, cheese, baked goods, sauces.

Flavoring agents

Mode of action.

Add or improve taste or aroma of food. They restore taste lost during food processing and make the food sweet, salty, bitter, sour etc.

Natural (extracted from natural resources) flavouring agents include;

- Honey, sugar,
- Salt,
- Peppermints extracts,
- Screw pine extracts.

Synthetic flavouring agents include:

- Monosodium glutamate(MSG),
- Aspartame, Saccharin, esters.

Ascorbic acid: Add citrus flavor can be applied in Fruit juices, cereals, fruit flavoured candies, frozen fruits.

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Stabilizers and thickeners

Mode of action.

Stabilizers: Prevent fats and oils from clotting, making it remain in emulsified form (well mixed suspension) at all times by inhibiting reactions between chemicals in food, making it taste smooth and finer.
Thickeners: Increase viscosity of food, making it thicker

Stabilizers

Acacia gum: Mix two liquids that do not mix, forming an emulsion. Can be used in Chewing gum, gummy candies, marshmallow.
Lecithin: Controls sugar crystallization, and flow properties, ensures homogeneneous mixing of ingredents.
Gelatine: Prevent formation of coarse grained ice crystals, reduce melting speed.. Can be used in Ice cream, yorghut, margarine, fruit jams.
Mono/di-glycerides of fatty acids. Mix oil and water. Can be used in Ice cream, chewing gum, beverages, margarine.

Thickeners

Starch: Thicken food. Can be applied in Soup, noddles, pasta.
Gelatine: Prevent formation of coarse grained ice crystals, reduce melting speed Can be applied in Ice cream, yorghut, margarine, fruit jams

MODULE: 043

CHEMICALS FOR COMSUME

MEDICINE

Traditional medicine

These are the Medicines derived from natural sources such as plants and animals.

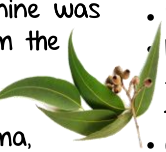
Plant extract

- Garlic extract
- Regulates blood pressure, reduces cancer risk, controls cholesterol levels, treat colds, flu, fungal and bacterial infections.
- Aloe vera extract

- Treats burns, malaria, ulcers, allergic reactions, fever, diabetes, skin diseases, indigestion
- Ginger extract

- Treat colds, flu, bloating, cramps, diarrhea, relieve pain, cancer, diabetes, heart diseases, asthma, bronchitis
- Lemon juice

- Treat Hypertension, obesity, fever, bronchitis, bacterial and fungal infections, fever
- Quinine
- Treat malaria, arthritis, fever, joint pain, muscle cramps. Quinine was first isolated in 1820 from the bark of a cinchona tree,
- Eucalyptus leaf extract



- Treat coughs, colds, asthma, wounds, cuts, skin diseases, insect bites, fever, bacterial and fungal infections

Animal extract

- Ant extracts

- Treat Hepatitis B, Cancer, tuberculosis, wounds, skin conditions, diarrhea, diabetes, fever.
- Honey bee venom

- Arthritis, pain, inflammation
- Snake venom
- Pain, inflammation, cancer
- Scorpion venom

- Pain, inflammation, cancer
- Shark cartilage extract
- Cancer, arthritis
- Tiger bone
- Arthitis, pain
- Frog skin secretions

- Pain, inflammation
- Sea cucumber extract
- Artritis, cancer, wounds, cuts, ulcers, kidney diseases, skin diseases,
- Centipede extract
- Pain, fever, tuberculosis, cancer, wounds, snake bites, epilepsy, malaria.

Disadvantages of using traditional medicine

- Take a long time to act
- Not efficient for serious cases like heart attack
- May results into health concerns eg kidney failure, liver damage since some may have toxins or heavy metals
- Cause negative effects to the users eg allergic reactions, skin rashes, asthma, headaches, vomiting, nausea.
- Variation in quality and effectiveness.

Modern medicine

- These are synthesized in the laboratory. Active component is identified, extracted and purified from organic compounds.;

Analgesics (pain killers),

These medicines relieve a person from pain but they do not treat the cause of the pain.

Mode of action.

By relieving pain by blocking pain signals to the brain, reducing inflammation and swelling and interacting with pain receptors in the body. Examples of pain killers include; paracetamol, aspirin, codeine.

- Aspirin Used for pain relief, particularly where there is inflammation eg dental pain arthritic pain.

Also used in preventing blood clotting and relieving fever.

Active ingredient in aspirin is acetylsalicylic acid.

- Paracetamol Can be taken to relieve mild to moderate pain such as headache, muscle and joint pains, back aches, menstrual pains.
- Codeine Used in headache tablets and cough medicines
- Its mostly synthesized from morphine

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Antibiotics,

These are used to treat bacterial infections but cannot cure viral infections such as colds and flu.

Mode of action.

They destroy or prevent or slow down the growth of disease causing bacteria. They do this by interfering with bacteria's ability to build their cell walls, leading to their death or making it easier for immune system to fight the bacteria.

Antibiotics are obtained from micro-organisms such as bacteria and fungi. Examples of antibiotics include penicillin, streptomycin among others.

- Penicillin: Extracted from fungus *Penicillium notatum.*

Used to cure bacterial diseases such as pneumonia pneumonia, gonorrhea, syphilis, bronchitis etc.

Its only effective on some bacteria. it cannot treat tuberculosis.

- Streptomycin These are the Antibiotics produced by bacteria of genus *Streptomyces.*

Used to treat some tuberculosis, whooping cough, typhoid, plague, gonorrhea and some forms of pneumonia.

NB.

Both penicillin and streptomycin are broken down by acid in the stomach, and so are usually administered by injection not orally.

Psychotherapeutic medicines

Used to treat mental illnesses

How they work

Alter abnormal thinking, feeling or behaviors in people with mental illness.

NB. These medicines do not cure mental illness, but reduce on the symptoms and help a person to get on with life.

These medicine are divided into; stimulants, antidepressants and antipsychotics.

- Stimulants: Used to reduce fatigue and increase alertness, attention, energy and elevate mood.

Mode of action.

Increase dopamine and norepinephrine levels in brain, enhancing neural activity in areas responsible for attention and motivation

Antidepressants: Used to treat depression, reduce tension and anxiety.

Mode of action.

Balancing neurotransmitters in the brain, balancing mood, appetite, sleep and reducing symptoms of depression and anxiety.

Examples of anti depressants include; tricyclic antidepressants(TCAs), atypical antidepressants, Monoamine Oxidase Inhibitors(MAOIs)

- Antipsychotics: Used to treat psychiatric illness like schizophrenia (mental disorder affecting how a person thinks, feels and behaves; characterized by disconnection from reality), bipolar disorder (characterised by extreme mood swings)

Mode of action.

Blocking dopamine receptors in the brain, reducing hallucinations and delusions, stabilizing mood and emotions, reducing aggression.

Examples of antipsychotics include; haloperidol, chlorpromazine, clozapine, cariprazine etc.

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SIDE EFFECTS

Side effects of aspirin
- Internal bleeding and ulceration
- Causes brain and liver damage if given to children with flue and chicken pox (it should never be given to children)
- Allergic reactions, skin rashes

Bleeding in stomach since its acidic

side effects of Paracetamol
- Skin rashes
- Blood disorders
- Acute inflammation of the pancreas
- Overdose can cause liver damage

Side effects of Codeine
- May cause drowsiness (state of feeling sleepy)
- Abuse of the medicine may lead to skin rashes, addiction, depression and nausea

General effects of Painkillers
Side effects
- Nausea and vomiting
- Dizziness and drowsiness
- Stomach upset and abdominal pain
- Fatigue
- Diarrhea
- Allergic reactions; causing rashes, itching, swelling
- Kidney and liver damage
- Stomach ulcers

Mitigations
- Take with food
- Minimize over dependence on them
- Stay hydrated
- Take as prescribed by the doctor
- Continually consult the doctor
- Get enough rest
- NB. Side effects must be explained and mitigation given

Side effects of using stimulants
- Insomnia (state of difficulty to get sleep)
- Anxiety
- Hallucinations (sensory experiences occurring in absence of external stimulus, may be visual, auditory, tactile, olfactory (smell). They are unreal sensations)
- Severe depression
- Increased heart rate and blood pressure
- Headache
- Weight loss
- Addiction due to excessive usage

Side effects of using Antibiotics
- Headache
- Allergic reactions causing rashes, itching, swelling
- Gastrointestinal issues eg vomiting, diarrhea, nausea
- Liver damage
- Kidney damage

Mitigations
- Take the dosage as prescribed by doctor,
- Take with food to avoid nausea
- Stay hydrated
- Inform doctor about the reactions
- Get enough rest
- Make follow up with a doctor about the progress of the infection

Side effects of using

- Insomnia (state of difficulty to get sleep)
- Anxiety
- Hallucinations (sensory experiences occurring in absence of external stimulus, may be visual, auditory, tactile, olfactory (smell). They are unreal sensations)
- Severe depression
- Increased heart rate and blood pressure
- Headache
- Weight loss
- Addiction due to excessive usage

Side effects of using Antidepressants
- Nausea and vomiting
- Insomnia
- Headaches
- Weight changes
- Dizziness
- Sexual dysfunction(decreased libido)
- Fatigue

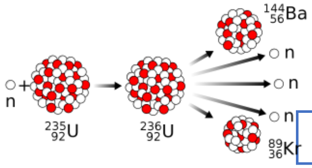
Side effects of using antipsychotics
- Weight gain
- Drowsiness
- Constipation
- Blurred vision
- Increased risk of diabetes and metabolic changes
- Increased risk of cardiovascular diseases
- NB. Above side effects should be explained.

- Mitigations to side effects caused by use of psychotherapeutics
- Follow prescribed dosage by doctor
- Make regular consultation with the doctor
- Priorities a balanced lifestyle including; a health diet, regular exercise, sufficient sleep.
- Seek social support
- Stress management
- NB. Mitigation should match with the side effect given.

Correct ways of using medicine
- Do not do self medication
- Follow instruction given by medical personnel regarding the dosage
- Do not take a drug for longer time than directed
- Follow the right method of taking drugs eg before food or after food, orally or by injection.
- Medicine for adults should not be given to children and vice versa
- Complete the whole dose when using antibiotics to avoid resistance to the drug
- Consult the doctor incase of side effects
- Do not take expired drugs

MODULE: 044

NUCLEAR PROCESSES.



uclear reactions are reactions that involve a change in an atom's nucleons (protons or neutrons), usually roducing a different element. The spontaneous disintegration (decay) of unstable nuclides (nuclei) to form table nuclides with emission of particles and radiations (energy) is called Radioactivity. Substances which ndergo radioactivity are called Radioactive and the Isotopes which are Radioactive are also called adioisotopes.

Nuclear fission

Is a process which involves splitting/ breaking a heavy nucleus into smaller nuclei accompanied by a large release of energy/ radiations.
The large and unstable nuclide splits into two almost equal fragments plus smaller particles, such as neutrons, with liberation of energy. The neutrons bombard more nuclides, resulting in a chain reaction. This is called a radioactive decay series. The energy can be tapped and used to produce other forms of energy, such as electricity, light energy in controlled conditions.

Nuclear fusion

Is a process which involves combination of light (small) nuclei when made to collide at high velocity resulting in the formation of heavy nuclei accompanied by a large release of energy.
Fusion reaction of hydrogen nuclides to form helium produces energy that powers the sun and other stars.

Differences between nuclear fission and nuclear fusion

Nuclear fission

- Occurs in the nuclei of heavy elements.
- Splits heavy nuclei to lighter nuclei.
- Can take place at ordinary temperatures.
- Energy emitted during the process is very high.
- Percentage efficiency of the energy conversion is comparatively less.
- Can be controlled for useful purposes.

Nuclear fusion

- Occurs in the nuclei of light elements.
- Joins lighter nuclei to form heavy nuclei.
- Takes place at high temperatures
- Energy emitted during the process is comparatively low.
- Percentage efficiency of the energy conversion is high (four times that of nuclear fission).
- Cannot be controlled.

APPLICATIONS OF NUCLEAR REACTIONS

Nuclear reactors; A nuclear reactor controls fission where by heavy nuclide is bombarded with fast moving neutrons and releases heat that is used to heat water and produce steam at high pressure which drives turbines that produce electricity in nuclear power plants.

Atomic bombs; An atomic bomb derives its violent explosive power from the rapid release of energy by nuclear fission.
An atomic bomb is set off by the rapid bringing together of uranium-235 and plutonium-239.

THE RADIATIONS PARTICLES & THAT CAN BE INVOLVED INCLUDE;

-**Alpha particles;** the helium nuclide (nucleus) with symbol $^4_2$He or α
-**Beta particles;** is an electron with symbol $^{0}_{-1}e$ or β
-**Gamma rays;** which are electromagnetic radiations (waves) with symbol of γ
-**Protons;** the hydrogen nuclide (nucleus) with symbol $^1_1$H
-**Neutrons;** with the symbol ^1_0n

A balanced radioactive equation is one where the sum of the mass numbers and the sum of the atomic numbers balance on either side of an equation.

Balancing radioactivity equations

Ensure that the;

- Sum of the atomic numbers on the left should equal to the sum of atomic numbers on the right-hand side.
- Sum of the mass numbers on the left-hand side should be equal to that on the right-hand side

NB: When the emitted particle is known, the new nucleus formed is identified by its atomic number and NOT mass number

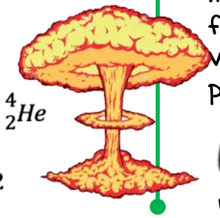
1. Determine the value of y in:

$$^{222}_{86}Rn \longrightarrow {}^{218}_{y}Po + {}^{4}_{2}He$$

Solution

222 = 218 + 4 and 86 = y+2

y = 84



The following are applications of radioactivity in our daily lives:

(a) **Energy generation** – Nuclear reactions produce large amounts of energy that can be controlled and harnessed for useful purposes such as production of electricity.

(b) **Chemistry**-Radioactive isotopes are used as tracers in chemical reactions whose mechanisms are difficult to follow. Radioisotopes are also used to study the rate a t which reactions proceed

(c) **Medicine** – Radioactive isotopes are used to stop growth of cancerous cells or kill them. This is called radiotherapy.

(d) **Agriculture** – Phosphate-32 is used to trace the uptake and metabolism of phosphorus by plants.

(e) **Carbon-dating** – Carbon-14 is radioactive and is used to the age of archeological and geological discoveries such as fossils found in rocks, ancient ruins and caves.

(f) **Food preservation** – Exposure to gamma radiation kills microorganisms that cause stored foodstuffs to rot. Fish, fruits and vegetables can be preserved in this way.

SIDE EFFECTS AND THEIR MITIGATIONS

All radioactive materials must be handled with great care, depending on their individual properties. For example:

- Exposure to radioactive materials can lead cause genetic mutations, should be mitigated by proper disposal of radioactive wastes, such as by burying them deep in the ground in geologically stable areas or recycling them.
- Nuclear bomb tests lead to Long-term harm to the environment and human health, hence should be done in a highly controlled environment where no radioactive materials escape into the atmosphere and nuclear power plants should have detection systems that can detect the smallest malfunction.

✓Alpha particles have the least penetrating power and cannot penetrate the skin. However, there is still a risk of the radioactive material penetrating thin epithelial membranes, such as in the nose and mouth. Use appropriate protective gear while exposed to alpha particles.
✓Beta particles have more penetrating power so the eyes and face should be protected using a sheet of thin aluminium sheet.
✓Gamma rays have the highest penetrating power. Thick lead or concrete structures should be used for protection from these rays.

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PROPERTIES OF RADIATIONS

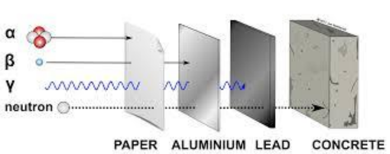
1. PENETRATING POWER

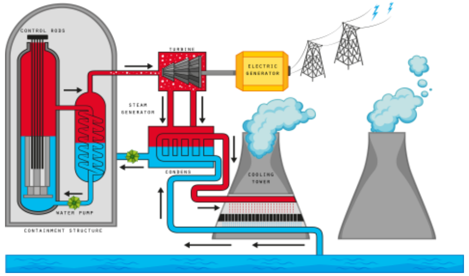
Alpha particles are the heaviest and travel at slower speed thus have very low penetrating power. They do not pass through a sheet of paper.

Beta particles are lighter and travel at higher velocity thus have a higher penetrating power. They can pass through a sheet of paper but are blocked by a sheet of aluminium.

Gamma rays have no mass. They travel at extremely high velocity almost equal to that of light. They have the highest penetrating power. They pass through a sheet of paper and a sheet of aluminium but are blocked by a thick lead or steel block.

Penetrating power of different types of radiation



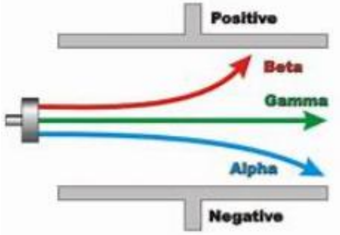


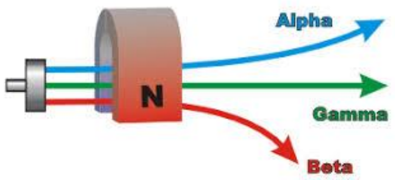
2. IONIZING POWER

Ionizing power refers to the ability of radiation (such as alpha, beta, or gamma rays) to remove tightly bound electrons from atoms resulting in the formation of ions.

The ability of radioactive emissions to form ions depends on mass and the charge of the radiation.

- Alpha particles have high ionizing power. This is enhanced by their strong positive charge and slow speed due to high mass.
- Beta particles have moderate ionizing power due to no mass and high speeds
- Gamma rays have no mass and no charge and move at high velocity therefore, they do not cause ionization as they pass through substances.





3. DEFLECTION IN;

In a magnetic field;

- Alpha particles are deflected towards the south pole.
- Beta particles are deflected towards the north pole.
- Beta particles can be deflected by a much weaker magnetic field than alpha particles due to their negligible mass(no mass).
- Gamma rays are unaffected thus no deflection

In an electric field;

- Alpha particles being positively charged and are deflected (attracted) towards the negative plate.
- Beta particles are negatively charged and are deflected(attracted) towards the positive plate.
- Gamma rays are unaffected thus no deflection

The magnitude of deflection depends on the mass of the particles.

Alpha particles are heavier and are thus deflected less while the lighter beta particles are deflected more.

Gamma rays are not particles but waves. They have no mass and carry no charge and are therefore not deflected in magnetic and electric fields.

RADIOACTIVE DECAY

The rate of radioactive decay depends on the number of nuclides present at a given time. This means that the rate of decay is directly proportional to the number of radioactive nuclides present at a particular time.

The rate of decay is expressed in terms of half-life.

Half-life

It is the time taken for half of the original amount of the sample to decay. It is denoted by t

When $t = t_{\frac{1}{2}}$, then $N_t = \frac{N_0}{2}$

The radioactive decay equation for any radioactive decay is given by;

$$N_t = N_0 e^{-kt} \quad \text{or} \quad \ln\left(\frac{N_t}{N_0}\right) = -kt$$

where N_t is amount present at time t ; N_0 is the original amount when $t = 0$ and k is the decay constant

When $N_t = \frac{N_0}{2}$; $t = t_{1/2}$

Now when substituted in the decay equation,

- $\frac{N_0}{2} = N_0 e^{-kt_{1/2}}$.
- $\frac{1}{2} = e^{-kt_{1/2}}$.
- $\ln(\frac{1}{2}) = \ln(e^{-kt_{1/2}})$.
- $-\ln 2 = -kt_{1/2}$
- $\ln 2 = kt_{1/2}$. $\quad t_{1/2} = \frac{0.693}{k}$

Half-life can also be defined as the time interval it takes for a radioactive material to be reduced to half its original mass.

Half-life is constant and the remaining amount never reduces to zero

Tasks

The half-life of a radioisotope is two days. What mass of 600 g of the sample will remain undecayed after eight days?

Using $N_t = N_0 e^{-kt}$ and $t_{1/2} = \frac{0.693}{k}$

where $t_{1/2} = 2$ days,

$t = 8$ days,

$N_0 = 600$ g

$$k = \frac{0.693}{t_{1/2}} ;$$

$$k = \frac{0.693}{2} \text{ per day} ;$$

$$k = 0.3465$$

$$N_t = 600e^{-0.3465 \times 8} ;$$

$$N_t = 37.5\ g$$

The Radioactive Decay Curve