S.3 CHEMISTRY WORK

INDUSTRIAL PROCESSES

MANUFUCTURE OF OXYGEN/NITROGEN

Raw material

- Liquid air/ air

Process of production

Air is passed through air filters to remove dust and smoke particles. Air is passed through concentrated sodium hydroxide solution to absorb/ remove carbon dioxide, which is acidic.

$2NaOH(aq)+CO_2(g) \longrightarrow Na_2CO_3(aq)+H_2O(l)$.

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/ pipes.

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 / tower.

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

Side effects of the process of production

- Explosion of oxygen cylinders due to high pressure. This can cause other materials to ignite spontaneously/catch fire. The resulting fire can cause damage to equipment and injury to people.

Mitigation can be done by:

- Regular maintenance and monitoring of cylinders.
- Keeping cylinders in cool areas / avoid exposure to heat.
- -Exposure to liquid oxygen can cause severe skin and eye irritations and burns. This may cause loss of vision and cancer.

Mitigation can be done by:

- Posting hazard and warning information in the working area.
- Communicating all information on the health and safety hazards of oxygen to potentially exposed workers; for example; submerging the affected body parts in warm water.
- -Air pollution by waste gases. Acidic gases can cause acid rain which leads to crumbling of buildings, lowering of soil pH and corrosion of roofs made of iron.

Mitigation can be done by:

- ✓ Fitting catalytic converters in exhaust pipes of machines to convert oxides of nitrogen into nitrogen and carbon monoxide to carbon dioxide.
- ✓ Neutralize the acidic gases before releasing waste gases into the atmosphere.

Social benefits of the process of production

- ✓ Employment opportunity; improved income thus better standards of living.

Development of infrastructure e.g. electricity lines, roads, hospitals schools etc., Improved road network will facilitate trade hence improved income and better standards of living.

MANUFACTURE OF OXYGEN

Raw material

Liquid air / air.

Process of production;

Air is passed through **air filters** to remove dust and smoke particles. It is then passed through concentrated sodium hydroxide solution to remove carbon dioxide,

$2NaOH(aq) + CO_2(g) \rightarrow Na_2CO_3(aq) + H_2O(l)$.

Air free from carbon dioxide is now passed through Silicon (IV) oxide to absorb water vapour. Carbon dioxide and water vapour are removed from air before it is liquefied because they would solidify and block the apparatus.

The air is then 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 / tower**.

Nitrogen boils off first because it has a lower boiling point (–196°C) leaving behind oxygen with a higher boiling point (-183°C). . Pure oxygen is then stored under pressure in steel cylinders.

Side effects of the process of production

- **Explosion of oxygen cylinders** due to high pressure **causing injuries and fire outbreaks** also **resulting into damage to equipment**, **mitigated** by;

* Regular maintenance and monitoring of cylinders.
* keeping cylinders in cool areas to avoid exposure to heat.

Exposure to liquid oxygen can **cause severe skin and eye irritations and burns, loss of vision and cancer**, m**itigated by**:

- Posting hazard and warning information in the working area.
- Communicating all information on the health and safety hazards of oxygen to potentially exposed workers; for example; submerging the affected body parts in warm water.

Social benefits

Source of employment opportunities, hence **improved income** and therefore **better standards of living**

Increased government revenue from taxes hence **improvement of infrastructure** such as roads, schools, health facilities leading **development of the society**.

Development of small-scale businesses, hence **generating income**, leading to **better life**

Sample items

Item 1

There is high demand of oxygen in referral hospitals in Uganda. An investor was contacted by government to set up an oxygen manufacturing plant at Namanve, one of the swamps near Kampala to tap into the opportunity. However, the residents seem not to understand how the process will occur plus its consequences and are resisting the project.

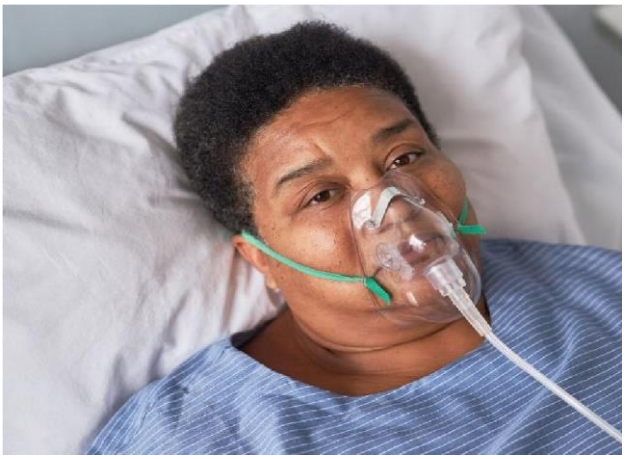
As a **senior four** candidate with the knowledge of chemistry, you are required to create awareness to the members and provide the necessary information.

TASK

Write a presentation you will use upon meeting them.

Item 2

Air is a mixture of different gases. It contains 21% oxygen. However, because of the widespread of respiratory illness caused by patients in hospitals. The government's supply of oxygen is insufficient. The government found an investor to help in the mass production of oxygen to be used. As a result, this investor found you as a chemist and wants to recruit you to help in the production. He organizes a meeting and requires that you make a presentation of the process you are to follow to produce the gas.



As a chemist, prepare a speech you are to present during the meeting.

Item 3

One of the critical processes in chemical industries is the production of nitrogen, which has various industrial and medical applications. However, the production of nitrogen can have environmental implications, and it's essential to assess its impact.

Task:

As a Chemistry student, prepare a comprehensive report addressing the production of nitrogen and its environmental impact.

MANUFUCTURE OF SOAPS AND DETERGENTS

Raw materials:

Concentrated sulphuric acid
Long chain of alkyl benzene
Sodium hydroxide solution

Process of production

A long chain of alkyl benzene is heated with concentrated sulphuric acid in a **reactor vessel** to form alkyl benzene sulphonate, which is then cooled and then reacted with sodium hydroxide solution to form alkyl benzene sodium sulphonate which is then **purified by evaporation**, **evaporated** and cooled to obtain the soapless detergent.

Side effects of the process of production

When the non-biodegradable soapless detergents **leak to water, they pollute it causing death of aquatic organisms, mitigated by**, not pouring water containing soapless detergents near water bodies.

Social benefits of the process of production

- Source of revenue to the government through taxes, hence, improved infrastructures for example; health facilities, roads etc. hence improvement in the other sectors such as health and transport resulting into living a better life.
- Source of **employment** resulting into **improved income** hence, **better standards of living**. **Provision of market** for goods of the community members, hence **generating income**, leading to **better lives**

Soapless Detergents

Raw material

- Benzene, concentrated sulphuric acid and concentrated sodium hydroxide solution

Process of production

- Benzene is reacted with a long chain alkene in the presence of concentrated sulphuric acid in a plastic container forming alkyl benzene.
- The alkyl benzene is heated with concentrated sulphuric acid and concentrated sodium hydroxide solution added to the resulted solution forming a detergent.
- This can be added to minimum volumes of water to form liquid detergents.
- Some additives such as whitening agents, biological enzymes, fragrances, stabilizers may be added during the process.

Side effects of the process of production

- Acid spills on surfaces that cause falls/accidents to the workers
- Burns from acids when in contact with the skin

Mitigation can be done

- Wearing proper personal protective gears like face masks, gloves etc.

Social benefits of the process of production

- Source of employment opportunities where people earn income, afford basic needs thus better and improved standards of living for the people.

- Development of infrastructure e.g. electricity lines, roads, hospitals, schools etc. improved road network will facilitate trade hence improved income and better standards of living.
- Increased government revenue, soap production plant generates tax revenue for local government which can be used to fund public services and infrastructure projects which result in improved standards of living.

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- This can be added to minimum volumes of water to form liquid detergents.
- Some additives such as whitening agents, biological enzymes, fragrances, stabilizers may be added during the process.

Side effects of the process of production

- Acid spills on surfaces that cause falls/accidents to the workers
- Burns from acids when in contact with the skin

Mitigation can be done

- Wearing proper personal protective gears like face masks, gloves etc.

Social benefits of the process of production

- Source of employment opportunities where people earn income, afford basic needs thus better and improved standards of living for the people.
- Development of infrastructure e.g. electricity lines, roads, hospitals, schools etc. improved road network will facilitate trade hence improved income and better standards of living.
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From an Alcohol;

Raw material

Duodecan-1-ol, concentrated sulphuric acid and concentrated sodium hydroxide solution

Process of production

Duodecan-1-ol is reacted with cold concentrated sulphuric acid in a plastic container forming duo decyl hydrogen sulphate which is reacted with concentrated sodium hydroxide solution to form a detergent. This mixture can be added to minimum volumes of water to form liquid for a detergent.

Some additives such as whitening agents, biological enzymes, fragrances, fillers, stabilizers may be added during the process.

Soapy Detergent

Raw material

- Concentrated sodium hydroxide solution
- Concentrated sodium chloride solution
- Vegetable oil/animal fat

Process of production

- Soap is manufactured through a process called saponification.
- A mixture of vegetable oil or animal fat and concentrated sodium hydroxide solution is boiled while stirring for some time until frothing stops/no more reaction occurs in a boiler/non aluminium tank.
- The resulted soap solution is cooled
- Concentrated sodium chloride solution is added to soap solution to precipitate out soap.
- Soap floats and it is skimmed off
- Additives like perfumes and dyes may be added

Side effects of the process of production

- Air pollution, soap production involves mixing and heating chemicals which can release volatile organic compounds and particulate matter into the air. This can lead to respiratory problems for nearby residents and the workers.
- Water pollution; soap production requires water for various processes which can lead to waste water discharge containing chemicals and detergents which can harm aquatic life.
- Soil contamination; chemical spills or leaks can contaminate the soil leading to ground water pollution and soil degradation.
- Exposure to hot concentrated chemicals by workers and residents may lead to skin irritation and allergic reactions, respiratory problems, long term health effects e.g. cancer. This is can be mitigated by; wearing PPE like gloves, Lab coats and masks for workers in the working environment
- Machinery noise, soap production involves various machinery which can generate noise pollution leading to disturbances to nearby residents, sleep disruptions, increased stress levels. This can be mitigated by implementing noise reduction measures e.g soundproofing, noise barriers, schedule noisy operations during less busy times, providing hearing protection gears for workers.

Social benefits of the process of production

- Source of employment opportunities where people earn income, afford basic needs thus better and improved standards of living for the people.
- Development of infrastructure e.g. electricity lines, roads, hospitals, schools etc. improved road network will facilitate trade hence improved income and better standards of living.
- Increased government revenue, soap production plant generates tax revenue for local government which can be used to fund public services and infrastructure projects which result in improved standards of living.

Manufacture of Soap

Raw material

- Concentrated sodium hydroxide solution
- Animal fat/vegetable oil like sun flower oil, palm oil etc.
- Concentrated sodium chloride solution

Process of production

- The process of making soap is called saponification
- A known volume of vegetable oil or fat is boiled with a known volume of concentrated sodium hydroxide solution for some time while stirring until frothing stops.
- Concentrated sodium chloride solution is added to the mixture to precipitate out the soap, this is salting out soap.
- The mixture is filtered and the remaining residue is left for some time to dry out. This is soap.
- The solid is then removed and compressed into a continuous block which is cut into bars and taken for further processing.
- Equation of reaction; OPTIONAL

Side effects of the process of production of soap

- Soil contamination; chemical spills or leaks can contaminate the soil leading to ground water pollution and soil degradation.
- Exposure to hot concentrated chemicals by workers and residents may lead to skin irritation and allergic reactions, respiratory problems, long term health effects e.g. cancer. This is can be mitigated by; wearing PPE like gloves, Lab coats and masks for workers in the working environment.

Social benefits of the process of production

- Source of employment opportunities where people earn income, afford basic needs thus better and improved standards of living for the people.
- Development of infrastructure e.g. electricity lines, roads, hospitals, schools etc. improved road network will facilitate trade hence improved income and better standards of living.
- Increased government revenue, soap production plant generates tax revenue for local government which can be used to fund public services and infrastructure projects which result in improved standards of living.

Soapy Detergents

Raw materials;

Vegetable oil

Concentrated sodium hydroxide solution

Concentrated sodium chloride solution

Process of production;

Vegetable is mixed with concentrated sodium hydroxide solution (or potassium hydroxide solution) in a **non aluminium tank** and the mixture boiled while stirring until no further change occurs, and allowed to cool.

Concentrated sodium chloride solution is added into the mixture to precipitate (salt out) soap from the solution. Solid soap is skimmed off, washed and dried.

Side effects of the process of production

- **Discharge of wastewater containing surfactants solvents, phosphates and other chemicals into water bodies** can cause **contamination** or **pollution**, **harming aquatic life and affecting water quality**, **mitigated** by treatment of the wastes
- **Accidental spills or leaks of raw materials and finished products** can lead to **contamination** or **pollution**, affecting soil fertility and hence plant growth, **mitigated** by use of proper storage and handling procedures for raw materials and chemicals.

Social benefits of the process of production

- Source of revenue to the government through taxes, hence, improved infrastructures for example; health facilities, roads etc hence improvement in the other sectors such as health and transport resulting into living a better life.
- Source of **employment** resulting into **improved income** hence, **better standards of living**.
- **Provision of market** for goods of the community members, hence **generating income**, leading to **better lives**

Sample Item

Item 1

People in Kisinza village only have access to borehole water which is not effective in cleaning clothes when soap is used. A local investor has been cleared by government to set up an industry that makes soapless detergents in the area however he is facing resistance from the community members about the issue of starting up the factory and he is equally lacking knowledge about the manufacturing process.

The head teacher has appointed you to go and represent the school in the meeting organized by the chairperson of the area to settle the wrangles between the investor and the citizens of the area.

Task

Write a message you would deliver in this meeting.

REVERSIBLE PROCESSES

Manufacture of Nitric Acid (Ostwald Process)

Raw material

- Ammonia
- Oxygen

Process of production

- Nitric acid is manufactured by the Ostwald process.
- Ammonia is burnt in excess air over red-hot catalyst (platinum (90%)/rhodium (10%) gauze catalyst) at high temperature of about 800- 900 to form nitrogen monoxide in the **catalytic oxidation chamber** or **ammonia oxidation reactor** according to the reaction,

$$4NH_3(g) + 5O_2(g) \longrightarrow 4NO(g) + 6H_2O(l)$$

- The nitrogen monoxide is cooled and reacts with excess air to form nitrogen dioxide in the **oxidation tower**.

$$2NO(g) + O_2(g) \longrightarrow 2NO_2(g)$$

- The nitrogen dioxide is mixed with excess oxygen and bubbled through hot water (hot) to form nitric acid in the **absorption tower.** Excess oxygen is used to prevent formation of nitrous acid.

$$4NO_2(g) + 2H_2O(l) + O_2(g) \longrightarrow 4HNO_3(aq)$$

Side effects of nitric acid production plant.

Air Pollution: Nitric acid plants release nitrogen oxides (NOx), including nitric oxide (NO) and nitrogen dioxide (NO_2). These gases contribute to ground-level ozone formation, acid rain, and smog, harming human health and the environment. **This can be mitigated by using catalytic converters in the engines of the machines to convert the oxides to harmless oxides.**

Water Pollution: Improper handling or disposal of nitric acid can contaminate water bodies, lowering pH and harming aquatic life. Nitric acid can also react with metals, releasing toxic substances. **Mitigated by neutralizing wastewaters before discharging using lime or other alkalis.**

Destruction of vegetation e.g trees, forest to clear land for the establishment of the factory, results in accumulation of carbon dioxide gas in the atmosphere, which causes global warming, it can also lead to soil erosion. **This can be mitigated by planting trees which grow and mature very fast to absorb carbon dioxide from the atmosphere.**

Greenhouse Gas Emissions: Nitrous oxide (N_2O), a potent greenhouse gas, is a byproduct of nitric acid production. Emissions contribute to climate change. **Mitigated by using catalytic converters to decompose it into nitrogen and oxygen which are harmless.**

Social benefits of the process of production

- Source of employment opportunities where people earn income, afford basic needs thus better and improved standards of living for the people.
- Development of infrastructure e.g. electricity lines, roads, hospitals, schools etc. improved road network will facilitate trade hence improved income and better standards of living.
  Increased government revenue, soap production plant generates tax revenue for local government which can be used to fund public services and infrastructure projects which result in improved standards of living.

Manufacture of Sulphuric Acid (Contact Process)

Raw material;

Sulphur dioxide gas

Oxygen gas

Process of production

- Sulphric acid is manufactured by the contact process.
- Dry sulphur dioxide gas free from impurities is heated with dry pure oxygen gas at temperature of about (400-550°C), high pressure of about (1-3 atmosphere) in the presence of vanadium (v) oxide catalyst forming sulphur trioxide. The reaction occurs in a combustion cylinder.

  $2SO_2(g) + O_2(g) \longrightarrow 2SO_3(g)$
- Sulphur trioxide is dissolved in little concentrated sulphuric acid forming fuming liquid called oleum in a tank.

  $SO_3(g) + H_2SO_4(l) \longrightarrow H_2S_2O_7(l)$
- Oleum is added to regulated volume of distilled water to form 98% concentrated sulphuric acid.

  $H_2S_2O_7(l) + H_2O(l) \longrightarrow 2H_2SO_4(l)$

Side effects of the process of production

- Toxic misty fumes from oleum which when inhaled may cause breathing problems and many side effects.
- Acid spills on the floor leading to accidents.

Mitigations

Proper use of personal protective equipment

Social benefits of the process of production

- Source of employment opportunities where people earn income, afford basic needs thus better and improved standards of living for the people.
- Development of infrastructure e.g. electricity lines, roads, hospitals, schools etc. improved road network will facilitate trade hence improved income and better standards of living.

- Increased government revenue, the sulphuric acid production plant generate tax revenue for local government which can be used to fund public services and infrastructure projects which result in improved standards of living.

Manufacture of Sulphuric Acid

Raw material

Sulphur dioxide gas

Oxygen gas

Process of production

- ❖ Sulphuric acid is manufactured by the contact process.
- ❖ Dry sulphur dioxide free from impurities is heated with dry pure oxygen at lower temperature of about 450°C – 500°C, high pressure of about 1-3 atmosphere in presence of vanadium (V) oxide catalyst to form sulphur trioxide in a combustion cylinder.
- ❖ Sulphur trioxide is dissolved in little concentrated sulphuric acid forming oleum in a tank.
- ❖ The oleum is then diluted with a known volume of water to form sulphuric acid with the 98% concentration.
- ❖ The produced sulphuric acid is 98% concentrated and it is stored in safe plastic or glass containers.

Side effects of the process production

- ➢ Toxic misty fumes from oleum which when inhaled may cause breathing problems and many side effects.
- ➢ Acid spills on the floor leading to accidents.

Mitigations

Proper use of personal protective equipment

Social benefits of the process of production

- Source of employment opportunities where people earn income, afford basic needs thus better and improved standards of living for the people.
- Development of infrastructure e.g. electricity lines, roads, hospitals, schools etc. improved road network will facilitate trade hence improved income and better standards of living.
- Increased government revenue, sulphuric acid production plant generates tax revenue for local government which can be used to fund public services and infrastructure projects which result in improved standards of living.

Social benefits of the process of production

- Source of employment opportunities where people earn income, afford basic needs thus better and improved standards of living for the people.
- Development of infrastructure e.g. electricity lines, roads, hospitals, schools etc. improved road network will facilitate trade hence improved income and better standards of living.
- Increased government revenue, sulphuric acid production plant generates tax revenue for local government which can be used to fund public services and infrastructure projects which result in improved standards of living.

Manufacture of Ammonia (Haber Process)

Raw material

- Nitrogen gas
- Hydrogen gas

Process of production

Ammonia is manufactured in the Haber process by direct synthesis of nitrogen and hydrogen.

The nitrogen is obtained by fractional distillation of liquid air while hydrogen is from steam reforming hydrocarbons.

Nitrogen is mixed with hydrogen with hydrogen in the volume ratios of 1:3 respectively and passed over finely divided iron catalyst heated at a temperature of about 450˚C and at high pressure of about 2 atmospheres to form ammonia in a **combustion cylinder**

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

About 10-15% of the gases combine and the rest is recycled for more ammonia.

The ammonia produced is packed in tight air cylinders for proper storage.

Side effects of the process of production

- ❖ Air pollution; release of ammonia, nitrogen oxides into the atmosphere lower the quality of air.
- ❖ Exposure of ammonia and other chemicals can cause respiratory issues, eye irritation and other health problems.
- ❖ Suffocation of workers due to release of hydrogen gas in confined spaces, this can be mitigated by installing effective exhaust ventilation to ensure fresh air supply.

Mitigation can be done by;

Proper use of the PPE

- Destruction of vegetation e.g trees, forest to clear land for the establishment of the factory, results in accumulation of carbon dioxide gas in the atmosphere, which causes global warming,

it can also lead to soil erosion. This can be mitigated by planting trees which grow and mature very fast.

- Poisonous fumes/waste gases from the factory pollutes air and can cause respiratory problems. This can be mitigated by use of catalytic converters in the exhaust pipes of the machines to convert the fumes into non-toxic compounds and also use of masks

Social benefits of the process of production

- Source of employment opportunities where people earn income, afford basic needs thus better and improved standards of living for the people.
- Development of infrastructure e.g. electricity lines, roads, hospitals, schools etc. improved road network will facilitate trade hence improved income and better standards of living.
- Increased government revenue, soap production plant generates tax revenue for local government which can be used to fund public services and infrastructure projects which result in improved standards of living.

Production of Charcoal

Raw material

Trees

Process of production

- ❖ Mature trees are cut into short logs which are piled together in an orderly manner.
- ❖ The logs are covered with leaves then soil is hipped on the logs. A few openings are left to let in air so that firewood is ignited to start the destructive distillation of wood.
- ❖ Once the logs have been ignited the holes are closed so that the process occurs in limited air.
- ❖ The distillation occurs slowly for 3 days until the smoke stops being evolved.
- ❖ It is left to cool and soil is carefully removed. Charcoal is obtained and packed for sale.

Side effects of the process of production

1. Soil degradation, the soils are baked by heat from the wood killing microorganisms; humus is destroyed and minerals burnt. The soil crumble structure is spoilt

Mitigation

- ✓ Discourage charcoal burning and seek for alternative sources of energy.

2. Greenhouse gas emissions which cause greenhouse effect and global warming. Carbon monoxide causes air pollution, carbon dioxide dissolve in rain water to cause acidic rain. $C(s) + O_2(g) \longrightarrow CO_2(g)$

Mitigation;

- ✓ Practicing re-afforestation to absorb greenhouse emissions.

- ✓ Put up laws inhibiting charcoal burning.

Social benefits of the process of production

- ✓ Source of employment opportunities to people where they earn income and improve standard of living.

  Improved infrastructure development like roads, electricity lines therefore better services and improved standards of living.

Manufacture of Ethanol

Raw material

Cassava /maize/millet/sorghum

Yeast

Process of production of ethanol

- ❖ Ethanol is prepared by fermentation of sugars in the presence of yeast.
- ❖ Cassava is crushed and heated in steam under pressure to extract starch.
- ❖ Starch is heated with malt for some time at 60°C
- ❖ Malt supplies an enzyme, diastase which hydrolyses starch to maltose

$$2C_5H_{10}O_5 + H_2O(l) \longrightarrow C_{12}H_{22}O_{11}(aq)$$

- ❖ Yeast is then added at room temperature which contains maltase which catalyze the hydrolysis of maltose to glucose

$$C_{12}H_{22}O_{11}(aq) + H_2O(l) \longrightarrow 2C_6H_{12}O_6(aq)$$

- ❖ Yeast also contains an enzyme zymase which catalyses the decomposition of glucose to ethanol and carbon dioxide.

$$C_6H_{12}O_6(aq) \longrightarrow 2C_2H_5OH(aq) + 2CO_2(g)$$

- ❖ The resulting solution is s crude ethanol which is converted to pure ethanol by fractional distillation.

Side effects of the process of production

- Exposure to hot ethanol can cause severe skin and eye irritation and burns which may cause loss of vision and cancer.

Mitigation can be done by;

- ✓ Posting hazard and warning information in the area.
- ✓ Wearing PPE like gloves, masks by the workers

- Air pollution by waste gases such as carbon dioxide, acidic gases can cause acid rain which may lower soil pH, corrode roofs made of iron, crumble rocks.

Mitigation can be done by;

- ✓ Fitting catalytic converter in exhaust pipes to convert the gases into harmless products.
- ✓ Neutralize the acidic gases before releasing waste gases into the atmosphere.

Accept: 1 side effect + explained the side effect and mitigate it = 03 scores

Social benefits of the plant

- Source of employment opportunities where people earn income, afford basic needs thus better and improved standards of living for the people.
- Development of infrastructure e.g. electricity lines, roads, hospitals, schools etc. improved road network will facilitate trade hence improved income and better standards of living.
- Increased government revenue, the production plant generates tax revenue for local government which can be used to fund public services and infrastructure projects which result in improved standards of living.

Manufacture of Ethanol from Molasses

Raw material

Sucrose (Molasses)

Yeast

Process of production

- ✓ Calculated amount of water is added to molasses in container then yeast is added and then covered.
- ✓ It is left to stand for 3 days.
- ✓ Sucrose enzyme in yeast converts sucrose to glucose and fructose.
- ✓ Zymase enzyme in yeast catalysts the breakdown of glucose and fructose to crude ethanol and carbon dioxide.

  Equation of reaction: It's optional
- ✓ Crude ethanol is converted to pure ethanol by fractional distillation.

Side effects of the process of production

- Hot surface burns from distillation tanks cause wounds hence pain to workers.

  Mitigation is done by proper use of personal protective equipment like gloves, closed shoes and masks.
- Ethanol spills on the surface leading to falls and accidents. Mitigation is done by appropriate use of personal protective equipment.

Social benefits of the process of production

- ❖ Source of employment opportunities to people where they earn income and improve standard of living.
- ❖ Improved infrastructure development like roads, electricity lines therefore better services and improved standards of living.

Manufacture of Ethanol from Bananas

Raw material

- ✓ Ripe bananas, sorghum and millet

Process of production

- ✓ Ripe bananas are peeled and put in a boat/canoe things squeezed into juice using spear grass.
- ✓ The juice is filtered out, mixed with little water and roasted sorghum.
- ✓ It is put in an air tight container such as a pot in a hole dug underground.
- ✓ Germinated flour/ yeast is added to the mixture before it is covered and buried for a period of 2 days for it to fully ferment.
- ✓ Crude ethanol is formed
- ✓ The alcohol is removed and distilled to obtain ethanol solution which can be refined better through fractional distillation.
- ✓ The pure ethanol is an antibiotic as it kills most bacteria hence used as a sanitizer to disinfect surfaces.

Side effects of the process of production

- ✓ Ethanol is flammable and can cause fires which may lead to destruction of property and loss of lives.

This can be mitigated by;

Installation of fire extinguishers to put out the fires.

Implementing protective measures to avoid causes of fires like no smoking in the working environment.

- ✓ Pollutant emissions of machines that cause greenhouse effect like global warming

This can be mitigated by;

Planting trees and vegetation to remove carbon dioxide for photosynthesis in order to reduce the greenhouse effect.

Social benefits of the process of production

- ✓ Source of employment opportunities to people where they earn income and improve standard of living.
- ✓ Improved infrastructure development like roads, electricity lines therefore better services and improved standards of living.

Manufacture of Ethanol from Bananas

Raw material:

Bananas,

Sorghum

Water

Process of production

The bananas are covered after harvesting for about a week to ripen. The carbohydrates are converted into maltose by means of enzymes diastase.

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 sorghum provides maltase enzyme which catalyses hydrolysis of maltose to glucose Zymase enzyme from yeast catalyses the decomposition of glucose to ethanol which is crude The crude ethanol is **purified by fractional distillation** to obtain pure ethanol.

Side effects of the process of production

Bursting of distilling tanks, causing **wounds and even death to the workers**, **mitigated** by regular inspection and maintenance of the distilling tank

Social benefits of the process of production

- Source of **employment** resulting into **improved income** hence, **better standards of living**.
- **Provision of market** for goods of the community members, hence **generating income**, leading to **better lives**
- **Provision of ethanol to the community members** or **use as a sanitizer and disinfector** hence **living a better health**

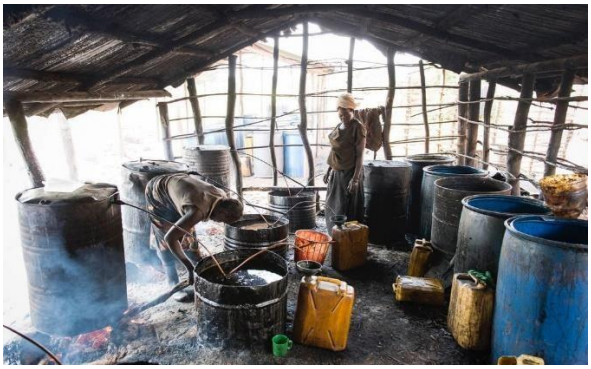
Sampe items

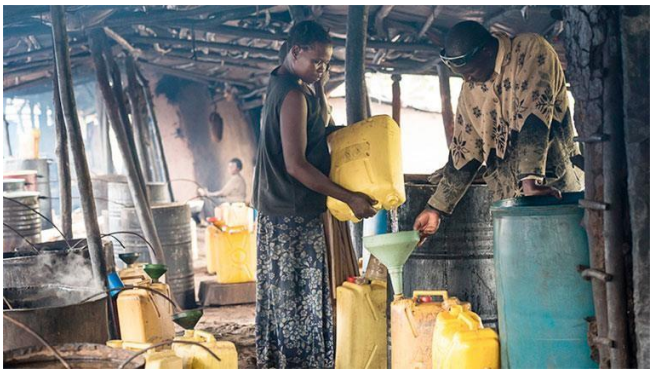
Item 1

Many people in villages make a living by manufacturing local waragi (ethanol). However, the government is against the business due to associated challenges. The area Member of Parliament wants to sensitize the community about the large-scale production process and its impact to enable them understand the government position.

The area Member of Parliament has contacted you as a student with the knowledge of chemistry

in your village to provide relevant information.



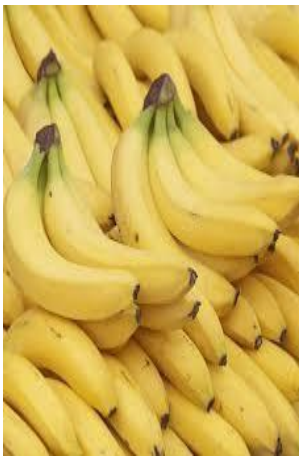


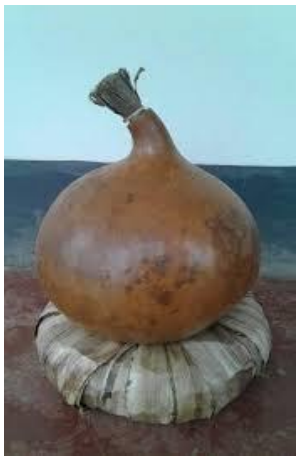
Task:

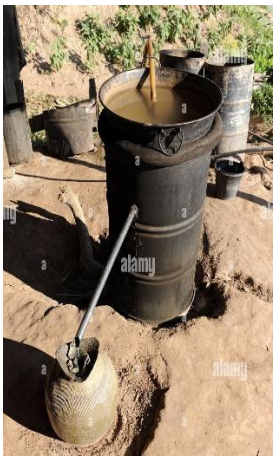
Make a write-up to use upon meeting the community.

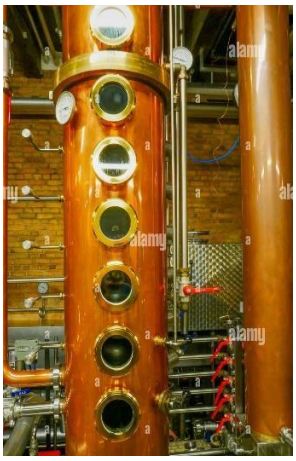
Item 2

Many people in villages make a living by manufacturing local waragi (ethanol). However, the government is against the business due to associated challenges. The district's LC5 chairperson wants to sensitize the community about the large-scale production process and its impact to enable them understand the government position.









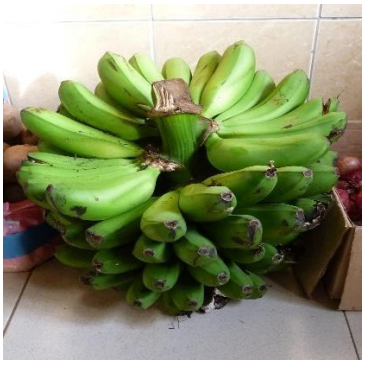
The district's LC5 chairperson has contacted you as a student with the knowledge of chemistry in your village to provide the relevant information.

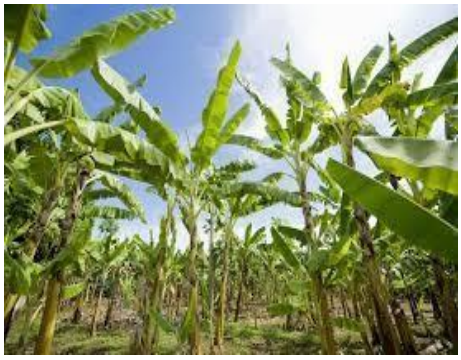
Task

Make a write up to use upon meeting the community

Item 3

A farmer in Kamwenge village has a large piece of land on which he planted bananas and millet for commercial purpose. He realized that a lot of bananas were ripening at the same time and therefore rotted before sale and he considered them wastes which led to a lot of loses





Task:

Advise the farmer on how to to generate a useful product from the wastes and generate products.

Item 4

Due to the need to provide its citizens with alcohol based sanitizers, government, is planning to set up an ethanol production plant with minimal environmental impact in one of the villages in Mukono District.

However, the locals in the selected village are wondering how the production process will be carried out. As a result, a sensitization workshop has been organized in the village by the government through the Local Council Chairperson.

Task

As a chemistry student, make a write up you will use during presentation if invited.

Item 5

A woman's group dealing in selling matooke(bananas) and millet have registered heavy losses due to ripening of bananas and germination of millet in storage. A parent who visited the school on the science fare, remembers that a sanitizer which is now on high demand due to Red Eye infections can be processed from these materials. The parent has consulted the leaders of the women's group and advised them to come to your school for an educative visit.

Task

As a learner of Chemistry, prepare a presentation of the message that would be used to produce and market the sanitizer.

1.13 Manufacture of Sodium Carbonate

Raw Material

- Brine
- Ammonia

Process of production

- Very concentrated brine (28% sodium chloride) is saturated with ammonia gas in a tower to form ammonia gas in a tower to form ammoniacal brine.
- The ammoniacal brine is run downwards from the top of the tower while carbon dioxide (formed from decomposition of calcium carbonate) is forced to rise up the tower from the base of the tower.
- The tower is fitted with perforated mushroom shaped baffles at intervals that delay the flow of ammoniacal brine and also offer surface for the reaction.
- The ammoniacal brine reacts with carbon dioxide to form sodium hydrogen carbonate as precipitates since it is not very soluble in water. Precipitation is assisted by cooling the lowest third of the chamber.

$$NaCl(aq) + NH_4OH(aq) + CO_2(g) \longrightarrow NaHCO_3(s) + NH_4Cl(aq)$$

- Sodium hydrogen carbonate is filtered from the white sludge at the base of the tower and washed to remove ammonium compounds. The sodium hydrogen carbonate is the heated to form sodium carbonate.

$$2NaHCO_3(s) \longrightarrow Na_2CO_3(s) + CO_2(g) + H_2O(g)$$

- The anhydrous sodium carbonate formed ha a wide market.
- If crystalline form (washing soda) is required, the anhydrous solid is dissolved in hot water, crystallization takes place as the solution cools. The crystals are removed and allowed to dry.

$$Na_2CO_3(aq) + 10H_2O(l) \longrightarrow Na_2CO_3.10H_2O(s)$$

Side effects of the process of production

❖ Carbon dioxide accumulation in the atmosphere from wearing out of the carbon anode can contribute to global warming due to heat it traps and reflects back on earth.

Mitigation can be done by planting trees to reduce on the amount of carbon dioxide in air by absorption during photosynthesis.

❖ Acid rain formation which lowers soil pH, causes rock like limestone to crumble and roofs made of iron to corrode.

Mitigation can be done by

Installing catalytic converters to convert the greenhouse emissions into harmless products.

- ❖ Burns from hot concentrated sodium carbonate solutions and other chemicals which can cause injuries and death to the workers.
- ❖ **Mitigation** can be done by wearing PPE like face masks, overalls to avoid injuries.

Social benefits of the process of production

- Source of employment opportunities where people earn income, afford basic needs thus better and improved standards of living for the people.
- Development of infrastructure e.g electricity lines, roads, hospitals, schools etc improved road network will facilitate trade hence improved income and better standards of living.
- Increased government revenue, the production plant generates tax revenue for local government which can be used to fund public services and infrastructure projects which result in improved standards of living.

Fractional Distillation of Crude Oil

Raw material

Crude oil

Process of production

- ➢ Crude oil is fed into a fractional distillation column/tower and heated. Crude oil separates into fractions based on boiling points; natural gas, gasoline, naphtha, kerosene, diesel etc.
- ➢ Heavy fractions are fed into a fluid catalytic cracking (FCC) unit. Heat, pressure and catalysts break down heavy molecules into lighter ones; gasoline, diesel
- ➢ Reforming; naphtha fractions are fed into a catalytic reformer, catalysts and heat convert naphtha into higher-octane gasoline.
- ➢ Hydro treating; fractions are fed into a hydrotreater, hydrogen and catalysts remove impurities like sulphur and nitrogen.
- ➢ Purification; fractions undergo solvent extraction or adsorption to remove impurities.
- ➢ Blending of fractions to meet specific product specifications.

Side effects of the process of production

- ❖ Water pollution; release of chemicals and wastes into water bodies.
- ❖ Noise pollution; noise from machinery and transportation which may lead to hearing problems.
- ❖ Loss of biodiversity; habitat destruction and impact on wild life
- ❖ Soil degradation; overuse of land, soil erosion and nutrient depletion which result in low crop production.

Social benefits of the process of production

- Source of employment opportunities where people earn income, afford basic needs thus better and improved standards of living for the people.
- Development of infrastructure e.g. electricity lines, roads, hospitals, schools etc. improved road network will facilitate trade hence improved income and better standards of living.
- Increased government revenue, soap production plant generates tax revenue for local government which can be used to fund public services and infrastructure projects which result in improved standards of living.

Process of Production of Crude Oil(Recommended)

Raw material

Underground petroleum resources/ fossil fuels

Process of production

The extraction process involves;

Primary recovery/extraction

This involves drilling wells into underground reserves allowing oil to flow out under natural pressure. This is usually done through traditional drilling techniques using a derrick and drill pipes.

Secondary recovery/extraction

After natural pressure decreasing, water or gas is injected into the reservoir to displace the oil and push it to the surface.

Tertiary recovery/extraction (enhanced oil recovery)

Involves use of advanced techniques like steam injection or miscible gases to extract remaining oil.

After extraction, oil is separated into different components based on density (gravity separation). Desalting which involves removing impurities such as salts, water and sediments is done prior to fractional distillation.

Final purification of oil is done in the fractionating chamber/tower in which oil vapourise and different components (called fractions) condense at different temperatures due to their varying boiling points.

Side effects of the process of production

Air pollution by waste gases. Acidic gases can cause acid rain which leads to crumbling of walls of the building, alters soil pH, and corrodes roofs made of iron. This can be mitigated by fitting catalytic converter in exhaust pipes of machines to convert oxides of nitrogen into nitrogen and carbon monoxide to carbon dioxide.

-Destruction of vegetation e.g trees, forest to clear land for the establishment of the factory, results in accumulation of carbon dioxide gas in the atmosphere, which causes global

warming, it can also lead to soil erosion. This can be mitigated by planting trees which grow and mature very fast

-Poisonous fumes/waste gases from the factory pollutes air and can cause respiratory problems. This can be mitigated by use of catalytic converters in the exhaust pipes of the machines to convert the fumes into non-toxic compounds and also use of masks.

Social benefits of the process of production

Employment opportunities, increased income among residents hence improved standards of living

Source of government revenue, improved infrastructure hence better standards of living

Sample Items

Item 1

The discovery of crude oil and natural gas in Bunyoro region has caused excitement to people while the neighboring communities are worried about the impact of the extraction process on the environment. The National Oil Company (UNOC) officials have organized a sensitization meeting with the residents to address their worries.

Task

Using your knowledge of chemistry, make a write up of what the officials would present to the residents.

Summary of Industrial Processes

INDUSTRIAL PROCESSES (SECTION B- ITEM 3 AND 4) attempt only one item					
		RAW MATERIALS(Rm)	**PROCESS OF PRODUCTION (PP)**	**DANGER OR SIDE EFFECTS, EXPLANATION & IMPACT [DEM]**	**SOCIAL BENEFITS, EXPLANATION & IMPACT[BEI]**
	Process	3 scores		3 scores	
1	Oxygen	(liquid) air	**V-** vessel **Pi-** process(cp,pp) **ch**-coherence **Pr-** purification **cd**- conversion to desired product	-Destruction of vegetation e.g trees, forest to clear land for the establishment of the factory, results in accumulation of carbon dioxide gas in the atmosphere, which causes global warming, it can also lead to soil erosion. This can be mitigated by planting trees which grow and mature very fast. -Poisonous fumes/waste	-Employment opportunities, increased income among residents hence improved standards of living. -source of government revenue, improved infrastructure hence better standards of living
2	Ethanol	Starch, yeast, malt			
3	Soapy detergent	Vegetable oil or animal fat, sodium hydroxide			
4	Soapless detergent (non-soapy detergent)	Benzene, alkene, concentrated sulphuric acid, sodium hydroxide			
5	Chlorine	Brine			
6	Sodium hydroxide	Brine			
7	Sulphuric acid	Sulphur, oxygen, water, concentrated sulphuric acid			
8	Ammonium nitrate fertilizer	Nitrogen, hydrogen			
9	Cement	Limestone, clay, gypsum			

10	Aluminium	Bauxite		gases from the factory pollutes air and can cause respiratory problems. This can be mitigated by use of catalytic converters in the exhaust pipes of the machines to convert the fumes into non-toxic compounds and also use of masks	
11	Copper	Copper pyrites			
12	Iron	Iron ore (e.g haematite), coke, limestone , air			

D. DETERGENTS	
Basis of assessment	**Expected responses**
Category of the product	Detergents are classified as Soapy detergents Soapless detergents
Functions of the product	A detergent/soap molecule contains two parts; namely the hydrophilic part(loves water but hates dirt) and hydrophobic part(loves dirt but hates water) During washing, the surface tension between water and oil/dirt is lowered With constant agitation, the dirt is removed off the cloth through emulsification.

	The cloth is rinsed several times with cleaned and dried. **OR** Detergent molecule works by lowering the surface tension between dirt and water. The molecule consists of two parts: the hydrophilic (polar) part, which is water soluble and the hydrophobic (non-polar) part which is fat soluble. During washing, the polar part dissolves the dirt, while the hydrophilic part is attracted and dissolves in water. Due to constant agitation, the dirt is removed from the cloth and is suspended in water. The cloth is rinsed several times with clean water and dried.
Dangers/side effects + explanation + mitigation	<u>For soapy detergents.</u> Soap contains chemicals that can cause skin burns and hence pain and cancer threats. Soap contains chemicals which can cause eye redness and pain hence loss of vision Mitigation Thoroughly washing the affected areas with enough water. **<u>Soapless detergents</u>** Soapless detergents contain phosphates, an algae nutrient leading to algal bloom that cuts off oxygen supply to the aquatic organisms, eventually, leading to suffocation and hence death Mitigation; Proper disposal of detergent
Evaluation of the product	**Similarities** Both are salts of organic acids of long chain carbon

	Both are effective cleansing agents in soft water **Differences** Soapy detergent / Soapless detergent Forms scum with hard water / Does not form scum with hard water Gentle on skin when using it / Not gentle on skin Biodegradable / Non-biodegradable

Detergent;

How it works.

Detergent molecule works by lowering the surface tension between dirt and water. The molecule consists of two parts: the hydrophilic (polar) part, which is water soluble and the hydrophobic (non-polar) part which is fat soluble. During washing, the polar part dissolves the dirt, while the hydrophilic part is attracted and dissolves in water.

Due to constant agitation, the dirt is removed from the cloth and is suspended in water. The cloth is rinsed several times with clean water and dried.

Sample items

Item 1

Upon getting borehole water and on their way back home, John and Peter slipped, fallen down and their white shirts became dirty. John decided to use a detergent **A** to clean his shirt but it remained with some brown stains despite rinsing it many times. Peter also used another detergent **B** and his shirt was cleaned with in one rinse.

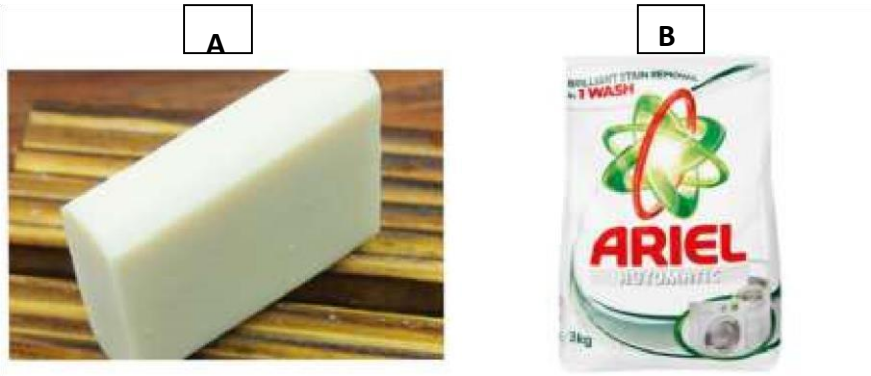


Fig 1. Shows detergents used by John and Peter to wash their shirts.

Task:

As a chemistry learner;

(a) Explain

i) The categories of products used by John and Peter.

ii) How the products work and the challenges associated with the long term use of the products?

iii) Evaluate the products.

Item 2

Joan and Priscilla went to wash their clothes around the nearby well surrounded by racks. Joan used detergent T and Priscilla used detergent Q two days later, Joan realized that her white clothes had some dirty marks yet she rinsed them with water several times. Priscilla, on the other hand never had such complaints.

Joan is now frustrated and cannot understand what went wrong. As a result, both Joan and Priscilla have approached you to help them understand their situation.

Task.

As a chemistry learner, write a message you will share with the two ladies, In your message:

(a) Explain categories of products T and Q used by the two ladies

(b) Help Joan to understand how the product works.

(c) Advice the two ladies on the challenges associated with the use of the products.

Item 3

Most of the youths in Kampala depends on the fast foods prepared by peasant ladies for breakfast and lunch. They say the food has a nice aroma, the food can stay for some time when kept hence attracting them. On a certain day one the youths got stomach upset and decided to use paracetamol tablets for relief.

Task:

Use your chemistry knowledge to; Explain

(i) Categories of the products used.

(ii) The suitability of the products.

(iii) What are the side effects of using the products?

(iv) How can these side effects be mitigated?

Item 5

Onyera, living in an area where they use bore hole water, slid, fell and his white shirt became dirty. He decided to use a detergent to clean his shirt. The shirt remained with some brown spots yet he had rinsed it several times.

Task:

As a chemistry learner;

(a) point out the problem Onyera made when choosing a product.

(b) help Onyera understand how the product works.

(c) advice Onyera on the challenges associated with the long term use of the product.

Item 6

In one of the towns in Uganda, residents are facing an unexpected challenge of water wasting detergents. The locals are frustrated and do not know what to do. They have been advised to try other alternatives on the market to overcome the challenge but they need more advice on this

As a concerned chemistry student in the town,

Task:

Help the residents,

(a) understand the variety and mode of action of the detergents

(b) on the consequences of the detergent.

Item 7

Joan and Priscilla went to wash their clothes around the nearby well surrounded by racks. Joan used detergent T and Priscilla used detergent Q two days later, Joan realized that her white clothes had some dirty marks yet she rinsed them with water several times. Priscilla, on the other hand never had such complaints.

Joan is now frustrated and cannot understand what went wrong. As a result, both Joan and Priscilla have approached you to help them understand their situation.

Task.

As a chemistry learner, write a message you will share with the two ladies, In your message:

(a) Explain categories of products T and Q used by the two ladies

(b) Help Joan to understand how the product works.

(c) Advice the two ladies on the challenges associated with the use of the products.