INDUSTRIAL PROCESSES

FIRST ELEMENT OF CONSTRUCT-EOC 1:

The learner appreciates contribution of chemistry to our economy.
(For item 3 and 4 in part I of section B)
TOPICS;

- ✓ Industrial processes
- ✓ Air. (Mainly one manufacture of oxygen.)
- ✓ Chemistry and society.
- ✓ Carbon in life. (Mainly on crude oil, fermentation and saponification)
- ✓ Chemical reactions. (In iron extraction and for concepts of electrolysis in extraction of Aluminium, copper, manufacture of sodium hydroxide and chlorine)

ASSESSABLE AREAS

Assessable areas	**What each process involves**
(a) Manufacture of oxygen gas (b) Manufacture of chlorine gas (c) Extraction of metals (A1, Fe, Cu) (d) Manufacture of fertilizers (e) Manufacture of detergents (f) Manufacture of sodium hydroxide (g) Manufacture of Sulphuric acid. (h) Manufacture of cement (i) Manufacture of Ethanol (j) Manufacture of Bio gas. (k) Manufacture of ammonia	**V**- vessel **Cp** – chemical process **Cd** – conversion to desired product **Ch**- coherence **Pr** – Purification

1. MANUFACTURE OF OXYGEN

RAW MATERIALS; Air, Concentrated sodium hydroxide and silica
Air is passed through air filter to remove dust and smoke particles.
Air is passed through concentrated sodium hydroxide solution to remove carbon dioxide.
Air is then passed through silica jet 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 remaining components of air are repeatedly compressed at 200 atmospheres and allowed to cool at about – 200 ^{0}C to obtain liquid air
The liquid air is fractionally distilled using a fractionating column.
Nitrogen boils off first because it has a lower boiling point (-196^{0}C) leaving behind oxygen with a higher boiling point (-1830^C). Pure oxygen is then stored under pressure in steel cylinders.

SIDE EFFECTS AND MITIGATION

Explosion of oxygen cylinders due to high pressure; This can cause other materials to catch fire causing injury to people; **Mitigation** can be done by regular maintenance and monitoring of cylinders.

SOCIAL BENEFITS

Employment opportunity; improved income; thus **better standards of living;**

TRIAL ITEM WITH A RESPONSE

During the Covid 19 Pandemic, there was a high demand of oxygen in referral hospitals in Uganda. An investor was contacted by the Ugandan government to set up an oxygen manufacturing plant in one of the swamps near Kampala city authority in order to increase oxygen production. However, the residents seem not to understand how the process was to occur plus its consequences and were resisting the project. As a **senior two** 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.

Air;✓ ***Rm*** *is passed through* ***air filters*** *to remove dust and smoke particles;✓* ***Pr*** *It i s then passed through concentrated sodium hydroxide;✓* ***Rm*** *solution to remove carbon dioxide;✓* ***Pr*** $2NaOH_{(aq)} + CO_{2\,(g)} \rightarrow Na_2CO_{3(\,aq)} + H_2O_{(l)}$. *Air free from carbon dioxide is now passed through Silicon (IV) oxide;✓* ***Rm*** *to absorb water vapour.;✓* ***Pr*** *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;✓* ***Pc*** *and allowed to cool;✓* ***Pp*** *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^{o}C. The liquid air is* ***fractionally distilled;✓*** ***Pc*** *using a* ***fractionating column / tower;✓*** ***V*** ***Nitrogen boils;✓*** ***Pc*** *off first because it has a lower boiling point (–196^{o}C) leaving behind oxygen with a higher boiling point of (-183^{o}C). Pure oxygen;✓* ***Cd*** *is then stored under pressure in steel cylinders.;✓* ***Ch***

3Rm+1V+3Pp+3Pc+1Pr+1Cd+1Ch =P$_3$=06score

Side effects/Dangers of the process of production

- ***Explosion of oxygen cylinders*** *due to high pressure;✓* ***Di causing injuries and fire outbreaks*** *also* ***resulting into damage to equipment,;✓*** ***De mitigated*** *by the following;* ***first****, regular maintenance and monitoring of cylinders;* ***secondly****, keeping cylinders in cool areas to avoid exposure to heat.;✓* ***Dm*** ***Di + De + Dm = S$_3$ = 06scores***
- ***Exposure to liquid oxygen;✓*** *can* ***cause severe skin and eye irritations and burns, loss of vision and cancer,;✓*** ***mitigated 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,;✓* ***Sb*** *thus improved income;✓* ***Se*** *and therefore* ***better standards of living;✓*** ***Si***
- ***Increased government revenue*** *from taxes;✓* *hence* ***improvement of infrastructure*** *such as roads, schools, health facilities;✓* *leading to the* ***development of the society.;✓***
- ***Development of small scale businesses****, hence* ***generating income****, leading to* ***better life;✓*** ***Sb+Se+Si = B$_3$ =06Scores***
- ***Availability of oxygen for patients****, hence* ***saving lives of the people in the area*** *and living a* ***better health*** ***TOTAL = P$_3$ + S$_3$ + B$_3$ = 06 + 06 + 06 = 18***

2. MANUFACTURE OF SULPHURIC ACID

Dry Sulphur dioxide gas free from impurities is heated with dry pure **oxygen** gas at low temperatures of about 450°C high pressure of about 1 atmosphere in the presence of vanadium (v) oxide catalyst forming Sulphur trioxide. This occurs in a **combustion cylinder.**
Sulphur trioxide is dissolved in little **concentrated Sulphuric** acid forming fuming liquid called oleum.
Oleum is added to a regulated volume of distilled water to form 98% concentrated sulphuric acid.

SIDE EFFECTS, EXPLANATION AND MITIGATIONS

1. **Hot surface burns** from combustion cylinders causing wounds hence pain to workers, this can be **mitigated** by proper use of personal protective equipment
2. **Poisonous fumes** by waste gases which when inhaled can cause **respiratory complications**, this can be mitigated by **fitting catalytic converters** in exhaust pipes of machines
3. Destruction of **vegetation/cutting down trees** for space for construction and installing machines that increases carbon dioxide in air hence **global warming**. This can be mitigated by **planting trees** that grow and mature faster absorb carbon dioxide gas**.**

SOCIAL BENEFIT; EFFECT AND IMPACT

1. Employment opportunities; increased income among residents hence improved standards of living
2. Government gets revenue; develops infrastructure e.g. roads which facilitates trade, hence improved income thus improved standards of living.
3. Government gets revenue; develops infrastructure e.g. schools hence access to better and cheaper education thus well- informed community.

3. MANUFACTURE OF ETHANOL

The starch containing substance is crushed to extract starch.
Malt is then added to starch in a **container** and it is then covered, malt contains an enzyme diastase that catalyzes hydrolysis of starch to maltose
Yeast is then added to maltose after about 5 days at room temperature.
The maltase in yeast catalyzes the hydrolysis of maltose to glucose.
Zymase enzyme in yeast catalyzes the breakdown of glucose to crude ethanol and carbon dioxide. Crude ethanol is converted to pure ethanol by fractional distillation

SIDE EFFECTS, EXPLANATION AND MITIGATIONS

1. **Hot surface burns** from distillation tank causing **wounds** hence pain to workers, this can be **mitigated** by proper use of personal protective equipment.
2. Destruction of **vegetation/cutting down trees**for space for construction and installing machines that increases carbon dioxide in air hence **global warming**. This can be mitigated by **planting trees**that grow and mature faster**.**

SOCIAL BENEFIT; EFFECT AND IMPACT

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4. Government gets revenue; develops infrastructure e.g. hospitals hence access to better and cheaper health services thus better health community.

4. MANUFACTURE OF DETERGENT (SOAPY)

A mixture of vegetable oil and concentrated sodium hydroxide solution is boiled while stirring until no more reaction occurs in a boiler (Reactor vessel or container made of stainless steel).

The resultant soap solution is cooled; concentrated sodium chloride solution is added to soap solution to precipitate out the soap.

Soap floats and it's skimmed off. Additives like perfumes and dyes may now be added

It is then purified by boiling it in water and re-precipitated with brine.

Soap is baked into desired bars and it is stored

SIDE EFFECTS, EXPLANATION AND MITIGATIONS

1. **Hot surface burns** during the heating process causing **wounds** hence pain to workers, this can be mitigated by **proper use of personal protective equipment.**
2. Destruction of **vegetation/cutting down trees** for space for construction and installing machines that increases carbon dioxide in air hence **global warming**. This can be mitigated by **planting trees** that grow and mature faster**.**

SOCIAL BENEFIT; EFFECT AND IMPACT

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5. EXTRACTION OF IRON

Coke, heamatite, and limestone are fed into a **blast furnace** from the top. Hot air is from the bottom of the furnace Coke is oxidized by hot air to carbon dioxide.

The carbon dioxide formed is then reduced by unreacted coke to carbon monoxide.

The carbon monoxide reduces the hematite to molten iron and Carbon dioxide is given off

Limestone decomposes to calcium oxide and carbon dioxide. The calcium oxide reacts with silicon dioxide which is an impurity, forming calcium silicate which is tapped off

SIDE EFFECTS, EXPLANATION AND MITIGATIONS

1. **Hot surface burns** during the process causing **wounds** hence pain to workers, this can be mitigated by **proper use of personal protective equipment.**
2. Destruction of **vegetation/cutting down trees** for space for construction and installing machines that increases carbon dioxide in air hence **global warming**. This can be mitigated by **planting trees** that grow and mature faster**.**

SOCIAL BENEFIT; EFFECT AND IMPACT

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6. EXTRACTION OF COPPER

Copper pyrites are crushed and **concentrated by froth floatation.** The concentrated ore is dried and roasted in **air** in a **furnace** to form copper (I) sulphide, iron (II) oxide and sulphur dioxide gas.

Silicon dioxide is added and reacts with iron (II) oxide to form iron (II) silicate hence iron (II) oxide is removed.

The remaining copper (I) sulphide is then heated in controlled air supply to form **impure copper.**

The impure copper is then **purified** by electrolysis in an **electrolytic cell** to form pure copper.

SIDE EFFECTS, EXPLANATION AND MITIGATIONS

1. Destruction of **vegetation/cutting down trees** for space for construction and installing machines that increases carbon dioxide in air hence **global warming**. This can be mitigated by **planting trees** that grow and mature faster**.**
2. **Toxic gases** like Sulphur dioxide are released to the atmosphere and cause **respiratory complications**. This can be mitigated by **fitting scrubbers in the exhaust pipes** of machines to neutralize the acidic gases.

SOCIAL BENEFIT; EFFECT AND IMPACT

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7. EXTRACTION OF ALUMINIUM

Aluminium is extracted from Bauxite as the principle ore. The ore is first roasted in air to drive off any water in it. The ore is then crushed into fine powder and concentrated with hot pure Aluminium hydroxide solution in **a container** to form pure aluminum hydroxide by Bayer's process. The Aluminium hydroxide is heated to form pure Aluminium oxide.

$$Al_2O_{3\,(s)} + 2\bar{O}H_{\,(aq)} \longrightarrow 2AlO_2^-{}_{(aq)} + H_2O_{\,(l)}$$

The Aluminium oxide is dissolved in molten cryolite to lower its melting point to about 800^0c. The molten Aluminium oxide is electrolyzed between graphite electrodes. Aluminium ions migrate to the cathode where they are reduced and discharged as pure Aluminium metal.

At Cathode: $Al^{3+}_{(l)} + 3e^- \longrightarrow Al_{(s)}$

Oxide ions migrate to the anode where they are oxidized and liberated as oxygen gas.

At Anode: $2O^{2-}_{(l)} \longrightarrow O_{2\,(g)} + 4e^-$

SIDE EFFECTS AND MITIGATION

- Hot surface burns causing wounds hence pain to workers and this can be mitigated by proper use of required personal protective equipment.
- Poisonous fumes by waste gases which when inhaled can cause respiratory disorders. This can be mitigated by fitting catalystic converters in exhautst pipes of the machines to converter oxides of nitrogen into nitrogen and carbon monoxide to carbon dioxide.

SOCIAL BENEFITS

Employment opportunities; This leads to increased income among residents hence improved standards of living.

8. MANUFACTURE OF CEMENT

A mixture of limestone and clay are crushed and milled into fine powder.
The powder is then mixed with water and allowed to flow down a **rotating cylinder** in which it is heated to a temperature of about 1500oC
Limestone decomposes to calcium oxide and carbon dioxide.
Calcium oxide reacts with aluminum oxide and silicon dioxide in clay to form lumps of calcium aluminate and calcium silicate
The lumps are crushed to form cement as fine powder.
Gypsum is added during the grinding process to moderate the reaction between cement and water. Cement is then packed in bags for use.

SIDE EFFECTS, EXPLANATION AND MITIGATIONS

1. **Toxic gases** and dust are released to the atmosphere and cause **respiratory complications**. This can be **mitigated** by fitting scrubbers in the exhaust pipes of machines to neutralize the toxic gases.
2. Destruction of **vegetation/cutting down trees** for space for construction and installing machines that increases carbon dioxide in air hence **global warming**. This can be mitigated by **planting trees** that grow and mature faster**.**
3. **Hot surface burns** from combustion process causing **wounds** hence pain to workers, this can be mitigated by **proper use of personal protective** equipment

SOCIAL BENEFIT; EFFECT AND IMPACT

1. Employment opportunities; Increased income among residents hence improved standards of living
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9. MANUFACTURE OF AMMONIUM NITRATE FERTILIZER

Nitrogen from air and hydrogen from natural gas are compressed and passed over heated iron catalyst in a catalytic chamber. The two gases react to form ammonia.
Ammonia is mixed in excess oxygen, purified and passed over platinum catalyst at 7000C and ammonia is oxidized to nitrogen monoxide and water. The gases are cooled and mixed with more air to form nitrogen dioxide. Nitrogen dioxide is absorbed in hot water and excess oxygen to form nitric acid in the absorption tower.
Nitric acid is reacted with concentrated ammonia to form ammonium nitrate. The product is evaporated to dryness to obtain pure ammonium nitrate.

SIDE EFFECTS, EXPLANATION AND MITIGATIONS

1. **Toxic acidic gases** released to the atmosphere and cause **acidic rain that lowers pH of soil hence reduced yields**. This can be mitigated by **fitting catalytic converters** that convert nitrogen oxides to nitrogen**.**
2. **Toxic gases** released to the atmosphere and cause **respiratory complications**. This can be mitigated by **fitting scrubbers in the exhaust pipes** of machines to neutralize the toxic gases.
3. Destruction of **vegetation/cutting down trees** for space for construction and installing machines that increases carbon dioxide in air hence **global warming**. This can be mitigated by **planting trees** that grow and mature faster**.**

SOCIAL BENEFIT; EFFECT AND IMPACT

1. Employment opportunities; increased income among residents hence Improved standards of living
2. Government gets revenue; develops infrastructure e.g. roads which facilitates trade, hence improved income thus improved standards of living.

10. MANUFACTURE OF BIO GAS

Organic wastes are put in a **tank as shown above,** and mixed with some little water. The tank is covered to prevent aerial oxidation. The tank and contents are maintained at room temperature for about 2 weeks. Anaerobic bacteria break down the organic matter (formation) **to produce biogas.** The biogas compressed and collected in gas cylinder for storage, by means of pipes.

SIDE EFFECTS AND MITIGATION

1. Side effects:

Explosion of biogas cylinders due to high pressure: This can cause other materials to ignite spontaneously and catch fire.

Mitigation :

Mitigation can be done by **keeping cylinders in cool areas.**

2. Side effects: Air pollution by waste gases (such as hydrogen sulphide and ammonia) in case of any leakage. This may cause stomach and respiratory disorders.

Mitigation: This can be mitigated by regular maintenance and monitoring of cylinders.

3. Side effects : Leakage of hydrogen sulphide as a waste gas that can cause acid rain which leads to crumbling of buildings.

Mitigtion: This can be mitigated by regular maintenance and monitoring of cylinders.

SOCIAL BENEFITS

- Employment opportunities; increased income among residents hence improved standards of living. Or; The gas is used for lighting and a fuel sources of cooking hence improved standards of living among residents

11. SODIUM HYDROXIDE AND CHLORINE

Brine is electrolyzed in an electrolytic cell having mercury cathode and graphite anode.
During the process, chloride and the hydroxide ions move to the anode. Chloride ions are discharged and lose electrons to form chlorine gas. This is due to their high concentration. **The chlorine formed is dried liquefied and stored in tightly closed tanks.**
Sodium and hydrogen ions move to the cathode and sodium ions are discharged. They gain electrons to form sodium metal.
The sodium metal dissolves in mercury to form sodium amalgam which is reacted with water to form sodium hydroxide solution, hydrogen and mercury. Mercury is fed back for reuse the cathode
The sodium hydroxide solution is evaporated to dryness to molten sodium hydroxide and cooled to form solid sodium hydroxide.

SIDE EFFECTS, EXPLANATION AND MITIGATIONS

1. **Mercury poisoning:** Exposure to mercury inhalation can cause damage to the nervous system, kidneys, liver and immune system hence cancer. This can be mitigated by posting hazard warning information in working areas.
2. **Toxic acidic gases** released to the atmosphere and cause **acidic rain that lowers pH of soil hence reduced yields**. This can be mitigated by **fitting catalytic converters** that convert nitrogen oxides to nitrogen**.**
3. Destruction of **vegetation/cutting down trees** for space for construction and installing machines that increases carbon dioxide in air hence **global warming**. This can be mitigated by **planting trees** that grow and mature faster

SOCIAL BENEFIT; EFFECT AND IMPACT

1. Employment opportunities; Increased income among residents hence improved standards of living
2. Government gets revenue; develops infrastructure e.g. roads which facilitates trade, hence improved income thus improved standards of living.

END

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