CHAPTER:16 INDUSTRIAL PROCESSES

Key words	Learning Outcomes
Ore Extraction Roasting Purification Concentration Crushing Cement Lime Fertilizers Electrolysis Industry Minerals	By the end of this chapter, you should be able to: a) Know about some of the main industries that produce useful chemicals such as the oil industry for organic chemicals, the production of metals, the acid industry, the alkali industry, the fertilizer industry and cement industry. b) Understand the processes of obtaining useful chemicals from rocks. c) Understand the properties involved in extracting and purifying metals, with particular reference to processes used in Uganda. d) Understand the importance of nitrates as fertilizers in food production and how they are produced from the nitrogen in the air. e) Outline four industrial processes that make use of natural resources obtained in Uganda. f) Recognize the importance of industrial processes in utilizing natural resources to make useful chemicals and appreciate that industrial processes have social benefits, as well cause problems of pollution and environment destruction. g) Describe some of the dangers to the community, arising from these industrial processes, and steps that may be taken to minimize these dangers. h) Understand the processes involved in the manufacture of lime and cement. i) Understand the production of alkali and chlorine through the electrolysis of salt solution. j) Evaluate the uses of synthetic polymers.

COMPETENCY: The learner should appreciate the principles behind some industrial processes and the importance of the products formed.

a) MAIN INDUSTRIES IN UGANDA

These include mainly industries that produce useful chemicals such as the oil industry for organic chemicals, the production of metals, the acid industry, the alkali industry, the fertilizer industry and cement industry.

Table below shows the main industries and useful products they produce.

Batteries	Cement	Iron bars
		
		
Plastic bottles	**Fertilizers**	**Plastic wares**

Table below shows some of the major industries and products they produce

Product(s) produced	Industry in charge
Cooking oils	Oil industry
Soda and mineral water	Beverage industry
Acids and alkalis	Acid and alkali industry
Cosmetics	Cosmetic industry
Medicines	Pharmaceutical industry
Vehicles	Automotive industry
Steel tubes/pipes/sheets	Manufacturing industry
Detergents/soaps	Laundry industry
Cement	Mining industry
Fertilizers	Agro - based industry
Synthetic polymers	Plastic industry

a) EXTRACTION OF METALS FROM ROCKS

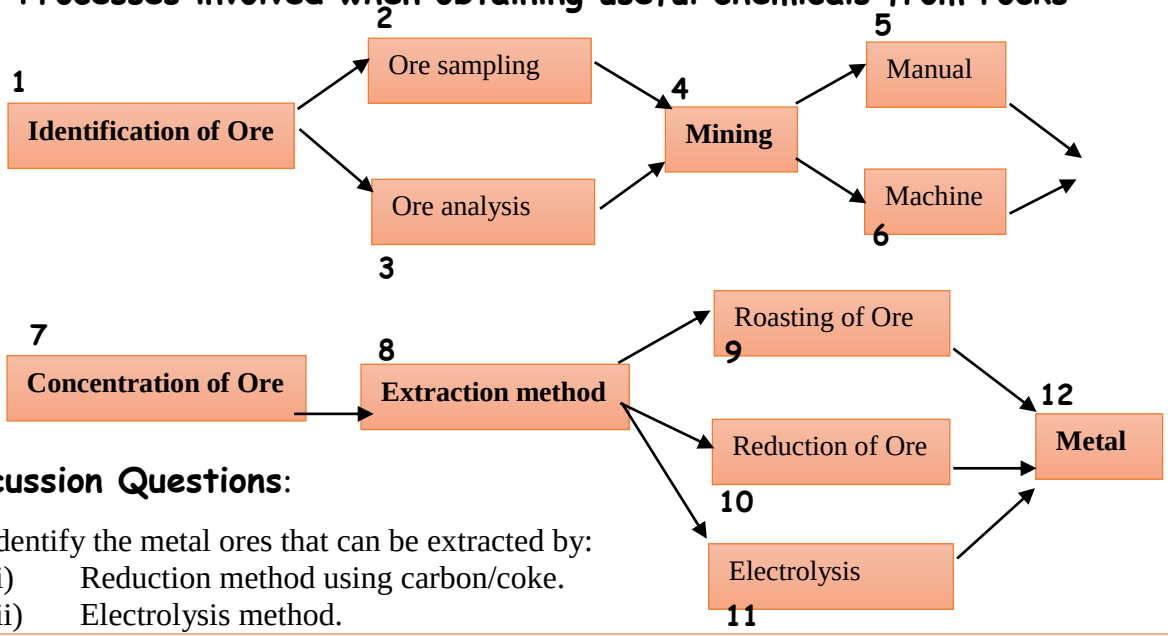
This is the process of obtaining pure metals from their impure ores.

Ores: Are naturally occurring minerals that contain sufficient quantities of metals to be extracted. The process of metal extraction involves several steps including mining, concentration, reduction and purification.

Methods of Extracting some metals from their native ores

Ore	Chemical name	Metal extracted	Method of extraction
Bauxite	Hydrated aluminium oxide	**Aluminium**	Electrolysis of aluminium oxide in molten cryolite.
Impurities	Silicon dioxide, Iron (III) oxide		
Copper pyrites	Copper (II) sulphide	**Copper**	Reduction method followed by Electrolysis of blister copper
Impurities	Silicon dioxide, Iron (II) oxide		
Haematite/ spathic	Hydrated iron (III) oxide /iron (II) Carbonate	**Iron**	Reduction of iron (III) oxide by carbon or its oxide.
Impurities	Silicon dioxide, Aluminium oxide		

Processes involved when obtaining useful chemicals from rocks



Discussion Questions:

a) Identify the metal ores that can be extracted by:
(i) Reduction method using carbon/coke.
(ii) Electrolysis method.

b) Suggest the reason for your answers in (a) above.
c) Why are the following steps important during metal extraction?
   (i) Rock sampling and analysis.
   (ii) Roasting, adding a frothing agent to the ores and smelting ores.

What you may need to know

1) Identification of Ore in the rocks: This involves locating and determining the presence of minerals that contain the desired metal to be extracted, though geological surveys and samplings.

2) Ore sampling: This is done when the potential ore deposits are identified, by collecting samples from different locations to assess its quality and quantity.

3) Ore analysis: This step involves testing the collected samples to determine the composition and concentration of the desired metals to be extracted by use of various methods such as atomic mass spectroscopy.

4) Mining: This step involves the use of several methods depending on the type of the ore and its location, such methods include manual mining or surface/underground mining by use of machines.

5) Concentration of Ore: This methods vary based on the type of mineral to be extracted. These methods of concentrating ore include:

(i)Roasting: This involves heating the ore to convert any carbonates and sulphides to oxides and to remove water vapour. This step makes it easier to reduce the oxides than carbonates or Sulphides during reduction reaction.

(ii) Crushing/Grinding: This involves crushing and grinding the large lamps of ores into fine particles to expose the desired metal intended to be extracted.

(iii) Screening: This involves removing the large and uncrushed particles, or waste materials from the fine powdered ore.

(iv) Froth flotation: This involves adding a frothing agent that causes the ore to float while the impurities sink. This step aids the separation between impurities and ores.

(v) Magnetic separation: This involves the use of magnets to remove metals with magnetic property leaving behind the non – magnetic substances. This method is suitable for the extraction of iron metal from its ores.

6) Reduction method: This is the final step of metal extraction. It involves using various methods to obtain pure metal from concentrated ores. These methods include:

(i)Pyrometallurgical reduction. It involves heating the ores at high temperatures to separate metals from their ores. It is employed in the extraction of metals like iron, copper and others from their respective ores. It involves **smelting** where the ore is heated in the presence of a reducing agent (mainly carbon inform of coke). The heat generated during smelting also helps to melt the metal, allowing it to be separated from impurities.

(ii)Hydrometallurgical reduction: It involves the use of aqueous solution to extract metals from their ores. For example Blister copper is extracted from its sulphate solution using electrolysis.

(iii)Electrometallurgical reduction: It involves the use of electricity to drive the process of reduction reaction during electrolysis. This method only applies for the most reactive metals such as Aluminium and Magnesium. For example during Hall – Heroult extraction of Aluminium, from its ores and purification of blister copper.

EXTRACTION & PURIFICATION OF COPPER

Raw materials & process of production	Copper pyrites, ***$CuFeS_2$*** is the chief ores from which copper metal is extracted containing impurities such as silicon dioxide. **During froth flotation:** The ore obtained from the mine is first added to a frothing agent, filtered, concentrated, dried and grounded into fine powder. **During Roasting**: The dry powdered ore is then heated at high temperatures to convert any sulphides/carbonates to oxides and copper (I) sulphide in a Reverberatory/Blast furnace. $2CuFeS_2(s) + 4O_2(g) \longrightarrow Cu_2S(s) + 3SO_2(g) + 2FeO(s)$ The mixture of copper (I) sulphide and iron (II) oxide is then fed into a mixer tank containing silicon dioxide to remove iron (II) oxide forming iron (II) silicate as slag which floats as copper (I) sulphide sink to the bottom of the tank. $FeO(s) + SiO_2(s) \longrightarrow FeSiO_3(l)$ **During Reduction reaction**: Copper (I) sulphide is reduced to blister copper by heating the ore in air.

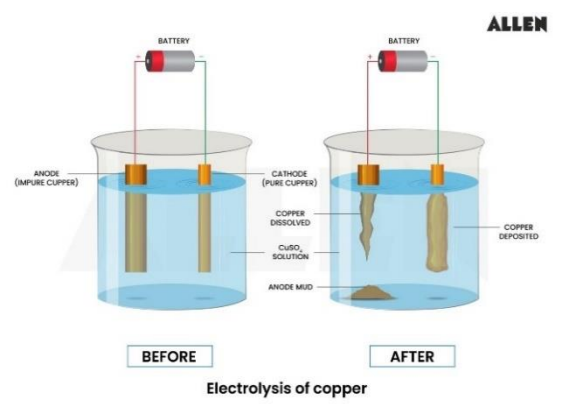
	$Cu_2S(s) + O_2(g) \longrightarrow Cu(s) + SO_2(g)$ **During Purification**: Blister copper is purified by electrolysis, using blister copper as the anode and pure copper as the cathode, both placed in an electrolytic cell containing an electrolyte of copper (II) sulphate solution. At the anode, blister copper undergoes oxidation reaction by loss of electrons, and migrate towards the cathode leading to a decrease in its anode size. At the cathode, copper (II) ions undergo reduction reaction by gain of electrons, depositing brown solid leading to an increase in the cathode size. $Cu^{2+}(aq) + 2e \longrightarrow Cu(s)$
Impact and mitigation	**Environmental impacts:** - Dust particles, high emission of sulphur dioxide gas leading to air pollution and increased greenhouse gas in the environment. This can be mitigated by installing an effective air quality monitoring equipment to absorb and reduce dust and sulphur dioxide gas emission. - Soil destruction from the activity of mining; leading to its erosion and exhaustion of plant nutrients. This is mitigated by use of hybrid equipment that when used, leave no harm to the environment. **Social impacts:** - Community displacement by the miners; leading to loss of land and properties. This is mitigated by engaging the community in the relocation and compensation plans. - Cultural heritage destruction by the miners, leading to loss of societal cultural values. This is mitigated by encouraging cultural heritage preservation policies. **Health Impacts:** - Respiratory problems, cancer, accidents; leading to unhealthy body organs and loss of body parts/life. This can

	be mitigated by use of personal protective equipment (PPE) and having routine health – checkup.
Social benefits	**Economic and societal benefits:** - Job opportunity for both skills and unskilled labours; hence getting income; this enables them improve their standard of living such as meeting their basic needs. - Economic growth to the National treasure through government taxation, this enables the government improve on the socio – economic development of the Country in other sectors like health, infrastructures, and schools.

Discussion Questions: <u>ICT Corner</u>

Carryout research using internet and make notes about the following:

a) Identify three other mineral ores of copper with their chemical formulae.
b) Explain the importance of the following steps in the extraction of copper.
(i) Addition of a frothing agent to the ore.
(ii) Roasting
(iii) Reduction
(iv) Purification



Electrolysis of copper

c) Suggest four (4) uses of copper in our day – to – day activity. Give reasons using the physical property of each use.
d) Name places where copper metal is extracted from in Uganda

EXTRACTION & PURIFICATION OF ALUMINIUM

Raw material and process of production	Bauxite is the major ore from which Aluminium is extracted. The impurities present include, silicon dioxide and iron (III) Oxide. **During Roasting**: The ore is heated at high temperatures in a blast furnace to convert any iron (II) oxide to iron (III) Oxide and drive off water vapour from the ore. **During Crushing**: The ore is then crushed into fine powder. **During Concentration**: The fine powdered ore is then heated in a sealed tank with concentrated sodium hydroxide solution to form a mixture of sodium aluminate, sodium silicate, followed

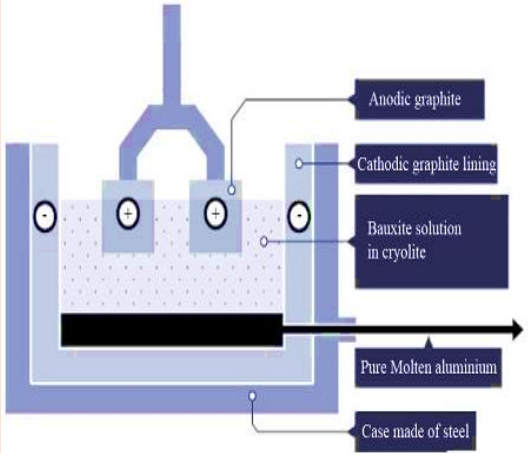
	by filtration to remove the undissolved iron (III) hydroxide as impurities. Carbon dioxide gas is bubbled at high pressure through the filtrate or addition of pure aluminium hydroxide to the filtrate to solidify/precipitate out sodium aluminate into solid aluminium hydroxide, leaving sodium silicate in the solution as impurity. The mixture is then filtered off to obtain solid aluminium hydroxide, washed, dried and heated strongly to form aluminium oxide. $2Al(OH)_3(s) \longrightarrow 2Al_2O_3(s) + 3H_2O(l)$ **During Electrolysis**: Molten aluminium oxide is reduced to aluminium in an electrolytic cell at 850°C; in an electrolyte of molten cryolite using graphite electrodes. **At the cathode**, aluminium ions migrate towards the cathode and undergoes reduction reaction by gain of electrons depositing pure aluminium metal. $Al^{3+}(l) + 3e \longrightarrow Al(s)$
Side effect and mitigation	**Environmental impacts:** - Dust particles, particulate matter, high emission of sulphur dioxide gas, volatile organic compounds and nitrous oxides leading to air pollution and increased greenhouse gas in the environment. This can be mitigated by installing an effective air quality monitoring equipment to absorb and reduce dust and sulphur dioxide gas emission. - Soil and habitat destruction from the activity of mining; leading to loss of ecosystem, increased soil erosion, and exhaustion of plant nutrients. This is mitigated by use of hybrid equipment that when used, leave no harm to the environment. **Social impacts:**

	□ Community displacement by the miners; leading to loss of land and properties. This is mitigated by engaging the community in the relocation and compensation plans. □ Cultural heritage destruction by the miners, leading to loss of societal cultural values. This is mitigated by encouraging cultural heritage preservation policies. **Health Impacts:** □ Respiratory problems, cancer, accidents, neurological disorders to exposure to heavy metals such as lead and mercury; leading to unhealthy body organs and loss of body parts/life. This can be mitigated by use of personal protective equipment (PPE) and having routine health – checkup. □ Skin, eye irritation, exposure to extreme temperatures; may lead to damage of the body organs. This can be mitigated by use of personal protective equipment (PPE) and having regular health body checkup.
Social benefits	□ Job opportunity for both skills and unskilled labours; hence getting income; this enables them improve their standard of living such as meeting their basic needs. □ Economic growth to the National treasure through government taxation, this enables the government improve on the socio – economic development of the Country in other sectors like health, infrastructures, and schools.

Discussion Questions: <u>ICT Corner</u>

Carryout research using internet and make notes about the following:

a) Write the chemical formula of chemical formula Bauxite.
b) Why are the following steps important in the extraction of Aluminium?
(i) Roasting
(ii) Addition of concentrated sodium hydroxide solution
(iii) Addition of carbon dioxide gas.



Electrolysis of Molten aluminium

c)	Suggest four (4) uses of aluminium in our day – to – day activity. Give reasons using the physical property of each use.	

EXTRACTION & PURIFICATION OF IRON

Raw material and process of production	Haematite/spathic iron is the major ore containing impurities such as silicon dioxide and aluminium oxide. **During Roasting**: The ore is heated at high temperatures in a blast furnace; to convert any iron (II) carbonate to iron (III) oxide and drive off water vapour from the ore. The ore is then crushed into fine powder. **During Reduction**: The powered ore is fed into the blast furnace from the top containing coke and calcium carbonate and heated at 1800°C. Coke burns to form carbon dioxide which reacts with unburnt coke to form carbon monoxide. $C(s) + O_2(g) \longrightarrow CO_2(g)$ $CO_2(g) + C(s) \longrightarrow 2CO(g)$ The carbon monoxide formed reduces iron (III) Oxide to form molten cast/pig iron. $Fe_2O_3(s) + 3CO(g) \longrightarrow 3CO_2(g) + 2Fe(s)$ **During Purification**: The molten silicon dioxide and aluminium oxide react with calcium oxide formed from the decomposition of calcium carbonate to form molten slag (calcium silicate/aluminate) that float on top of molten iron metal, filtered off as impurities.
Side effects and mitigation	**Environmental impacts:** □ Dust particles, particulate matter, high emission of carbon dioxide and carbon monoxide gas; leading to air pollution and increased greenhouse gas in the environment. This can be mitigated by installing an effective air quality monitoring equipment to absorb and reduce dust and carbon dioxide and carbon monoxide gas emission.

	□ Soil and habitat destruction from the activity of mining; leading to loss of ecosystem, soil erosion, exhaustion of plant nutrients. This is mitigated by use of hybrid equipment that when used, leave no harm to the environment. **Social impacts:** □ Community displacement by the miners; leading to loss of land and properties. This is mitigated by engaging the community in the relocation and compensation plans. □ Cultural heritage destruction by the miners, leading to loss of societal cultural values. This is mitigated by encouraging cultural heritage preservation policies. **Health Impacts:** □ Respiratory problems, cancer, accidents, neurological disorders to exposure to heavy metals such as lead and mercury; leading to unhealthy body organs and loss of body parts/life. This can be mitigated by use of personal protective equipment (PPE) and having routine health – checkup. □ Skin, eye irritation, exposure to extreme temperatures; may lead to damage of the body organs. This can be mitigated by use of personal protective equipment (PPE) and having regular health body checkup.
Social benefits	□ Job opportunity for both skills and unskilled labours; hence getting income; this enables them improve their standard of living such as meeting their basic needs. □ Economic growth to the National treasure through government taxation, this enables the government improve on the socio – economic development of the Country in other sectors like health, infrastructures, and schools.

Discussion Questions: ICT Corner

Carryout research using internet and make notes about the following:

a) Identify three other mineral ores of iron with their chemical formulae.
b) Explain the importance of the following steps during the extraction of iron in a blast furnace.
(i) Roasting
(ii) Reduction
(iii) Purification
c) Suggest four (4) uses of iron in day – today activity. Give reasons using the physical property of each use.
d) Name places where iron metal is extracted from in Uganda

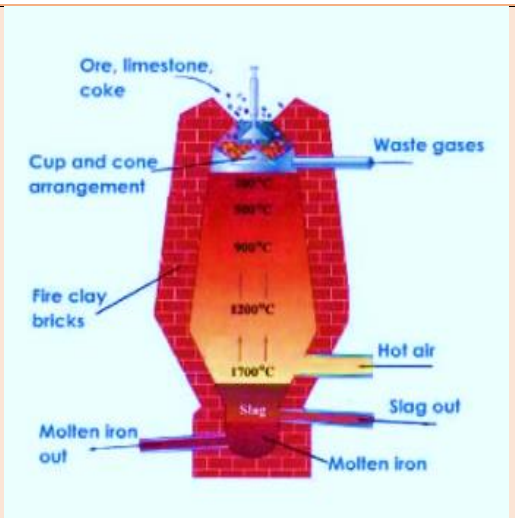
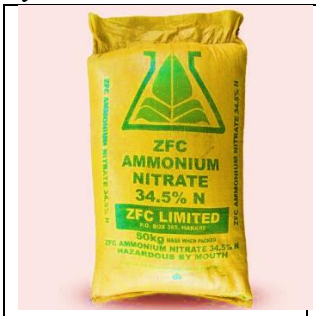


Fig 25.5 Extraction of iron from its ore

CHEMICAL INDUSTRY

a) AMMONIUM FERTILIZERS



Ammonium nitrate

Ammonium sulphate

CAN

Urea

MANUFACTURE OF AMMONIUM NITRATE

Raw material and process of production	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. $N_2(g) + 3H_2(g) \longrightarrow 2NH_3(g)$ **During Catalytic Oxidation of ammonia**: ammonia gas is oxidized to nitric oxide gas in a sealed container in the present

	of platinum – rhodium catalyst. The nitric oxide gas then reacts with water to form Nitric acid. $3NO_2(g) + H_2O(l) \longrightarrow 2HNO_3(aq) + NO(g)$ Both nitric acid and ammonia gas are heated in a neutralizer reactor tank to form ammonium nitrate as fertilizer, purified, concentrated and packed. $NH_3(g) + HNO_3(aq) \longrightarrow NH_4NO_3(s)$
Side effect and mitigation	**Environmental impacts:** • Air pollution from nitric oxide gas, particulate matter and ammonia gas; this lowers the air quality in the area. This can be mitigated by use of electrostatic precipitators and ammonia absorption system. **Health impacts:** • Prolong exposure to ammonia gas, causes potential risk of respiratory disorders, skin and eye irritation since the gas is highly toxic and poisonous. This effect is mitigated by encouraging the workers to use personal protective equipment (PPE). • Ammonium nitrate exerts potential risk of explosion, this may lead to loss of lives and properties. This effect can be mitigated by use of proper storage facility and explosion – proof equipment. **Societal impacts:** • Community displacement by the plant; leading to loss of land and properties. This is mitigated by engaging the community in the relocation and compensation plans.
Social benefits	**Economic and societal benefits:** • Job opportunity for both skills and unskilled labours; hence getting income; this enables them improve their standard of living such as meeting their basic needs. • Economic growth to the National treasure through tax revenue, hence infrastructure development.

	▯ Stimulates agriculture, by providing supports to the local farmers, improving crop yields and enhancing food security in the Country.

MANUFACTURE OF UREA FERTILIZER

Raw material and process of production	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. $N_2(g) + 3H_2(g) \longrightarrow 2NH_3(g)$ Both ammonia gas and carbon dioxide gas react in a sealed reactor tank to form Urea as fertilizer, purified, concentrated and packed. $2NH_3(g) + CO_2(g) \longrightarrow H_2NCONH_2(s) + H_2O(l)$
Side effects and mitigations	**Environmental impacts:** ▯ Air pollution from ammonia gas; this lowers the air quality in the area leading to respiratory problems, and eye irritation. This can be mitigated by use of electrostatic precipitator - absorption system. **Health impacts:** ▯ Prolong exposure to ammonia gas, causes potential risk of respiratory disorders, skin and eye irritation since the gas is highly toxic and poisonous. This effect is mitigated by encouraging the workers to use personal protective equipment (PPE). **Societal impacts:** Community displacement by the plant; leading to loss of land and properties. This is mitigated by engaging the community in the relocation and compensation plans.

Social Benefits	**Economic and societal benefits:** • Job opportunity for both skills and unskilled labours; hence getting income; this enables them improve their standard of living such as meeting their basic needs. • Economic growth to the National treasure through tax revenue, hence infrastructure development. • Stimulates agriculture, by providing supports to the local farmers, improving their crop yields and enhancing food security in the Country.

MANUFACTURE OF AMMONIUM SULPHATE FERTILIZER

Raw material and process of production	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. $N_2(g) + 3H_2(g) \longrightarrow 2NH_3(g)$ **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. $S(s) + O_2(g) \longrightarrow SO_2(g)$ $SO_2(g) + O_2(g) \longrightarrow SO_3(g)$ 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 Sulphur acid. $SO_3(g) + H_2SO_4(L) \longrightarrow H_2S_2O_7(L)$ (Oleum) $H_2S_2O_7(L) + H_2O(l) \longrightarrow 2H_2SO_4(aq)$

	Both Sulphuric acid and ammonia gas are heated in a sealed reactor tank to form ammonium sulphate as fertilizer, purified, concentrated and packed. $2NH_3(g) + H_2SO_4(aq) \longrightarrow (NH_4)_2SO_4(s)$
Side effects and mitigations	**Environmental impacts:** - Air pollution from sulphur oxide gas, particulate matter and ammonia gas; this lowers the air quality in the area. This can be mitigated by use of electrostatic precipitators and ammonia absorption system. **Health impacts:** - Prolong exposure to ammonia gas and Sulphuric acid, may cause potential risk of respiratory disorders, brain damage, skin, and eye irritation since their fumes is highly corrosive and poisonous. This effect can be mitigated by encouraging the workers to use personal protective equipment (PPE). - Ammonium sulphate is highly explosive at higher temperatures, this may lead to loss of lives and properties within the plant. This effect can be mitigated by use of proper storage facility and explosion – proof equipment. **Societal impacts:** - Community displacement by the plant; leading to loss of land and properties. This can be mitigated by engaging the community in the relocation and compensation plans.
Social Benefits	**Economic and societal benefits**: - Job opportunity for both skills and unskilled labours; hence getting income; this enables them improve their standard of living such as meeting their basic needs. - Economic growth to the National treasure through tax revenue, hence infrastructure development. - Stimulates agriculture, by providing supports to the local farmers, improving crop yields and enhancing food security in the Country.

Discussion Questions:

You have been give four (4) fertilizers whose percentage composition of nitrogen in each compound is not known. The farm manager would like to know which fertilizer is the best.

Fertilizer	Chemical formula	Percentage % of Nitrogen
Ammonium nitrate	NH_4NO_3	
Ammonium sulphate	$(NH_4)_2SO_4$	
Potassium nitrate	KNO_3	
Calcium ammonium nitrate (CAN)	$Ca(NH_4NO_3)_2$	
Urea	$(NH_2)_2CO$	

Task:

a) Calculate the:

(i) Molecular mass of each compound in the table above.
(N =14, H =1, K = 39, O = 16, S = 32, Ca = 40, C = 12)

(ii) Percentage composition of nitrogen in each fertilizer provided.

b) Arrange these fertilizers with respect to percentage composition of nitrogen starting with highest and ending with least percentage fertilizer. Make conclusion on the fertilizers which is the best for farming.

c) Explain the importance of the following during Nitrogen cycle.

(i) Nitrogen fixation and nitrification

(ii) Assimilation.

(iii) Ammonification and denitrification

d) Obtain diagram to show the major stages of nitrogen cycle.

INDUSTRIES THAT MAKE USE OF NATURAL RESOURCES

Discussion Questions:

a) Name and distinguish between the two types of natural resources obtained in Uganda.

b) List some of the examples of each type(s) of the natural resources named above.

c) Copy and complete the table below precisely.

Type of natural resource	Resource used	Process(es) that make use of natural resource	Industry where the resource is used
Renewable	Water	Hydroelectric power	Hydro-power industry
	Air	Wind turbines	Manufacture of oxygen

Non – renewable	Rocks	Mining	Mineral extraction
	Crude oil	Refinery	Petro chemical industry

MANUFACTURE OF CEMENT

Raw materials and process of production	Cement is obtained from limestone, aluminium oxide/clay, limestone, silica/sand and gypsum (calcium sulphate). The process of production occurs in two ways: **During wet Process**: silicon dioxide, aluminium oxide is washed with water to remove impurities. They are then mixed with powdered limestone to form slurry paste, fed into a rotating kiln, heated and grounded into fine powder called clinker. **During dry process:** aluminium oxide, silicon dioxide are introduced into a rotating kiln, heated and grounded into fine powder called clinker. In both wet and dry processes, the clinker is mixed with gypsum, heated and grounded further to form cement, purified and packed.
Side effects and mitigations	**Environmental impacts:** □ Air pollution from sulphur oxide gas, particulate matter dust particles and nitrogen dioxide gas; this lowers the air quality in the area leading to respiratory problems, eyes and skin irritation. This can be mitigated by use of electrostatic precipitator - absorption system. **Health impacts:** □ Prolong exposure to dusty plant causes potential risk of respiratory disorders, skin, and eye irritation, leading to failure of normal body functioning. This effect is mitigated by encouraging the workers to use personal protective equipment (PPE). □ High risk of accident during mining, hot surfaces from high temperatures, leading to loss of lives, properties. This

	effect is mitigated by encouraging the workers to use personal protective equipment (PPE). **Societal impacts:** - Community displacement by the plant; leading to loss of land and properties. This is mitigated by engaging the community in the relocation and compensation plans.
Social Benefits	**Economic and societal benefits:** - Job opportunity for both skills and unskilled labours; hence getting income; this enables them improve their standard of living such as meeting their basic needs. - Economic growth to the National treasure through tax revenue, hence infrastructure development. - Stimulates industry construction, by providing construction materials in the building projects, hence improving on infrastructure development in the Country. - Cement enables the construction of roads, bridges, hospitals, schools, and homes. This improves the standard of living in the areas.

MANUFACTURE OF LIME:

Raw material and process of production	Lime is obtained from limestone and water. Limestone is grounded into fine particles, then fed into a kiln, heated at about 900°C to form quick lime. $CaCO_3(s) \longrightarrow CaO(s) + CO_2(g)$ The quick lime (calcium oxide) formed is then cooled, added to water forming slake lime (Calcium hydroxide) in a sealed reactor tank. $CaO(s) + H_2O(l) \longrightarrow Ca(OH)_2(aq)$ The slake lime formed is passed through the purifiers to remove any impurities and water, concentrated and packed.

Side effects and mitigations	**Environmental impacts:** □ Air pollution from sulphur oxide gas, particulate matter dust particles and nitrogen dioxide gas; this lowers the air quality in the area, leading to formation of acid rain that corrode buildings and plants. This can be mitigated by use of electrostatic precipitator – absorption system. **Health impacts:** □ Prolong exposure to dusty plant may cause potential risk of respiratory disorders, skin, and eye irritation, leading to failure of normal body functioning. This effect can be mitigated by encouraging the workers to always use personal protective equipment (PPE). □ High risk of accident during mining, from hot surface – containers, leading to burnt, loss of lives, and properties. This effect can be mitigated by encouraging the workers to always use personal protective equipment (PPE). **Societal impacts:** □ Community displacement by the plant; leading to loss of land and properties. This is mitigated by engaging the community in the relocation and compensation plans.
Social Benefits	**Economic and societal benefits**: □ Job opportunity for both skills and unskilled labours; hence getting income; this enables them improve their standard of living such as meeting their basic needs. □ Economic growth to the National treasure through tax revenue, hence infrastructure development. □ Stimulates industry construction, by providing construction materials in the building projects, hence improving on infrastructure development in the Country. □ Lime enables the construction of roads, bridges, hospitals, schools, and homes. This improves the standard of living in the areas.

MANUFACTURE OF SODIUM HYDROXIDE

Raw material and process of production	Sodium hydroxide is obtained from concentrated brine/sodium chloride solution. **During Mercury cell**: concentrated sodium chloride (brine) is fed in the cell as an electrolyte using graphite as anode and mercury as cathode. **At the cathode**: Both sodium and hydrogen ions migrate towards the cathode for discharge, but sodium ions is preferentially discharged to hydrogen ions since it is very concentrated. Sodium ions undergo reduction reaction by gains of electrons and get deposited at the mercury – cathode to form sodium – mercury amalgam, which is dissolved in water to form sodium hydroxide, purified, concentrated and stored. **Equation**: $Na^+(aq) + e \longrightarrow Na(s)$ $2Na - Hg(l) + 2H_2O(l) \longrightarrow 2NaOH(aq) + H_2(g) + 2Hg(l)$
Side effects and mitigations	☐ Air pollution from emission of chlorine, hydrogen gas and particulate matter into the atmosphere; this reduces the air quality and safety in the area; leading to eye irritation, skin irritation, and breathing difficulty. This effect can be mitigated by enforcing proper use of personal protective equipment (PPE). ☐ Prolong exposure to the plant, has hazardous potential threat of workers to corrosive and toxic substances like sodium hydroxide and mercury; this may cause respiratory disorder, skin, and eye irritation. This effect can be mitigated by enforcing proper use of personal protective equipment (PPE). ☐ Water pollution from effluent discharge, containing mercury and other contaminants; this lowers water quality and safety for both man and aquatic animals, leading to their suffocation and death. This effect is mitigated by

	encouraging effluent treatment plant through neutralization, sedimentation and filtration before discharge.
Social benefits	Employment opportunity to both the skills and unskilled labours in the area, hence earning income; this enables them improve their standard of living by meeting some of their basic needs. Source of government revenue through taxation; this supports government programs though infrastructure development, hence improving the standard of living of the people in the Country.

MANUFACTURE OF CHLORINE:

Raw material and process of production	Sodium hydroxide is obtained from concentrated brine/sodium chloride solution. **During diaphragm cell**: concentrated sodium chloride (brine) is used as an electrolyte using graphite as anode and mercury as cathode. **At the anode**: Both chloride and hydroxide ions migrate towards the anode for discharge, but chloride ions is preferentially discharged to hydroxide ions since it is very concentrated. Chloride ions undergo oxidation reaction by loss of electrons to form chlorine gas, collected, purified, compressed and stored in tight metallic container. **Equation at the anode**: $2Cl^-(aq) \longrightarrow Cl_2(g) + 2e$
Side effects and mitigations	Air pollution from emission of chlorine, hydrogen gas and particulate matter into the atmosphere; this reduces the air quality and safety in the area; leading to eye irritation, skin irritation, breathing difficulty. This effect can be mitigated by enforcing proper use of personal protective equipment (PPE). Prolong exposure to the plant, has hazardous potential threat of workers to corrosive and toxic substances like

	sodium hydroxide and mercury; this may cause respiratory disorder, skin, and eye irritation. This effect can be mitigated by enforcing proper use of personal protective equipment (PPE).
Social Benefits	▯ Employment opportunity to both the skills and unskilled labours in the area, earning income; this enables them improve their standard of living such as meeting their basic needs. ▯ Source of government revenue through taxation; this supports government programs though infrastructure development, hence improving the standard of living of the people in the Country.

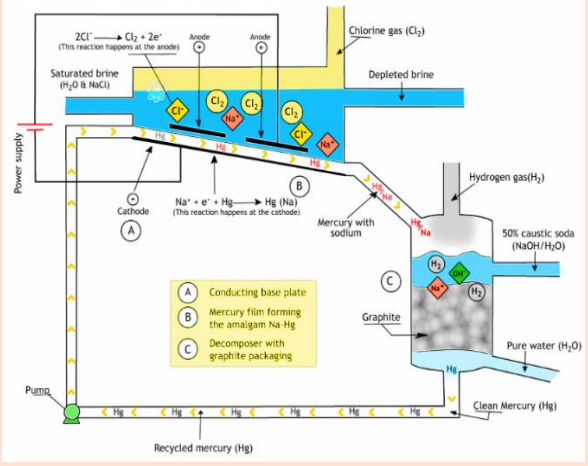
ALTERNATIVE MANUFACTURE OF NaOH

Raw material and process of production	Sodium hydroxide is obtained from concentrated brine/sodium chloride solution. **During Membrane cell**: concentrated sodium chloride (brine) is used as an electrolyte using **Titanium** as anode and **Nickel** as cathode. **At the cathode**: Both sodium ions and water move across the membrane cell towards the cathode compartments where water is reduced to hydrogen ions and hydroxide ions. Both sodium ions and hydroxide ions in the cathode compartment, react to form sodium hydroxide, collected, purified, concentrated and stored.

ALTERNATIVE MANUFACTURE OF CHLORINE

Raw material and process of production	Sodium hydroxide is obtained from concentrated brine/sodium chloride solution. **During Membrane cell**: concentrated sodium chloride (brine) is used as an electrolyte using **Titanium** as anode and **Nickel** as cathode.

	At the anode: It is chloride ions present for discharge, since the membrane is impermeable to chloride ions. Chloride ions undergo oxidation reaction by loss of electrons to form chlorine gas, collected, compressed purified and stored in tight container.



Electrolysis of brine using Mercury cell

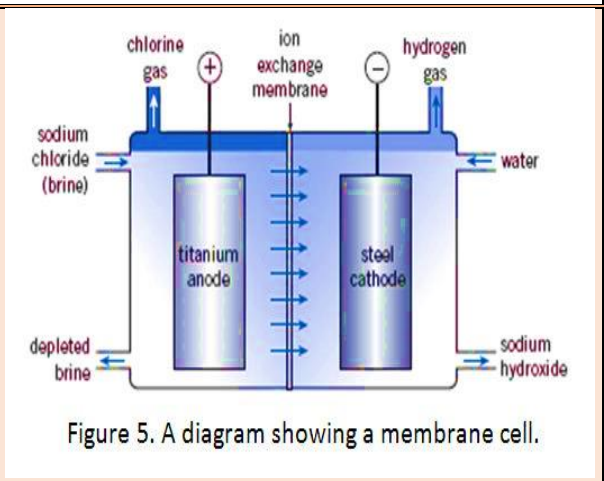


Figure 5. A diagram showing a membrane cell.

Electrolysis of brine using Membrane cell

Discussion Questions: ICT Corner

Carryout research using internet to investigate about the different methods of Electrolysis of brine. Share and compare your findings with the rest of the class.

a) Make some evaluations between mercury cell and membrane cell during electrolysis of brine in terms of.

(i) Other environmental side effects of the plant and their mitigations.

(ii) Other health side effects of the plant and their mitigations.

(iii) Other economic side effects of the plant and their mitigations.

b) What are the major uses of chlorine and sodium hydroxide?

MANUFACTURE OF CRUDE OIL

Raw material and process of production	Petroleum fractions are obtained from raw crude oils by fractional distillation method in a fractionating column compartments/tower. Crude oil is fed into the furnace of the tower, heated to vapourize into different fractions each with their different boiling point. Each vapour fraction moves through the vertical

	columns of the tower, as their temperature decreases, causing them to condense into liquid fractions. The fractions whose boiling point is below the others, comes out first as distillate in the order of Gas, followed by different liquid fractions, depending on the molecular weight of each liquid fraction of the hydrocarbons as the solid fractions are left behind as residual components. Each distillate fraction is purified, liquefied, concentrated and stored.
	Environmental impacts: • Air pollution caused by emission of sulphur dioxide, carbon dioxide, nitric oxide gas and particulate matter from the plant; this effect reduces air quality and safety leading to respiratory disorders, eye irritation and global warming. This effect can be mitigated by installing catalytic engine convertors and fuel desulphurization system to remove sulphur. • Water pollution, caused by direct disposal of untreated hazardous chemicals, hot waste water from the plant. This increases temperature of water, causing death to aquatic animals. This can be mitigated by treating and cooling the untreated waste water before releasing it directly into the water body. **Health impacts:** • Prolong exposure to hazardous chemicals, volatile organic compounds from the plant causes potential risk of respiratory disorders, and skin, eye irritation, leading to failure of normal body functioning. This effect is mitigated by encouraging the workers to use personal protective equipment (PPE). • High risk of accident during refineries, hot surfaces due to high temperatures, this may lead to loss of lives, properties. This effect is mitigated by encouraging the workers to use personal protective equipment (PPE).

Social Benefits	▯ Employment opportunity to both the skills and unskilled labours in the area, hence income; this enables them improve their standard of living such as meeting their basic needs. ▯ Source of government revenue through taxation; this supports government programs though infrastructure development, hence improving the standard of living of the people in the Country.

Discussion Questions: ICT Corner

Using interne, carry out research about crude oil and its fractions. Share and compare your findings with the rest of the class.

a) Copy and complete the table below

Fraction	Boiling point	Use(s)
Natural gas		
Naphtha		
Gasoline		
Kerosene		
Diesel		
Fuel oil		
Lubricating oil		
Bitumen		

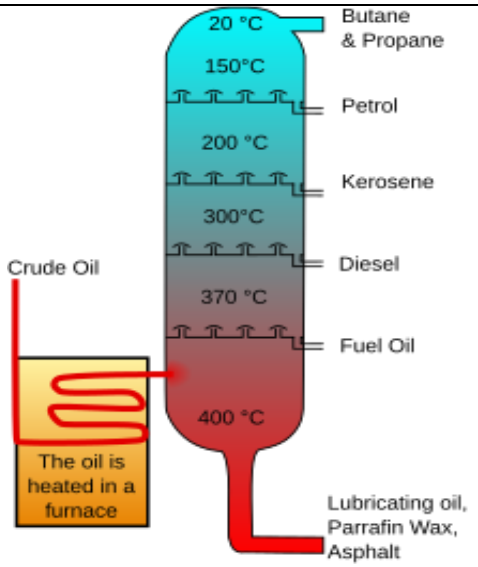


Fig 8.2 Fractional distillation of crude oil

b) Make some evaluations between human activities and crude oil fractions as Natural resources in terms of.

(i) Other environmental side effects of the plant and their mitigations.

(ii) Other health side effects of the plant and their mitigations.

(iii) Other economic side effects of the plant and their mitigations.

(iv) Importance of each different fraction of crude oil.

POLYMERS:

Polymers: are large molecules made up of repeated units of monomers joined together to form long chain of complex molecules. **Monomers:** are units of small molecules which chemically combine together to form large and complex molecules called polymers.

Natural polymers: These are complex molecules made up of repeated units of natural monomers.

Synthetic polymers. These are complex molecules made up of repeated units of man-made monomers.

Polymerization reaction is a chemical reaction where several monomers react with each other to form repeated units of large molecules. It involves two types of reactions, addition polymerization and condensation polymerization.

Evaluating the uses of different Synthetic polymers

Synthetic Polymer	Properties (Choice)	Use(s)
Polyethene	**Low density ones**: ○ Are lightweight. ○ Flexible with low melting point ○ Water proof, chemically resistant. **High density ones:** ○ Are rigid and hard ○ Have high melting point.	Low density ones are used for making packaging materials. High density ones are used for making plastic pipes, toys, kitchen ware, medical ware like syringes.
Polyvinyl chloride (PVC)	○ Are waterproof ○ Resistant to (corrosion, chemicals, abrasion) ○ High melting points	Suitable for making construction materials like water pipes, window frames, door frames, electrical and heat insulators such as electric sockets
Teflon	○ Are waterproof. ○ Resistant to (high temperatures, corrosion, chemicals and abrasion),	They are used for making frying pans handles and heat cooker insulators.
Polypropene	○ Are heat resistant ○ Are resistant to chemicals ○ Are water proof	They are used as containers, such as bottle caps, and automotive parts such as bumpers, dashboards

Nylon (Polyamide)	○ Are strong and durable ○ Elastic, and flexible, ○ Resistant to abrasion and heat	Suitable for making clothing, carpets, medical devices such as sutures, implants, and automotive devices such as engine parts
Perspex	○ Are transparent ○ Weather resistant (non – corrosive) ○ Lightweight	Suitable for making aquarium glasses, aircraft window frames, and medical devices such as lenses, and implants.