INDUSTRIAL PROCESSES

ACTIVITY: Identifying some materials produced by industries in Uganda.

Name of industrial products and industries where they are manufactured

Product name	Industry
Clothes	Textile
Steel bars	Steel-making
Batteries	Battery/electronic
Cement	Mining
Plastic chairs	Plastic industry
Fertilizers	Fertilizer industry
Soda	Food industry/ Beverage
Water	Water/ food industry
Sugar	Sugar/food industry

Complete the table below6* by identifying industries with their corresponding products and classes.

Industry	product	Class of the industry
Mining	Limestone	Primary
Processing	Cars	Secondary
Service	telecommunication	Tertiary

Common products from industries in Uganda

Activity: common products produced by some industries.

What is needed, internet relevant chemistry textbooks

What to do

Complete the table below

Common products	Uses of the product
Steel/pipe	Construction
Sodas and mineral water	Human consumption
Cement	Building houses
Fertilizer	Restoring soil fertility
Soap and detergent	Washing
Sanitizer	Killing micro organism
Battery	Providing electric energy
Jerry	Human beautification

Process for obtaining useful chemicals from rocks

Mineral	Chemical formula	Uses
Silver	Ag	Making jewelery Making trophies Making mirrors
Copper	Cu	Making electric wires Making jewelery Used in construction such as roofing
Graphite	C	Making lead pencils Making lubricants Making electrodes
6Iron pyrites	FeS_2	Production of sulphur dioxide Production of sulphuric acid
Rock salt	NaCl	Added to food to make it tasty Preserves food Maintain blood pressure
Gypsum	$CaSO_4.2H_2O$	Manufacture of wallboard, cement
Haematite	Fe_2O6_3	Producing pigment, radiation shielding
Quartz	SiO_2	To make oscillators for watches, clocks, radios, televions, computers, etc.

- Sampling helps in obtaining information which is necessary for economic assessment of the ore
- Analysis gives information about the ore before massive mining can begin
  Sampling can be done in the following ways
- Hand sampling
- Machine sampling

  Note Manual method consumes more time than the excavation method.

QN State three properties of the ore considered before concentration of the ore is done

- Chemical composition of the ore
- Conductivity of the ore
- Solubility of the ore
- Density of the ore

Outline three ways in which the ore is concentrated

- Froth flotation
- Roasting
- Gravity separation

Extraction and purification of metals

Ore is a compound from which metals are extracted.

The table below shows some metals and their principle ores

Metal	Ores	Formula
Sodium	Rock salt Cryolite	NaCl Na_3AlF_6
Potassium	Salt petre	KNO_3
Aluminium	Bauxite	$Al_2O_3.2H_2O$
Zinc	Calamine Zinc blende Zincite	$ZnCO_3$ ZnS ZnO
Iron	Spathic Haematite Magnetite Pyrite	$FeCO_3$ Fe_2O_3 Fe_3O_4 FeS_2

Copper	Copper pyrite Malachite Cuprite	$CuFeS_2$ $CuCO_3$. $Cu(OH)_2$ Cu_2O
Lead	Galena Cerussite Anglesite	PbS $PbCO_3$ $PbSO_4$
Silver	Silver glance	Ag_2S
Gold	Calve rite Sybarite	$AuTe_2$ $AgAuTe_2$
Magnesium	Dolomite	MgCO3.CaCO3

Methods of extracting metals from their respective ores.

This depends on the position of metal in the reactivity series.

There are two main methods of extracting metals

a) Electrolysis; Used to extract highly reactive metals because they form a very stable compound e.g. sodium, potassium, magnesium, calcium, Aluminium however it's an expensive method.
b) Reduction of the ore using carbon (coke) or carbon monoxide. This is used for moderately reactive metals e.g. zinc , iron, tin, lead, and copper.

Note

- Hydrogen can also be used to reduce oxides of metals .However the process is very expensive
- Zinc and lead can also be extracted using electrolysis
- Less reactive metals like mercury , silver and gold can be extracted by heating in air

Metal	Formula	Reactivity	Method of extraction
Potassium	K	Very reactive	Electrolysis
Sodium	Na	Very reactive	Electrolysis
Calcium	Ca	Very reactive	Electrolysis
Magnesium	Mg	Very reactive	Electrolysis
Aluminium	Al	Very reactive	Electrolysis
Zinc	Zn	Moderately reactive	Reduction using coke or carbon monoxide
Iron	Fe	Moderately reactive	Reduction using coke or carbon monoxide

Tin	Sn	Moderately reactive	Reduction using coke or carbon monoxide
Lead	Pb	Moderately reactive	Reduction using coke or carbon monoxide
Copper	Cu	Moderately reactive	Reduction using coke or carbon monoxide
Mercury	Hg	Least reactive	Heating 0
Silver	Ag	Least reactive	Heating
Gold	Au	Least reactive	Heating

EXTRACTION OF ALUMINIUM

Raw materials, ore (Bauxite, sodium hydroxide)

Formula of Bauxite ($AL_2O_3.2H_2O$)

Process of production

Concentration of the ore

Bauxite is ground to powder to increase surface area and heated to convert any iron(II)oxide the impurity present to iron(iii)oxide and also to remove water of crystallization

The powder is the boiled with hot concentrated sodium hydroxide solution that dissolves the amphoteric aluminum oxide and acidic silicon aluminate and sodium silicate respectively in a containers

Aluminium oxide + sodium hydroxide ⟶ sodium aluminate +water

$Al_2O_3(s) + 2NaOH\ (aq) \longrightarrow 2NaAlO_2\ (aq) + H_2O\ (l)$

Silicon dioxide + sodium hydroxide ⟶ sodium silicate + water

$SiO_2(s) + 2NaOH\ (aq) \longrightarrow NaSiO_{3\ (aq)} + H_2O\ (l)$

The undissolved basic iron (III) oxide and titanium (IV) oxide and filtered off.

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

Sodium aluminate + Carbon dioxide ⟶ Aluminium hydroxide + Carbon dioxide

$NaAl(OH)_4(aq) + CO_2 \longrightarrow 2Al(OH)3(s) + Na_2CO_3\ (aq) + H_2O(l)$

Or

$2NaAlO_2\ (aq) + CO_2\ (g) + 3H_2O \longrightarrow 2Al(OH)_3(s) + Na_2CO_3(aq)$

-Note=

The filtrate can also be mixed with little Aluminium hydroxide after dilution with water (hydrolysis) to precipitate Aluminium hydroxide (seeding)

$Al(OH)_4^- \xrightarrow{OH} Al(OH)_{3(s)} + OH^-\ (aq)$

- Aluminium hydroxide produced is then washed several times , dried and heated strongly to produced anhydrous Aluminium oxide.

Aluminium hydroxide $\longrightarrow$ Aluminium oxide + water

$2Al(OH)_3(s) \xrightarrow{heat} Al_2O_3(s)+3\ H_2O(l)$

Electrolysis of Aluminium oxide

Aluminium is dissolved in molten cryolite to lower its melting point to 800^{o}c. electrolysis of molten Aluminium oxide occurs using graphite electrode in an iron bath lined with graphite (Carbon)

At the cathode
$Al^{3+}(l) + 3e \longrightarrow Al(s)$

At the anode
$2\ O^{2-}(l) \longrightarrow O_2(g) + 4e$

Aluminium formed is collected at the bottom of the cell because aluminum has a higher density than the electrolytes .

Side effects and mitigation

- Pollution from poisonous fumes
  - Mitigation
- =Proper use of PPE.
- Burns. Caused by contact with hot surfaces / chemical spills.
  - Mitigation

  – Proper use of PPE

Social benefits.

- Employment opportunities to the residents/people.
- Source of revenue to the government hence improved infrastructures hence improved standards of living.

EXTRACTION OF COPPER

Chief ores

- Copper pyrites $CuFeS_2$

- Cuprite Cu_2O
- Copper glance Cu_2S
- Malachite
- Azurite $[CuCO_3.Cu(OH)_2]$

Raw Materials
-ore(copper pyrites)
-silicon dioxide

Production process
1. Concentration of the ore by the froth flotation
- The ore is crushed or ground into fine powder to increase surface area. it is then mixed with water containing frothing agent such as palm oil in a container
- Compressed air is blown in the mixture
- The oil coated particles float to the top of the tank while the rocky impurities like silicone(IV)oxide settle at the bottom of the tank
- The oil coated particles are skimmed off and dilute sulphuric acid is added to break the particles(froth) , filtered off and dried

2. Roasting
- Dred ore is roasted in air in a blast Furnace to form copper (i) sulphide , iron (ii) oxide and sulphur dioxide .

$$2CuFeS_2(s) + O_2(g) \longrightarrow Cu_2S(s)+2FeO(s)+3SO_2(g)$$

3 Smelting
Silicon dioxide is added to the resultant mixture in absence air all or in a furnace to remove Iron(ii)oxide leaving behind copper (i) sulphide

$$FeO(s) + SiO_2(s) \longrightarrow FeSiO_3(l)$$

-iron silicate (slag) floats on the surface of the mixture where it is skimmed off.
-copper (i) sulphide is heated in controlled amount of air to form copper (i) oxide and sulphur dioxide gas .

$$2Cu_2S(s) + 3O_2(g) \longrightarrow 2Cu_2O(s)+2SO_2(g)$$

-The remaining copper(i) sulphide reacts with copper (i)oxide to form copper metal and sulphur dioxide gas.

$$2Cu_2O(s)+Cu_2S(s) \longrightarrow 6Cu(s)+SO_2(g)$$

3. Purifying (refining)

-Impure (blister copper) is purified by electrolysis where pure copper is used as the cathode while impure copper is used as anode using copper (ii) sulphate solution as an

electrolyte (acidified copper (ii) sulphate solution using sulphuric acid to enhance conductivity)

At the cathode
-copper ion gain electron to form copper metal.

$Cu^{2+}(aq) + 2e \longrightarrow Cu(s)$

At the anode the anode dissolves leading to formation of copper ions in solution

$Cu(s) \longrightarrow Cu^{2+} + 2e$

Side effects and mitigation

- Toxic fumes from production lead to suffocation,

  - use PPE,
  - Proper control of waste gases

- sulphur dioxide produced as a by-product reacts with water forming acid rains that affects walls of houses
  - proper control of the waste gases.

Social benefits

- employment opportunity
- salary
- improved standards of living
- infrastructure development
- raw materials

Extraction of iron

ores
-Haematite Fe_2O_3
-Magnetite Fe_3O_4
-Spathic $FeCO_3$
-Pyrite FeS_2

Raw Material
-ore e.g.(Haematite)
-lime stone
-coke

Process of production

The raw materials e.g. Haematite, limestone and coke are fed into a blast furnace.

1. Oxidation of coke

- Hot air from the bottom reacts (oxidizes9) coke forming Carbon dioxide gas

$C(s) + O_2(g) \longrightarrow CO_2(g)$

2. Reduction of carbon dioxide

- Carbon dioxide reacts with excess coke forming carbon monoxide

$CO_2(g) + C(s) \longrightarrow 2CO(g)$

3 Reduction of Iron(iii)oxide (Haematite)

Carbon monoxide reduces haematite to molten iron and carbon dioxide .

$Fe_20O_3 + 3CO(g) \longrightarrow 2Fe(l) + 3CO2(g)$

Roles of lime stone(Calicium oxide)

Calicium carbonate decomposes to calcium oxde and carbon dioxide at high temperatures

$CaCO_3(s) \longrightarrow CaO(s) + CO2(g)$

-The calcium oxide reacts with silicone dioxide and Aluminium oxide forming calcium silicate , Aluminium silicate

$CaO(s) + SiO_2(s) \longrightarrow CaSiO_3(l)$

$CaO(s) + Al_2O3(s) \longrightarrow CaAl_2O_4(l)$

The calicium silicate and calicium aluminate form aslag which floats on molten ion and can also be tapped off.

Purification pure iron (wrought iron)is obtained by passing air through molten iron to remove non metal impurities

Side effects and mitigation

-poisonous fumes proper use of PPE

-Excessive noise from the plant PPE

-To much heat from furnance to worker

Social benefits

-Emoployment to the people

-Slag used as fertlizers

-Raw materials

MANUFACTURE OF CEMENT

Raw materials

-lime stone

-clay

-gypsum

Process of production

A mixture of lime stone and clay is crushed and milled into a fine powder

-The fine powder is then mixed in water and allowed to flow down a rotating drum (cylinder) in which it is strongly heated to about 1500^0c

-Calicium oxide reactes with Aluminium oxide and silicone dioxide to form lumps of calicium aluminate and calcium silicate

-The lumps are crushed to form cement as a final powder .

-Gypsum is added during the grinding process to moderate the reaction between cement and water (setting of cement)

-Cement is packed in bags ready for use.

Side effects and mitigation.

-Dust , noise , during crushing

-Poisionous fumes during crushing

Hot surface burns

Falling objects

Spills as falls during lifting , iover loading .

Social benefits

Employment opportunities to resident to improve their standards of leaving

Revenue to the government of Uganda to improve infrastructure.

Manufacture of chlorine or sodium hydroxide using mercury cathode cell.

Raw materials

Concentrated sodium chloride solution(brime)

Mercury, graphite anode

Process of production

Chlorine us manufactured by electrolysis of concentrated sodium chloride solution(brine) using graphite as anode and mercury as cathode in mercury cathode cell

At the anode chloride and hydroxide ions migrate to the anode and chloride ions are preferentially and form chlorine gas .

$2Cl^-(aq) \longrightarrow Cl_2(g)+2e$

At the cathode

$Na^+(aq)+ e \longrightarrow Na(s)$

Sodium mixes with mercury to form sodium amalgam

$Na\ (aq) + Hg(l) \longrightarrow NaHg\ (s)$

-Sodium amalgam reacts with water forming sodium hydroxide solution, hydrogen gas and mercury.

$2NaHg(s) + 2H_2O\ (l) \longrightarrow 2NaOH\ (aq) + H_2(g) + 2Hg(l)$

- ➢ Suffocation due to release of other gases like hydrogen.
- \- proper use of PPE
- ➢ /Exposure to high concentration of chlorine leading to death.
- \- proper use of personal protective equipment.
- \- Wear respiraters ,
- ➢ Exposure to excessive noise from mechanical objects or cylinders
- \- proper use of personal protective equipments

Social benefits

- ✓ Manufacturing plants are a source of revenue to the government hence improved infrastructures
- ✓ Employment opportunities hence improving standards of living.
- ✓ Chlorine used to manufacture weed killers.
- ✓ Sodium hydroxide is used in the manufacture of soap which is a detergent in homes.
- ✓ Chlorine is used in manufacturing of medicines to improve on health care.

- ✓ Chlorine is used in manufacture of plastics
- ✓ Chlorine is used to manufacture bullet resistant vests worn by soldiers and police officers
- ✓ Sodium hydroxide is used in the manufacture of medicines.
- ✓ Chlorine is used in the treatment of water.

MANUFACTURE OF FERTILIZERS

Fertilizers are natural or synthetic substances applied to the soil or the plants to improve on growth and productivity by providing nutrients to the plant

Types of fertilizers

- Natural or organic fertilizers .these are obtained from animal and plant remains. They are end products of naturally occurring materials e.g. manure,leaves,composte.They are also referred to as organic manure e.g. poultry manure,mushroom,blood meal,bone meal,cotton seed meal ,cow manure etc.
- Synthetic o5r inorganic manure .These are fertilizers manufactured artificially (chemically synthesized).They contain one or more major element required by plants for good growth e.g. ammonium nitrate ,.ammonium sulphate ,ammonium phosphate ,urea and super phosphate

Comparison between natural and synthetic fertilizers

Natural fertilizers	**Synthetic fertilizers**
Derived from animal and plant manure	Manufactured artificially
Contain less amount of NPK	Contain more amount of NPK
Add organic matter to the soil	Don't add organic matter
Slow in their action	Faster in their action
Less likely to cause damage to leaves and roots	Can cause damage to leaves and roots

The main components of fertilizers include

- Nitrogen vital for chlorophyll formation
- Phosphorous key plant function energy transfer ,photosynthesis ,nutrient movement, genetic transfer
- Potassium movement of water and mineral salts, enzyme activation.

Manufacture of fertilizers

a) Ammonium fertilizers e.g.
   - Urea(H_2CONH_2)
   - Ammoni3um nitrate
   - Ammonium sulphate
   - Ammonium phosphate
   - Calcium ammonium nitrate

Raw materials

Nitrogen gas from fractional distillation of liquid air

Hydrogen gas from electrolysis of dilute acid

Process of production

Nitrogen from fractional distillation of liquid air is reacted with hydrogen from natural gas in a ratio of 1:3 respectively to form ammonia by Haber process .The reaction requires low temperature (450-500 **℃)** an high pressure of 200 atm and finely divided iron catalyst

$$N_2 + 3H_2 \rightarrow 2NH_3$$

Ammonia produced is heated in excess oxygen in presence of platinum catalyst forming nitrogen monoxide and water all in the tank

$$4NH_3 + 5O_2 \rightarrow 4NO_{(g)} + 6H_2O$$

Nitrogen monoxide is cooled and then oxidized further by oxygen to form nitrogen dioxide

$$2NO + O_2 \rightarrow 2NO_2$$

Nitrogen monoxide is dissolved in water in presence of oxygen to form nitric acid

$$4NO_2 + O_2 + 2H_2O \rightarrow 4HNO_3$$

Urea is obtained by reacting liquid ammonia gas with carbon dioxide at high pressure

$$2NH_3 + CO_2 \rightarrow H_2 2NCONH_2 + H_2O$$

Ammonium nitrate by reacting nitric acid with ammonia gas

$$NH_3 + HNO_3 \rightarrow NH_4NO_3$$

Resultant solution is concentrated in a final concentration, the concentrated solution is fed to prilling tower and some part into slurry tank.

Ammonium sulphate: by reacting ammonia with concentrated sulphuric acid

$$2NH_3 + H_2SO_4 \rightarrow (NH_4)_2SO_4$$

The fertilizers are further concentrated and converted to solid form.

<u>Side effect and mitigation</u>

- Run off into water bodies promoting increased algae growth cutting off oxygen supply leading to suffocation of aquatic animals
- Some when dissolved in water form acidic solution that alters soil pH hence low crop production

<u>Social benefits</u>

- Source of employment as residents get salaries hence improved standards of living

- High levels of nutrients supplied leading to improved crop production hence better standards of living

NOTE

Ammonia gas on small scale can be obtained by heating a mixture of solid calcium hydroxide and ammonium chloride in a round bottomed flask which is in a slanting position fitted with a delivery tube.

The gas is passed through calcium oxide to dry it then collected by upward delivery since it is less dense than air

$$Ca(OH)_2 + 2NH_4Cl \rightarrow CaCl_2 + 2NH_3 + 2H_2O$$

$$NH_4{}^+ \ + \ \ OH^- \rightarrow NH_3 + \ H_2O$$

- Ammonia gas is used in;
- Manufacture of fertilizers
- Manufacture of nitric acid
- Used as refrigerant gas
- Used in the manufacture of plastic, pest cide, dye and other chemicals.

There are various fertilizers, however, some are better than others depending on their nitrogen composition.

Consider the fertilizers given in the table below,

Fertilizer	**Chemical formula**
Ammonium nitrate	NH_4NO_3
potassium nitrate	KNO_3
Urea	NH_2ONH_{23}

MANUFACTURE OF SULPHURIC ACID

Raw materials

- **Sulphur dioxide.**
- **Oxygen gas**

Process of production

- **Sulphur dioxide gas free** from impurities is heated with dry pure oxygen at low temperature about 450-500^{0}c and high pressure of about 1-3 atmospheres in presence of vanadium (V) oxide catalyst to form sulphur trioxide. The reaction occur in a combustion cylinder.

$2SO_2$ **(g) + O_2(g)** ⟶ **$2SO_3$(g)**

Sulphur trioxide is dissolved in little concentrated sulphuric sulphuric acid to form oleum

$SO_3(g) + H_2SO_4(aq) \longrightarrow H_2S_2O_7(l)$

Oleum carefully diluted using controlled (moderate volume of distilled water) forming 98% concentrated sulphuric acid.

$\mathbf{H_2S_2O_7\ (l) + H_2O(l) \longrightarrow 2H_2SO_4(l)}$

Side effect

- Toxic misty fumes from the oleum which when inhaled may cause breathing problems.
- Acid spill on the flour/surface leading to accidents.

Social benefits

- Employment, salaries , improved standards of living
- Manufacture of fertilizers hence increased farm yields therefore improving standards of living
- Used in car batteries as electrolytes.

DAD CHEM