Sulphuric Acid

The **Contact Process** is the primary method for producing **sulfuric acid** (H_2SO_4). It involves three main steps:

1. **Production of Sulfur Dioxide (SO_2):**
   - Sulfur or sulfur-containing ores (like **pyrite**) are burned in air to produce sulfur dioxide.
     $S + O_2 \rightarrow SO_2$

2. **Conversion of Sulfur Dioxide to Sulfur Trioxide (SO_3):**
   - Sulfur dioxide reacts with oxygen in the presence of a **vanadium(V) oxide** (V_2O_5) catalyst at **450–500°C** and **2-3 atmospheres of pressure** to form sulfur trioxide.
     $2SO_2 + O_2 \rightleftharpoons 2SO_3$

3 Passing SO3 into concentrated H2SO4 (addition reaction of sulphur trioxide and sulphuric acid to give oleum):

$$SO_3(g) + H_2SO_4(1) \rightarrow H_2S_2O_7(1)$$

Step 4: Addition of water to oleum i.e. Dilution of oleum to produce concentrated sulphuric acid

$$H_2S_2O_7(1) + H_2O(1) \rightarrow 2H_2SO_4(1)$$

Properties

- Anhydrous, 100% sulphuric acid is a colorless, odorless, heavy, oily liquid.
- It is heavier than water, with 98 gram/mole molar mass.
- Pure H2 SO4 melts at 10.5 °C and boils at 338 °C.
- It is soluble in all ratios with water. This chemical is highly corrosive, reactive and soluble in water.
- The sulphuric acid can be diluted by water to get acids in various strengths for different purposes. During the mixing process, sulphuric acid should be added to water, not the other way around. Since the dissolution of sulfuric acid in water is very exothermic i.e. a large amount of heat is released and the solution may even boil.
- it has a very high oxidizing power and thus, acts as a strong oxidizing and dehydrating agent.

Some Common Pesticides and Herbicides

- Pesticides are chemicals used to prevent or control pests, diseases, weeds and other plant pathogens. It decreases yield losses, and maintain high product quality.
- Chemical pesticides can be classified according to their chemical composition. This method allows the uniform and scientific grouping of pesticides to establish a correlation between structure, activity, toxicity and degradationmechanisms, among other characteristics.

Pesticides	Characteristics	Main composition
Organochlorines	✓ Soluble in lipids ✓ they accumulate in the fatty tissue of animals and transferred through the food chain ✓ toxic to a variety of animals ✓ long-term persistence	Composed of Carbon, Hydrogen, Chlorine, and Oxygen atoms. they are nonpolar and lipophilic
Organophosphates	✓ Soluble in organic solvents but also in water ✓ they infiltrate reaching groundwater, less persistent than chlorinated hydrocarbons ✓ some affect the central nervous system ✓ they are absorbed by plants and then transferred to leaves and stems which are the supply of leaf-eating insects or feed on wise.	Possess central phosphorus atom in the molecule. In relation whit organ chlorines, these compounds are more stable and less toxic in the environment. the organophosphate pesticides can bealiphatic, cyclicand heterocyclic.
Carbamates	✓ Carbamate acid derivatives ✓ kill a limited spectrum of insects for ✓ highly toxic to vertebrates ✓ Relatively low persistence	Chemical structure based on a plant alkaloid Physostigma venenosum
Pyrethroids	✓ Affect the nervous system but less than compared to the other pesticides ✓ the safest in terms of their use ✓ some are used as household insecticides	Compounds similar to the synthetic pyrethrins (alkaloids obtained from petals of Chysanthemun cinerariefolium
Biological	✓ Only the Bacillus thuringiensis (Bt) and its subspecies are used with some frequency ✓ are applied against forest pests and crops ✓ Particularly against butteries and also affect other caterpillar	Viruses, microorganisms or their metabolic product

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Organophosphate and Pesticides

Botanical Pesticides

Definition: Traditionally, farmers use botanical pesticides derived from plant parts (stems, seeds, roots, leaves, and flower heads) to protect crops such as fruits and vegetables.

Advantages:

- ❖ Broad-spectrum activity.
- ❖ Easy to process and apply.
- ❖ Short residual activity, reducing long-term environmental impact.
- ❖ Do not accumulate in the environment or in the fatty tissues of warm-blooded animals.

Common Natural Pesticides in Ethiopia:

Neem Leaf: Known for its medicinal, culinary, and pest-repellent properties. Neem oil, derived from the neem tree, is non-toxic to animals, birds, plants, and humans but effective against pests. It can be sprayed on young plants for up to 22 days. To prepare, mix neem oil with liquid soap and warm water, then spray on plants.

Salt Spray: Used for pest control in various agricultural settings.

Onion and Garlic Spray: Natural pest deterrents commonly applied in organic farming.

Herbicides (Chemical Weed Killers)

Definition: Herbicides are chemicals used to control or kill unwanted plants (weeds).

Types of Herbicides:

Selective Herbicides: Target specific weed species while leaving the desired crops unharmed.

Non-Selective Herbicides: Also known as total weed killers, they kill all plant material they come into contact with, making them effective but more destructive.

1	Chlorophenoxy acids	2,4-D and 2,4,5-T
2	Triazines	Atrazine, hexazinone, and simazine
3	Organic phosphorus chemicals	Glyphosate
4	Amides	Alachlor and metolachlor
5	Thiocarbamates	Butylate
6	Dinitroanilines	Trifuralin
7	Chloroaliphatics	Dalapon and trichloroacetate
8	Inorganic chemicals	Various arsenicals, cyanates, and chlorates

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Sodium Carbonate

Production Method (Solvay process)

- Sodium carbonate at present is mostly mined from its natural deposits.
- It also is manufactured synthetically by Solvay (or ammonia-soda) process. The natural production of sodium carbonate currently has surpassed its synthetic production.
- The Solvay process involves a series of partial reactions. The first step is calcinations of calcium carbonate to form lime and CO2. Lime is converted to calcium hydroxide.
- The most crucial step of the process involves reacting brine solution with carbon dioxide and ammonia to produce sodium bicarbonate and ammonium chloride.
- Sodium bicarbonate converts to sodium carbonate. The calcium hydroxide and ammonium chloride react to form calcium chloride as the by-product. The partial reactions are shown below:

- ✓ $CaCO_3 \rightarrow CaO + CO_2$
- ✓ $CaO + H_2O \rightarrow Ca(OH)_2$
- ✓ $2NaCl + 2CO_2 + 2NH_3 + 2H_2O \rightarrow 2NaHCO_3 + 2NH_4Cl$
- ✓ $2NaHCO_3 \rightarrow \mathbf{Na_2CO_3} + H_2O + CO_2$
- ✓ $Ca(OH)_2 + 2NH_4Cl \rightarrow CaCl_2 + 2NH_3 + 2H_2O$

Properties of Sodium Carbonate (Washing Soda)

- **Appearance**: White crystalline solid powder, exists as a decahydrate ($Na_2CO_3\cdot10H_2O$).
- **Density**: 2.54 g/cm^3, purity > 98%.
- **Melting Point**: 851°C.
- **Boiling Point**: 1,600°C.
- **Nature**: Hygroscopic (absorbs moisture from the air).

Forms of Sodium Carbonate

Light Soda: Lower density (0.7 g/mL).

Dense Soda: Higher density (0.9 g/mL).

Solubility and Reactions

- **Solubility in Water**: Dissolves easily, forming an aqueous solution with moderate alkalinity.
- **Reaction with Acids**: Dissolves by liberating CO_2.
- **Insolubility**: Does not dissolve in alcohol.

Other Characteristics

- **Thermal Stability**: Anhydrous sodium carbonate is unaffected by heat and melts without disintegrating.
- **Hydrolysis**: Releases OH^- ions, making its aqueous solution somewhat alkaline.
- **Reaction with Air**: Absorbs CO_2 from the air, producing sodium hydrogen carbonate.

Uses

- About half of the total production of sodium carbonate is used for the manufacturing of glass.
- During the production of glass sodium carbonate acts as a flux in the melting of silica. It is also largely used in production of detergents and soaps.
- It is used in the manufacturing of pulp and paper, textiles, drinking water.
- It can also be used for tissue digestion, dissolving ampihoteric metals and compounds, food preparation as well as acting as a cleaning agent. It is also used in the brick industry.

Sodium Hydroxide (NaOH)

Properties

- sodium hydroxide (NaOH) is a white, translucent crystalline solid with a melting point of 591 k. It is a stable compound.
- NaOH is often referred to as caustic soda, due to its corrosive action on many substances:
- It decomposes proteins at room temperatures and may cause chemical burns to human bodies.
- It dissolves readily in water and moderately soluble in alcohol; its solution has bitter and has a soapy feeling.
- It is strongly alkaline in nature commonly used as a Base.

Manufacturing process

It is manufactured from sodium chloride (NaCl) and water (H2O) in electrolysis process. Its preparation involves various methods like:-

1. Castner-Kellner process

2. Nelson Diaphragm cell

3. Loewig's process

Castner-Kellner Method for Sodium Hydroxide Production

Process: Electrolysis of brine solution in a Castner-Kellner cell to obtain sodium hydroxide.

Cell Structure:

- Tank: Rectangular steel, lined with ebonite.
- Anode: Titanium.
- Cathode: Mercury layer at the bottom.

Reactions:

- Ionization of Brine Solution:
- Sodium ions move to the mercury cathode, forming sodium amalgam.
- Chlorine ions move to the anode and exit the cell as chlorine gas.

Sodium Amalgam Treatment:

- The amalgam is transferred to a denuder chamber and treated with water to form sodium hydroxide solution.
- Evaporation yields solid sodium hydroxide.

Safety Considerations:

- Mercury: Toxic; precautions are necessary to prevent loss.
- NaOH: Strongly corrosive; can cause skin and eye irritation.
- Storage: Pure NaOH attracts water and forms hydrates; may require insulation or heating depending on conditions.

Uses

- it is widely used in numerous industrial processes such as in pulp and paper manufacturing, alumina extraction from bauxite in aluminum production, as well as in the textiles industry and drinking water production.
- It is also an important compound in the manufacture of soaps and detergents (i.e. a cleansing agent and in the manufacturing of washing soda), in waste gases scrubbing, saponification and esterification reactions; as well as in basic catalysis.

Some manufacturing industries in Ethiopia

Glass manufacturing

- ✓ It is an amorphous or non-crystalline solid material. It is inexpensive to make, easy to shape when it's molten, reasonably resistant to heat when it's set, chemically inert. It can be recycled any number of time.
- ✓ The main component of glass is **silica.**

Types of glass

i. **Quartz glass:**-is made by melting pure silica. SiO_2, at a temperature of about 2300°C and pouring the molten viscous liquid into moulds. It is high strength, low thermal expansion and highly transparent.

ii. **Soda-lime glass**:-is ordinary glass, a mixture of Na_2SiO_3 and $CaSiO_3$.the reaction that takes place are as follow i.e.

- ✓ $Na_2CO_3 + SiO_2 \longrightarrow Na_2SiO_3 + CO_2$
- ✓ $CaCO_3 + SiO_2 \longrightarrow CaSiO_3 + CO_2$
- ✓ Soda-lime glass accounts for about 90% of manufactured glass. It is used to make **window panes, bottles and dishes**

iii. **Borosilicate glass:**-is commonly known as **Pyrex glass**. It is consists of boron (III) oxide (B_2O_3), instead of limestone or calcium oxide.

- ✓ Has high resistance to chemical corrosion and temperature changes.
- ✓ Used to make laboratory equipment such as flask, beakers, and test tubes etc

- **Colored glass** is obtained by the addition of metallic oxides. For example cobalt produces blue glass, chromium produces green glass.

Steps in glass production

1. **Bach preparation:** - is raw material preparation step. The raw materials are mixed in a proportion of 60% sand, 21% sodium carbonate and 19% limestone
2. **Glass melting:** - the raw materials and recycled glasses are fed in to a glass melting furnace.
3. **Glass forming:**- melted glass is made in to a required shape.
4. **Annealing:**-removing internal stresses by reheating the glass followed by slow-cooling cycle during which the stress are relieved..
5. **Inspection:** - testing the quality of glass, whether it fulfills desired quality requirements or not.
6. **Packing and dispatching:**- **i**s the final stage before distribution

Manufacturing of Ceramics

- Is an inorganic non-metallic solid prepared by the action of heat and subsequent cooling

- Traditional ceramics, such as porcelain, tiles, and pottery are formed from minerals such as clay, talc and feldspar.
- Most industrial ceramics, however, are formed from extremely pure powders of specialty chemicals, such as silicon carbide, alumina, barium titanate, and titanium carbide.
- The minerals used to make ceramics are dug out of the earth and are then crushed and ground into a fine powder

The steps of manufacturing ceramics include

A. Moulding:-after purification, small amount of wax are often added to bind of the ceramic powder and make it more workable. Plastics may also be added to the powder to give the desired pliability and softness.

B. Densification:-uses intense heat to condense a ceramic object into strong, dense product. After being moulded, the ceramic object is heated in an electric furnace to temperatures between 1000 and 1700 . The goal of this heating process is to maximize the strength of ceramic by obtaining an internal structure that is compact and extremely dense.

Uses of Ceramics

- Well-Known Uses
- Art sculptures.
- Dishes, platters.

Kitchen and bathroom tiles.

- Lesser-Known Uses
- Electrical insulators.
- Computer parts.
- Dental replacements.
- Engine parts.
- Space shuttle tiles.
- Bone replacements (e.g., hips, knees, shoulders).

Future Uses

- Removing impurities from drinking water.
- Replacing diseased heart valves.

Cement

- The raw materials for the production of cement are limestone, clay, silica sand, gypsum, calcium silicate, calcium aluminate, iron (III) oxide, magnesium oxide and pumice.
- Limestone is the major ingredient for the production of cement. It is abundantly available in Africa. Ethiopia has huge amounts of reserve raw materials.

Manufacturing process

- Cement is made by heating limestone (chalk), alumina (Al_2O_3) and silica-bearing materials such as clay to 1450 °C in a kiln. This process is known as calcinations.

- Calcinations results a hard substance called clinker. The clinker is then ground with a small amount of gypsum into a powder. The resulting cement is known as Ordinary Portland cement (OPC).

- **Upper part of the kiln**
  Raw materials heated $\xrightarrow{\Delta}$ to complete elimination of moisture.
- **Middle part of kiln**
  $CaCO_3 \xrightarrow{\Delta} CaO + CO_2$
- **Lower End Of Kiln**
  The temperature reaches about1600□ the partly fused and sintered mixture undergoes a series of chemical reaction to from **calcium aluminates** and **silicates**

$$2CaO + 2SiO_2 \rightarrow 2CaO.SiO_2\ (di-calcium\ silicate)$$
$$3CaO + 3SiO_2 \rightarrow 3CaO.SiO_2\ (tri-calcium\ silicate)$$
$$CaO + 3Al_2O_3 \rightarrow 3CaO.Al_2O_3\ (tri-calcium\ aluminate)$$
$$4CaO + 4Al_2O_3 + 4Fe_2O_3 \rightarrow 4CaO.Al_2O_3.Fe_2O_3\ (tetra\ calcium\ aluminate\ ferrate)$$
$$MgO + SiO_2 \rightarrow MgSiO_3\ (Magnesium\ silicate)$$

Setting of cement

- The first setting occurs within 24 hours, where as the subsequent hardening requires about 2 weeks
- In the hardening process of cement, the transition from plastic to solid state is called setting

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