

CHEMISTRY GRADE 12TH

CHAPTER 5

Some Elements in Nature and
Industry

Cont.

SOME ELEMENTS IN NATURE

- ❖ **Elements** are pure substances that can not be decomposed in to simpler substance by chemical or physical means.
- ❖ They contain atom
- ❖ There are 113 elements known at present.
- ❖ 92 elements occur in nature, while the rest are man-made.
- ❖ All the materials on the earth are made of the naturally occurring elements.
- ❖ The elements are classified as **metals**, **non-metals** and **metalloids**.

Cont.

- ❖ A solid substance that occurs naturally in the earth's crust is called **mineral**.
- ❖ All minerals are not suitable for the extraction of elements.
- ❖ Minerals from which elements can be extracted easily and economically are called **ores**.
- ❖ Thus, all ores are minerals, but all minerals are not ores, because a mineral may not contain sufficient percentage of an element for economic extraction.
- ❖ In economic extraction, the cost of obtaining the element out of the ore is significantly less than the amount of money to be made by selling the element.

Occurrence of Elements

Abundance of elements in the Earth's crust.

❖ The twelve most abundant elements that constitute 99.7% by mass of the earth's crust are, in decreasing order of abundance:

- | | |
|-------------------|----------------------|
| 1) oxygen (O) | 7) Sodium (Na), |
| 2) silicon (Si) | 8) potassium (K), |
| 3) Aluminum (Al) | 9) titanium (Ti), |
| 4) iron(Fe) | 10) hydrogen (H) |
| 5) Calcium(Ca), | 11) phosphorous (P), |
| 6) Magnesium(Mg), | 12)manganese (Mn). |

Abundance of gases in atmosphere

Gas	Percentage by volume(%)
Nitrogen	78
Oxygen	21
Other gases	1

Cont.

- ❖ Very few elements exist in the **free** or **native** state.
- ❖ The most unreactive metals, i.e., those that are not affected by air and water, such as
 - ✓ Silver
 - ✓ gold,
 - ✓ Platinum
 - ✓ palladium
 - ✓ ruthenium and osmium are generally found in the **native state**.

Cont.

- ❖ Most metals, however, occur in combined form as compounds such as
 - oxides
 - carbonates
 - sulphides
 - sulphates
 - Silicates
 - Chlorides
 - nitrates and phosphates etc.
- ❖ Copper and silver exist both in combined and uncombined state

Cont.

- ❖ A variety of physical and chemical methods can be applied to separate the pure forms of elements from their ores.
- ❖ However, the financial cost of mining, separating and purifying an element is the major consideration before a process is chosen for implementation.

Cont.

- ❖ Metals at the top of the reactivity series (K,Na,Ca,Mg, and Al) are so reactive that they are never found in nature as free elements.
- ❖ The metals in the middle of the reactivity series (Zn,Fe,Sn, and Pb) are moderately reactive and also exist in the combined state.
- ❖ Copper and silver are the two metals that occur in free as well as in combined states, such as sulphide, oxide or halide ores

Cont.

Table 5.1 Reactivity series of elements (the most reactive is at the top and the least reactive is at the bottom).

Elements	Symbol
Potassium	K
Sodium	Na
Lithium	Li
Calcium	Ca
Magnesium	Mg
Aluminium	Al
Carbon	C
Zinc	Zn
Iron	Fe
Tin	Sn
Lead	Pb
Hydrogen	H
Copper	Cu
Silver	Ag
Gold	Au
Platinum	Pt

Cont.

The Recycling of Elements in Nature

- ❖ The major cycles that you will study are the carbon cycle, nitrogen cycle and phosphorus cycle.
- ❖ Note that the law of conservation of mass is obeyed in the recycling of substances

Cont.

Carbon cycle

- ❖ The Earth's atmosphere contains 0.035% carbon dioxide (CO₂), and the biological environment depends upon plants to convert carbon dioxide into sugars, proteins and fats.
- ❖ green plants convert atmospheric carbon dioxide and water into glucose and oxygen in a process called photosynthesis.



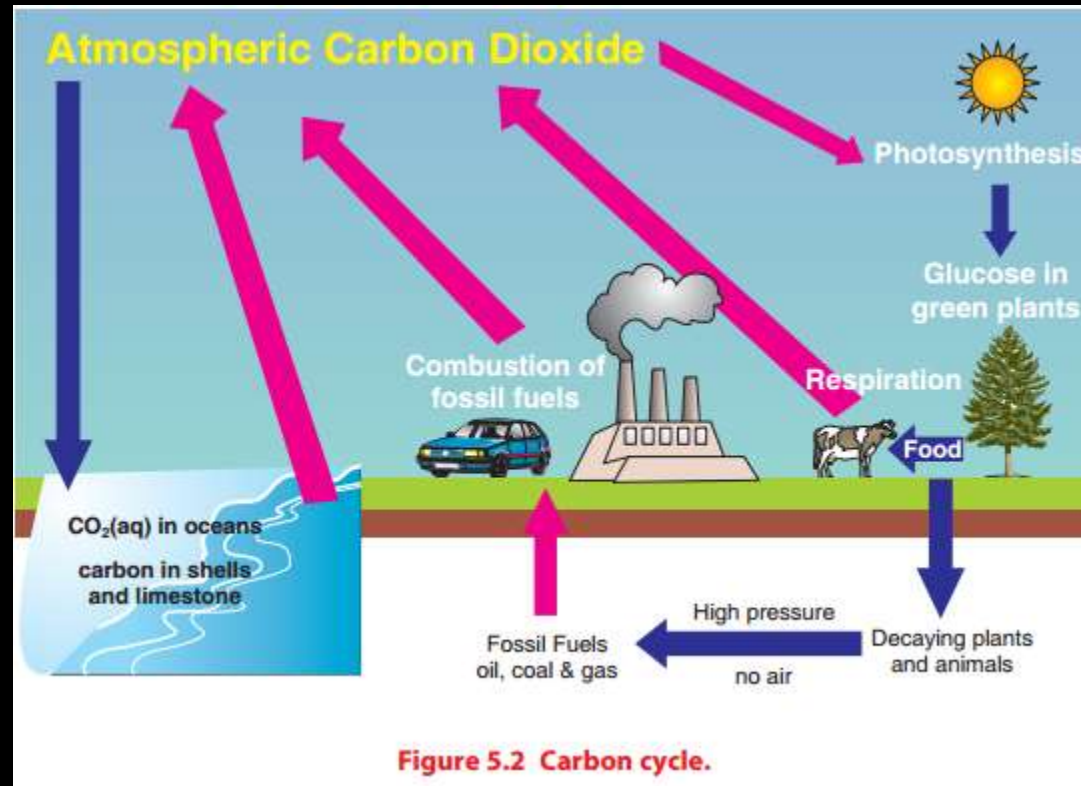
Cont.

- ❖ Photosynthesis is an endothermic reaction.
- ❖ Solar energy from the sun provides the necessary energy for the above reaction to proceed.
- ❖ Animals (including humans) eat plants, or eat other animals that have eaten plants, and incorporate the plants' carbon atoms into their cells.
- ❖ Carbon returns to the physical environment in a number of ways. Both plants and animals respire, and they release carbon dioxide during respiration.
- ❖ $\text{C}_6\text{H}_{12}\text{O}_6(\text{aq}) + 6\text{O}_2(\text{g}) \rightarrow 6\text{CO}_2(\text{g}) + 6\text{H}_2\text{O}(\text{l})$

Cont.

- ❖ Respiration is an exothermic reaction, releasing 2803 kJ/mol of energy.
- ❖ The process of decomposition of organic matter also releases carbon dioxide back into the atmosphere.
- ❖ Over a very long period of time, dead organisms under high pressure and in the absence of air can be converted into fossil fuels such as coal, oil and gas.

Cont.



Cont.

The Nitrogen Cycle

- ❖ Proteins and nucleic acids contain nitrogen, so nitrogen is a very important atom in biological organisms.
- ❖ Nitrogen makes up 78% of the earth's atmosphere, but most organisms cannot use nitrogen (N_2).
- ❖ This is because the $\text{N}\equiv\text{N}$ triple bond has large dissociation energy (945 kJ mol^{-1}), and N_2 is quite inert

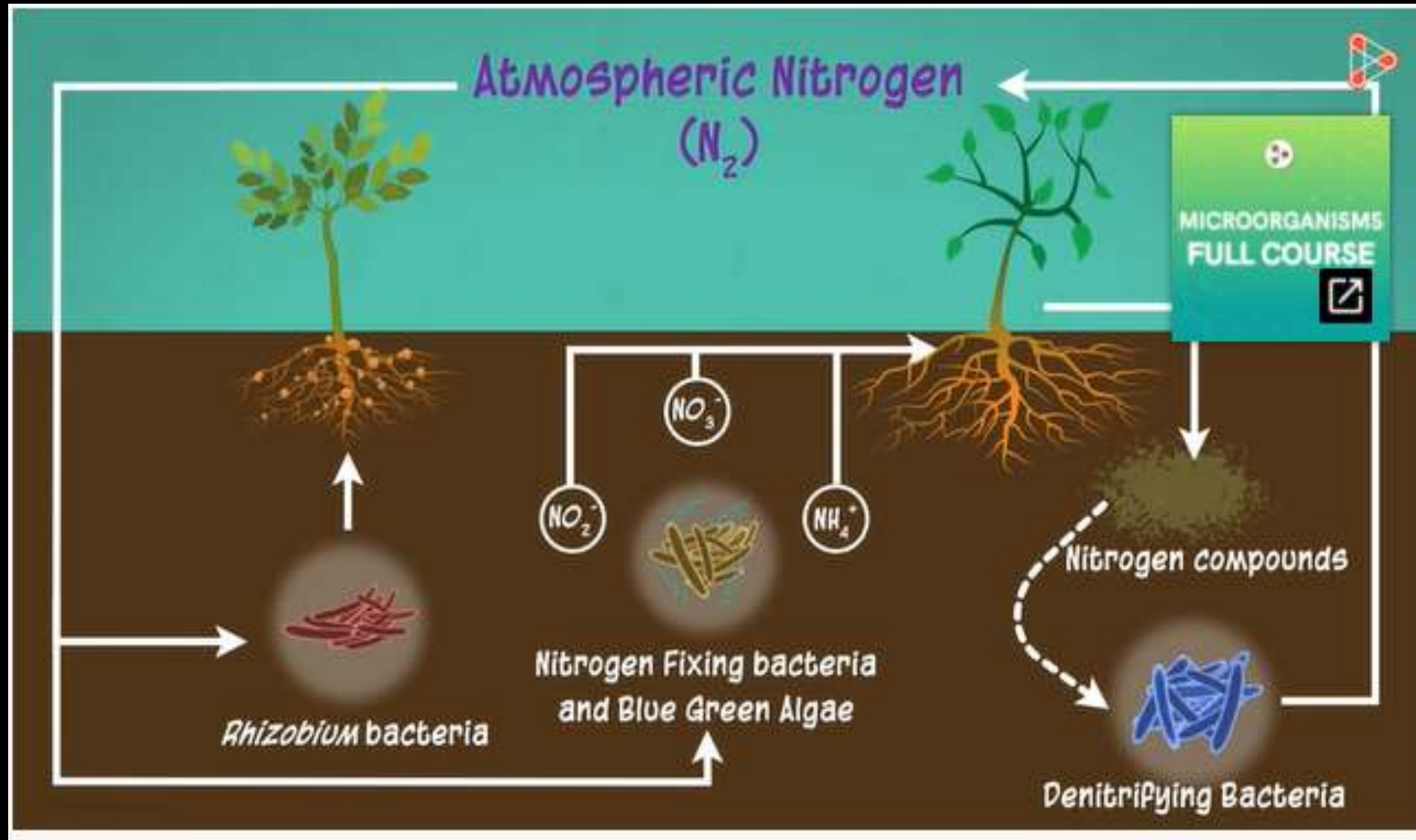
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- ❖ Nitrogen fixation refers to the conversion of nitrogen gas into nitrogen compounds.
- ❖ Natural fixation reactions can be initiated by lightning, which breaks nitrogen molecules and enables their atoms to combine with oxygen in the air, forming nitrogen oxides.
- ❖ These compounds are then washed into the soil by rain.

Cont.

- ❖ Bacteria found in nodules in the roots of leguminous plants, such as beans, lentils, and peas, can convert atmospheric nitrogen gas into nitrates (NO_3^-), which plants use to make plant proteins.
- ❖ Generally, soluble nitrogen compounds in the soil can be taken up by plants to make plant proteins
- ❖ Animals eat plants and convert plant proteins into animal proteins. Animals excrete nitrogenous wastes, partially as urea or uric acid, which is returned to the soil

Cont.



Cont.

The Phosphorus Cycle

- ❖ The phosphorus cycle differs from the nitrogen and carbon cycles primarily in that phosphorus is not found in the atmosphere in the gaseous state
- ❖ Phosphorus is mainly found in water, soil and sediments. It is an essential nutrient for
- ❖ plants and animals in the form of PO_4^{3-} and HPO_4^{2-} ions.
- ❖ It is part of DNA (deoxyribonucleic acid) molecules, molecules that store energy-rich ATP (adenosine triphosphate) and fats of cell membranes.
- ❖ Phosphorus is a building block of certain parts of the human and animal body, such as bones and teeth.

Cont.

- ❖ Phosphate salts are released when phosphate rocks are eroded by rainfall, weathering and runoff.
- ❖ The release of phosphate salts into the soil results in a constant phosphorus supply for plants.
- ❖ Phosphate salts are absorbed through the roots of plants and are used to make organic compounds.
- ❖ Animals absorb phosphates by eating plants or plant eating animals.
- ❖ When plants and animals die, they decompose and return phosphorus into the soil or water and complete the cycle.
- ❖ In comparison to the nitrogen and carbon cycles, the rate at which phosphate salts are released is extremely slow

CHEMISTRY GRADE 12
UNIT 5 PART 2
Metallurgy

Cont.

Some Elements in Industry

Metallurgy

- ❖ **Metallurgy** is the science and technology of extracting metals from their natural sources and preparing them for practical use.
- ❖ The principal steps that are carried out to obtain a metal from its ore are:

Concentrating the ore

Pre-treatment

Extracting the metal

Refining (purifying) the crude metal.

Cont.

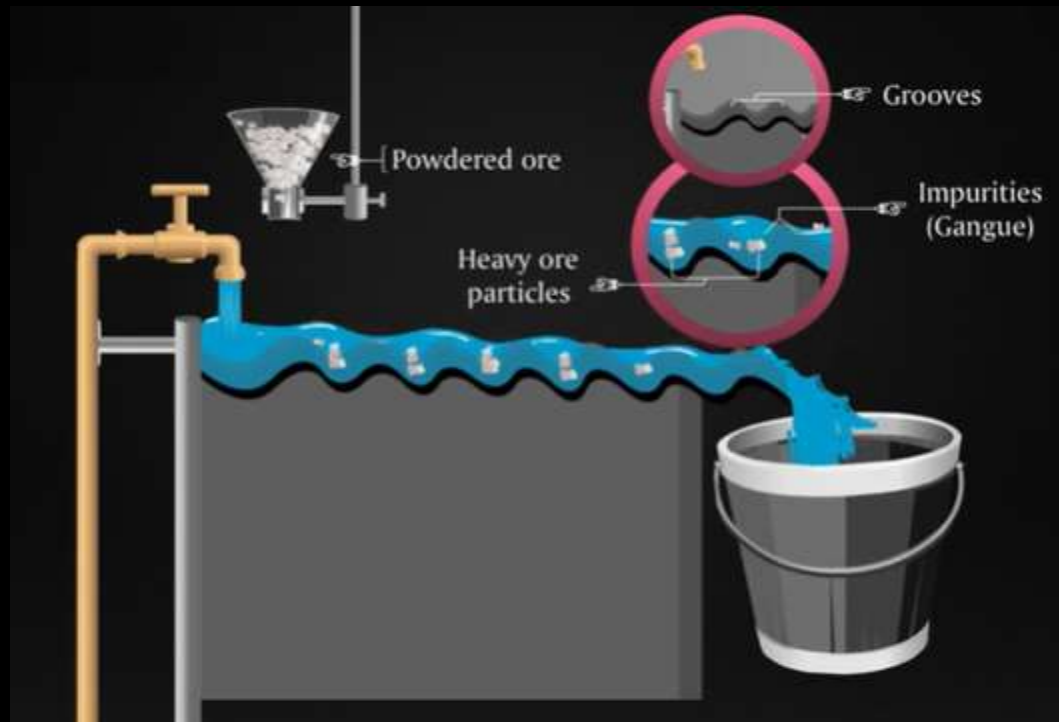
Concentrating the Ore

- ❖ **Concentrating an ore** increases the fraction of metal-bearing ore by eliminating most of the accompanying rock and soil, called **gangue**.
- ❖ A **gangue** is undesired material or impurity, which is found together with the ore.
- ❖ The ore must first be finely divided by crushing and grinding, and then the gangue can be removed in a number of ways
 - i) Gravity Separation
 - ii) Magnetic Separation
 - iii) Froth Floatation
 - iv) Amalgamation
 - v) Leaching

Cont.

i) Gravity Separation

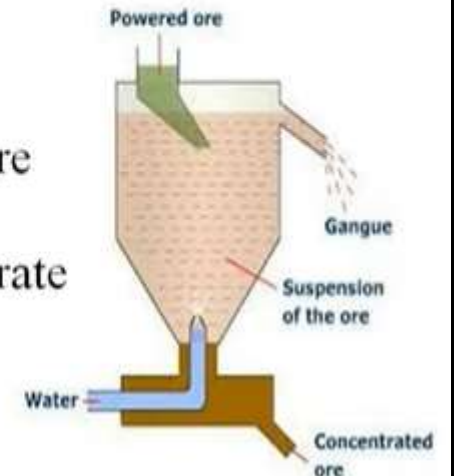
- ❖ Gravity separation depends on the difference in density between the mineral and the gangue.
- ❖ For example, since gold has a very large density (19.3 g/mL), it can be separated from its gangue by this method.



Process

➤ The water enters the tank through the jet stream from the bottom of the tank.

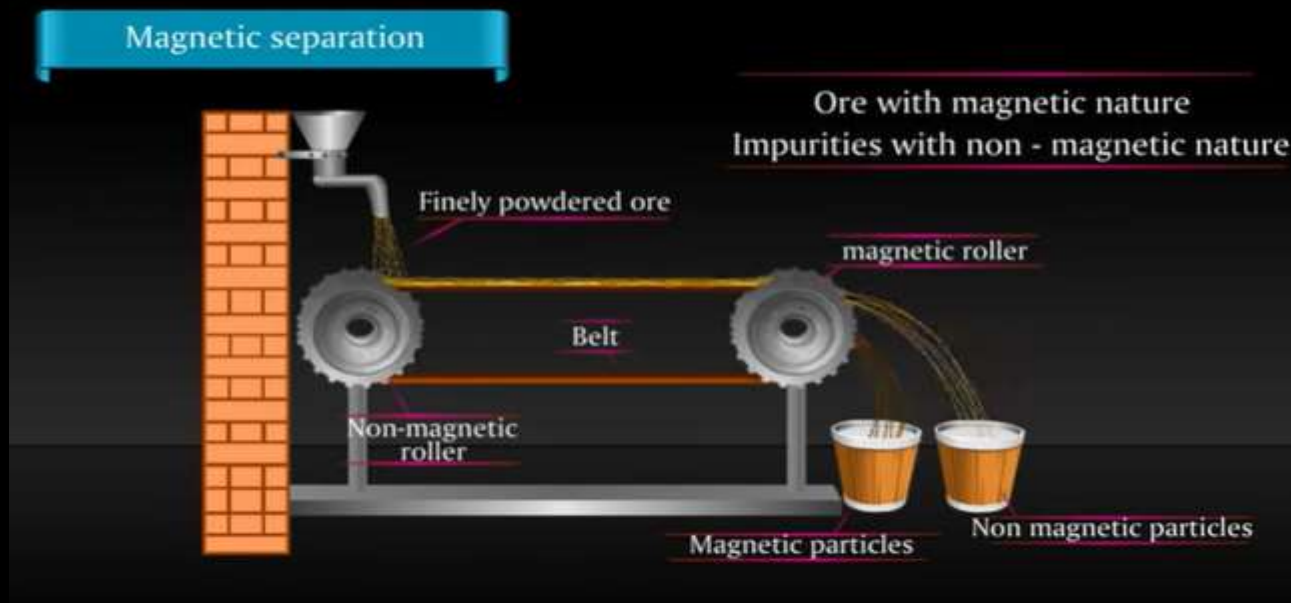
➤ The heavier ore particles settle at the bottom, and the lighter gangue particles separate out in the form of washing.



Cont.

ii) Magnetic Separation

- ❖ Magnetic separation can be used for separating ferromagnetic minerals from their impurities.
- ❖ For example, the mineral magnetite (Fe_3O_4) can be separated from gangue by using a strong electromagnet



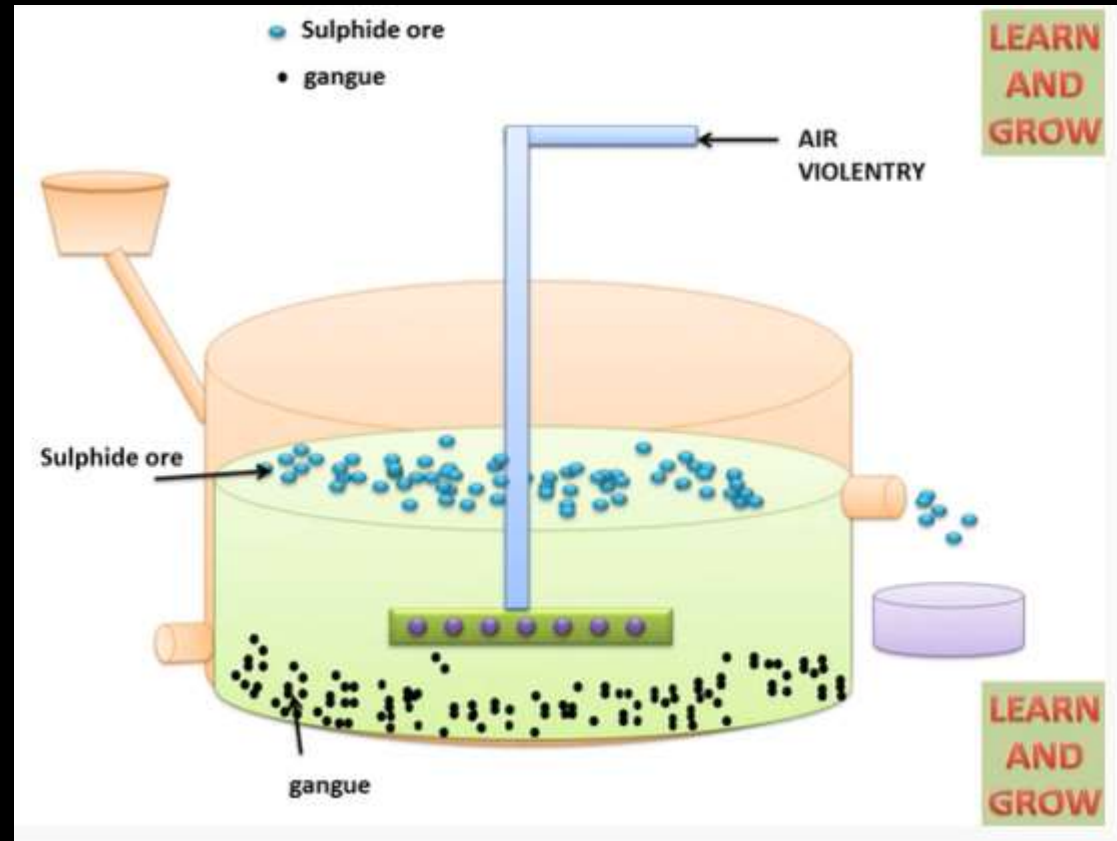
Cont.

iii) Froth Floatation

- ❖ In this process, the ore is finely ground and added to water containing oil and detergent.
- ❖ Because of the differences in the surface characteristics of mineral particles and the silicate rock particles, the oil wets only the mineral particles.
- ❖ A stream of air blown through the mixture causes tiny bubbles to form on the oil-covered pieces, which then float to the surface in the form of froth or foam, while the gangue settles to the bottom.

Cont.

- ❖ The froth is skimmed off, allowed to collapse, and then is dried to recover the mineral particles.
- ❖ For example, sulphide ores are concentrated by froth flotation.



Cont.

iv) Amalgamation

- ❖ An **amalgam** is an alloy of mercury with another metal or metals.
- ❖ Mercury forms amalgams with a number of metals and can be used to extract these metals from their ores.
- ❖ For example, mercury dissolves silver and gold in an ore to form a liquid amalgam, which is easily separated from the remaining ore.
- ❖ The gold or silver is recovered by distilling off the mercury.

Cont.

v) Leaching

- ❖ The methods we have seen so far are physical methods of concentrating ore.
- ❖ In contrast, leaching is a chemical process of concentrating ore.
- ❖ In this method, the ore is treated with a reagent that dissolves the target substance, leaving the impurities undissolved.
- ❖ For example, aluminum oxide, Al_2O_3 , is separated from bauxite ($\text{Al}_2\text{O}_3 \cdot 2\text{H}_2\text{O}$) and oxides of iron and silicon impurities.



Cont.

- ❖ Gold is sometimes found in ores in the elemental state, but it usually occurs in relatively small concentrations.
- ❖ A process called **cyanidation** treats the crushed ore with an aqueous cyanide solution in the presence of air. This process dissolves the gold by forming the complex ion $\text{Au}(\text{CN})_2^-$.

Cont.

2.Pre-treatment

- ❖ Pre-treatment converts a mineral to a form that is easy to reduce.
- ❖ For example, sulfides are converted to reducible oxides by heating them in dry air, a process called **roasting**:
- ❖ $2\text{PbS(s)} + 3\text{O}_2\text{(g)} \rightarrow 2\text{PbO(s)} + 2\text{SO}_2\text{(g)}$

Cont.

3. Production of Metals

- ❖ The production of a free metal usually involves a reduction process.
- ❖ The production of metals by reduction may be accomplished either
 - Chemically reduction
 - Electrolytically reduction

Cont.

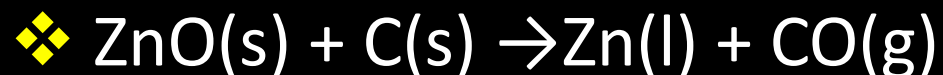
a) Chemical Reduction

❖ A more electropositive metal can be used as a reducing agent to separate a less **electropositive metal** from its compound at high temperatures.

❖ For example:



❖ The less electropositive metals like copper, tin, lead, zinc, manganese, cobalt, nickel and iron are obtained by reducing their oxides with **coke (carbon)** at high temperature.



Cont.

b Electrolytic Reduction

- ❖ Electrolytic reduction is suitable for highly electropositive metals, such as sodium, magnesium and aluminum by using electrolysis
- ❖ Example alkali metals, alkaline earth metal and aluminum

Cont.

4. Refining and Alloying

- ❖ Metals prepared by reduction usually need further treatment to remove impurities.
- ❖ The three common purification procedures are
 - Distillation
 - electrolysis
 - zone refining.

Cont.

a) Distillation

What kind of metals can be separated by distillation?

- ❖ Metals that have **low boiling points**, such as mercury, magnesium, and zinc, can be separated from other metals by fractional distillation.

Cont.

b) Electrolysis

- ❖ Electrolysis is another important purification technique.
- ❖ For example, the copper metal obtained by roasting copper sulphide usually contains impurities such as zinc, iron, silver, and gold.
- ❖ The more electropositive metals are removed by an electrolysis process in which the impure copper acts as anode and pure copper acts as the cathode.

Cont.

Zone Refining

- ❖ Another method of obtaining pure metals is zone refining.
- ❖ In this process, a metal rod containing a few impurities is drawn through an electrical heating coil that melts the metal in the metal rod.
- ❖ Most impurities dissolve in the molten metal.
- ❖ As the metal rod comes out from the heating coil, it cools and the pure metal crystallizes, leaving the impurities in the molten metal portion that is still in the heating coil

THE END OF PART 2
THANK YOU

Cont.

SOME ELEMENT IN INDUSTRY

Sodium

- ❖ is a very reactive metal and is not found free in nature.
- ❖ It exists in the form of compounds.
- ❖ It is a strong reducing agent and cannot be reduced by carbon.
- ❖ Sodium is obtained by the electrolysis of a molten mixture of about 40% NaCl and 60% CaCl₂ in a Downs cell
- ❖ Calcium chloride (CaCl₂) is added to lower the melting point of NaCl from 800°C to 600°C

Cont.

Chemical Properties of Sodium

a) Reaction with water

Sodium reacts with water, liberating hydrogen and forming sodium hydroxide solution.



b) Reaction with air

Sodium tarnishes readily in dry air to form sodium peroxide and sodium oxide.

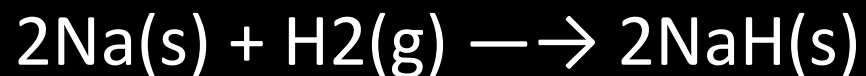


major product minor product

Cont.

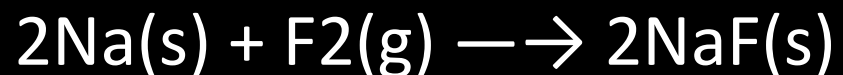
c) Reaction with hydrogen

- ❖ Sodium reacts with hydrogen to form sodium hydride.



d) Reaction with halogens (F₂, Cl₂, Br₂ and I₂)

- ❖ Sodium reacts with halogens to form sodium halides.



Cont.

Uses of Sodium

- ❖ The largest use of sodium is to make a Na/Pb alloy needed to make tetraethyl lead (PbEt_4) and tetramethyl lead (PbMe_4). These compounds are used as anti-knock additives to petrol.
- ❖ Another important use is to reduce TiCl_4 and ZnCl_4 to the metals.
- ❖ Liquid sodium metal is used as a coolant in nuclear reactors.
- ❖ It is also used to make Na_2O_2 and NaH , and for street lights.

Cont.

Calcium

Occurrence of Calcium

- ❖ Calcium is the 5th most abundant element in the earth's crust.
- ❖ The main ores of calcium are: limestone, chalk, and marble (CaCO_3), dolomite ($\text{CaCO}_3 \cdot \text{MgCO}_3$), gypsum ($\text{CaSO}_4 \cdot 2\text{H}_2\text{O}$), fluorite (CaF_2), and hydroxylapatite, $\text{Ca}_5(\text{PO}_4)_3\text{OH}$.
- ❖ In Ethiopia, gypsum deposits are found in the Danakil depression.

Cont.

Extraction of Calcium

- ❖ Calcium is prepared by the electrolysis of molten calcium chloride (CaCl_2).

Anode (oxidation): $2\text{Cl}^-(\text{l}) \longrightarrow \text{Cl}_2(\text{g}) + 2\text{e}^-$

Cathode (reduction): $\text{Ca}^{2+}(\text{l}) + 2\text{e}^- \longrightarrow \text{Ca}(\text{l})$

Overall reaction : $\text{Ca}^{2+}(\text{l}) + 2\text{Cl}^-(\text{l}) \longrightarrow \text{Ca}(\text{l}) + \text{Cl}_2(\text{g})$

- ❖ Calcium can also be prepared by the reduction of CaO by aluminum in vacuum, where the calcium produced distills off.

Cont.

Chemical properties of Calcium

a) Reaction with water

- ❖ Calcium reacts with cold water quite readily, liberating hydrogen gas and forming calcium hydroxide.



b) Reaction with oxygen

- ❖ Calcium reacts with oxygen to form calcium oxide.



Cont.

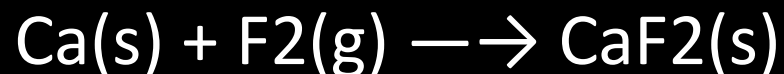
c) Reaction with nitrogen

Calcium reacts with nitrogen at high temperatures to form calcium nitride.



d) Reaction with halogens

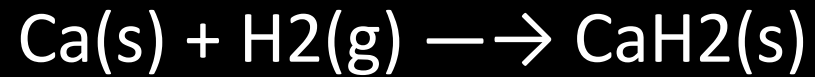
Calcium reacts with F₂, Cl₂, Br₂ and I₂ to form CaF₂, CaCl₂, CaBr₂ and CaI₂ respectively.



Cont.

e) Reaction with hydrogen

Calcium combines with hydrogen to form calcium hydride.



Cont.

Uses of Calcium

- ❖ Calcium is an essential element in living matter.
- ❖ It is the major component of bones and teeth.
- ❖ A characteristic function of Ca^{2+} ions in living systems is in the activation of a variety of metabolic processes.
- ❖ For example, calcium plays a vital role in heart action, blood clotting, muscle contraction, and nerve-impulse transmission.

Cont.

3. Tin

Occurrence

The only important ore of tin is cassiterite, SnO_2 .

Extraction of Tin

Chemical reduction by carbon



Cont.

Chemical Properties of Tin

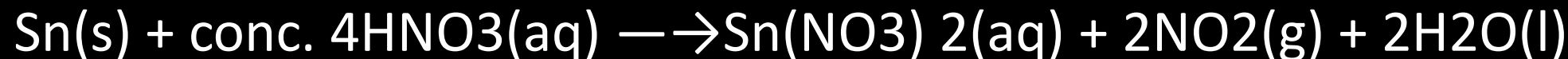
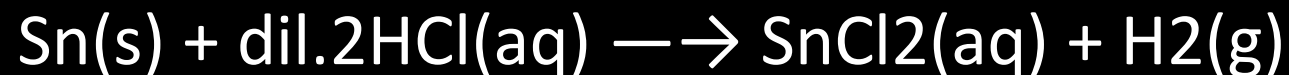
a) Reaction with water

- ❖ Tin does not react with cold water, but it reacts with steam to form SnO₂ and H₂.



b) Reaction with acids

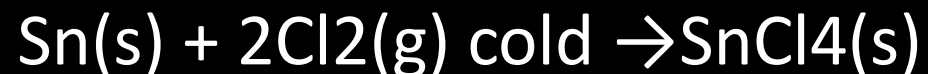
- ❖ Tin reacts with dilute and concentrated acids.



Cont.

c) Reaction with halogens

- ❖ Tin reacts with Cl_2 and Br_2 in the cold and with F_2 and I_2 on warming, forming the corresponding tin tetrahalide.



Cont.

Uses of Tin

- ❖ The main uses of tin are for electroplating steel, to make tin-plate, and alloys.
- ❖ Tinplate is extensively used for making cans for food.
- ❖ Tin is a constituent of many alloys, including type metal (Sn, Sb and Pb), bronze (Sn and Cu), and solder (Sn and Pb)

Cont.

4. Lead

Occurrence of Lead

The main ore of lead is **galena**, PbS . It is black, shiny and very dense.

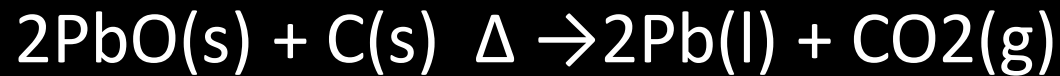
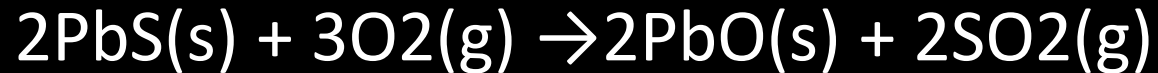
Extraction of Lead

Galena is mined and separated from its impurities by froth flotation.

Cont.

There are two methods of extracting the element:

- ❖ According to first method, the ore is roasted in air to give PbO, which is then reduced with coke or carbon monoxide in a furnace.



Cont.

- ❖ In second method, PbS is partially oxidized by heating and blowing air through it.
- ❖ After some time the air is turned off and heating is continued, and the mixture undergoes self-reduction.

$3\text{PbS(s)} + \text{O}_2\text{(g)}$ heated in air $\rightarrow \text{PbS(s)} + 2\text{PbO(s)}$ heated in absence of air $\rightarrow 3\text{Pb(l)} + \text{SO}_2\text{(g)}$

Cont.

Chemical Properties of Lead

- ❖ Lead is not affected by water because the metal is covered by a thin oxide film.
- ❖ It dissolves slowly in dilute HCl, forming the sparingly soluble PbCl_2 and quite readily in dilute HNO_3 , forming $\text{Pb}(\text{NO}_3)_2$ and oxides of nitrogen.
- ❖ However, it does not dissolve in dilute H_2SO_4 because a surface coating of PbSO_4 is formed.

Cont.

- ❖ Lead is slowly attacked by cold alkali, and rapidly by hot alkali, giving the plumbates $\text{Na}_2\text{Pb}(\text{OH})_6$. Thus, lead is amphoteric.
- ❖ It also reacts with F_2 in the cold, forming PbF_2 , and with Cl_2 on heating, giving PbCl_2 .

Cont.

Uses of Lead

- ❖ The major use of lead is to make lead-acid storage batteries.
- ❖ It is also used in the manufacture of PbEt_4 as an additive for petrol, in paints and pigments.
- ❖ In addition, lead is used for the production of lead sheets, lead pipes and solder.

Cont.

5. Zinc

Occurrence of Zinc

- ❖ Zinc is the 24th most abundant element in the earth's crust. The most important ore of zinc is zinc blende (ZnS).

Cont.

Extraction of Zinc

- ❖ How is zinc metal extracted from zinc blende? ZnS is concentrated by froth flotation and then roasted in air to give ZnO and SO₂.
- ❖ The SO₂ is used to make H₂SO₄.
- ❖ Zn is extracted from the oxide by two different processes.
- ❖ **Method 1.** ZnO may be reduced by carbon monoxide at 1200°C
$$\text{ZnO(s)} + \text{CO(g)} \longrightarrow \text{Zn(g)} + \text{CO}_2\text{(g)}$$

Cont.

- ❖ **Method 2.** ZnS is heated in air at a lower temperature, yielding ZnO and ZnSO₄.
- ❖ These are dissolved in H₂SO₄.
- ❖ Then the ZnSO₄ is electrolyzed to give pure zinc. This method is more expensive than the first.

Cont.

Chemical Properties of Zinc

- ❖ Zinc is a silvery solid that tarnishes rapidly in moist air.
- ❖ It dissolves in dilute HCl and liberates hydrogen gas.



- ❖ Zinc also reacts with aqueous solution of sodium hydroxide and forms sodium zincate, $\text{Na}_2\text{Zn(OH)}_4$. Hence, zinc shows amphoteric properties.
- ❖ On heating, it reacts with oxygen to form zinc oxide.



Cont.

Uses of Zinc

- ❖ Zinc is used in large amounts for coating iron to prevent it from rusting.
- ❖ A thin coating of zinc may be applied electrolytically. This process is called **galvanizing**.
- ❖ Large amounts of Zn are used to make alloys.
- ❖ The most common alloy is brass, which is an alloy of copper and zinc.

Cont.

- ❖ Zinc is also used as the negative electrode (anode) in sealed 'dry' batteries such as Leclanche' cells, mercury cells and alkaline manganese cells.
- ❖ Zinc oxide is sometimes used as a white pigment in paint.
- ❖ It is particularly bright as it absorbs UV light and reemits it as white light.

Cont.

6. Chromium

Occurrence

- ❖ Chromium is the 21st most abundant element, by weight, in the Earth's crust.
- ❖ The most important ore of chromium is **chromite** (FeCr_2O_4).

Extraction

- ❖ Chromium is produced in two forms which are ferrochrome and pure chromium metal.
- ❖ **Ferrochrome** is mainly an alloy of chromium and iron. It is prepared by reducing chromite with carbon.
- ❖ $\text{FeCr}_2\text{O}_4(\text{s}) + 4\text{C}(\text{s}) \xrightarrow{\text{electric furnace}} \text{Fe} + 2\text{Cr} + 4\text{CO}$ ferrochrome

Cont.

Four basic steps are followed to get pure chromium.

Step 1: When chromite is fused with NaOH in air, chromium (III) is oxidized to chromium (VI).



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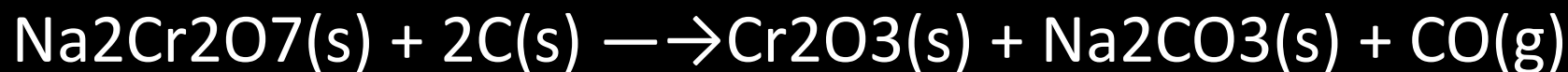
Step 2: Ferric oxide (Fe_2O_3) is insoluble, but sodium chromate (Na_2CrO_4) is soluble in water.

- ❖ Thus the sodium chromate is separated from ferric oxide by dissolving with water, followed by decantation or filtration.
- ❖ The sodium chromate solution is acidified to convert it to a less soluble sodium dichromate.



Cont.

Step 3: The sodium dichromate is reduced to Cr_2O_3 by heating with carbon.



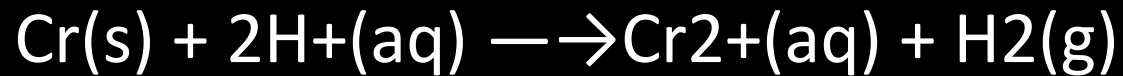
Step 4: Finally, Cr_2O_3 is reduced to the metal by Al.



Cont.

Chemical Properties

- ❖ Chromium is an active metal but it is protected from corrosion by a very thin transparent oxide film.
- ❖ Chromium dissolves in HCl and dilute H₂SO₄ to form **blue chromium (II)** ions, which are stable only in the absence of air.



- ❖ The **unstable chromium (II)** state is readily oxidized to the chromium (III) state.
- ❖ It can remove traces of oxygen by bubbling the gas through a solution containing chromium (II) ions.



Cont.

Uses

- ❖ Nichrome wire, commonly used in chemistry laboratories for flame tests, is an alloy of nickel and chromium.
- ❖ Ferrochrome, iron–chromium alloy, is used in the production of stainless steel.
- ❖ Sodium and potassium chromates and dichromates are used as pigments and corrosion inhibitors in heating systems and air-conditioning systems.

Cont.

- ❖ Chromium (VI) oxide, CrO_3 , appears as a bright-red precipitate when saturated potassium dichromate is treated with excess of concentrated sulphuric acid.
- ❖ The resulting acid mixture (also known as chromic acid) is a powerful oxidizing agent.
- ❖ It can oxidize grease and was used as a cleaning solution for laboratory glassware.

Cont.

Occurrence

- ❖ Silicon is the second most abundant element, after oxygen, in the Earth's crust.
- ❖ It occurs as silica (SiO_2) and silicate compounds containing the silicate ion, $(\text{SiO}_4)^{4-}$.
- ❖ **Quartz** is a pure crystalline form of silica, and **flint** is a hard amorphous form

Cont.

Extraction

- ❖ Silicon is prepared by heating silica with coke to approximately 3000°C in an electric furnace:



- ❖ Extremely high-purity silicon is needed for the electronics industry.

Cont.

Purifying raw silicon requires additional steps.

- ❖ First, the silicon in the impure sample is allowed to react with chlorine to convert the silicon to liquid silicon tetrachloride.



- ❖ Silicon tetrachloride (boiling point 57.6°C) is carefully purified by distillation and then reduced to silicon, using magnesium:



- ❖ The magnesium chloride is washed out with water, A final purification is carried out by zone refining.

Cont.

Chemical Properties

- ❖ Silica is resistant to attack by all acids except HF, with which it reacts to give SiF₄ and H₂O.
- ❖ This chemical attack is involved in the etching of glass. It also dissolves slowly in hot, molten NaOH or Na₂CO₃ to give Na₄SiO₄:
$$\text{SiO}_2(\text{s}) + 4\text{HF}(\text{l}) \longrightarrow \text{SiF}_4(\text{g}) + 2\text{H}_2\text{O}(\text{l})$$
$$\text{SiO}_2(\text{s}) + 2\text{Na}_2\text{CO}_3(\text{l}) \longrightarrow \text{Na}_4\text{SiO}_4(\text{s}) + 2\text{CO}_2(\text{g})$$
- ❖ Silicone polymers are non-toxic and have good stability to heat, light, moisture, and oxygen.

Cont.

Uses

- ❖ Silicon is a semiconductor and is used in the construction of transistors and microprocessors.
- ❖ Quartz crystals are used to control the frequency of radio and television transmissions.
- ❖ Silicone polymers are used in making lubricants, lipstick, car polish and other materials.

Cont.

Some Important Compounds of Selected Non-metal

1. Ammonia (NH₃)

Ammonia produced industrially by Haber process

$\text{N}_2 + 3\text{H}_2 \rightarrow \text{NH}_3$ at moderate temperature

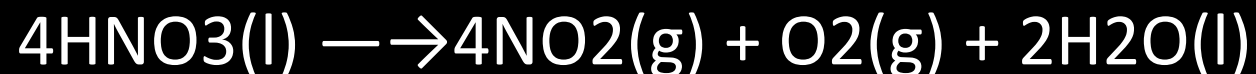
Use of ammonia

- ❖ Mainly used to make fertilizer
- ❖ Used to make nitric acid

Cont.

2. Nitric Acid (HNO₃)

- ❖ Pure nitric acid is a colorless liquid, but on exposure to light it turns brown because of slight decomposition into NO₂(brown) and O₂.



- ❖ Brown Nitric acid is a strong acid and dissociates completely to give H₃O⁺ and NO₃⁻ In dilute aqueous solution.
- ❖ Nitric acid forms a large number of salts, called nitrates, which are typically very soluble in water.
- ❖ Nitric acid is a strong oxidizing agent, particularly when it is hot and concentrated.

Cont.

Nitric acid is produced industrially from ammonia by the three-step **Ostwald process**:

- ❖ **Step 1**: Ammonia is burned in excess oxygen over a platinum catalyst to form nitric oxide (NO):



- ❖ **Step 2**: Additional air is added to cool the mixture and oxidize NO to NO₂:



- ❖ **Step 3**: The NO₂ gas is bubbled into warm water where it reacts to give nitric acid and nitric oxide: $3\text{NO}_2(\text{g}) + \text{H}_2\text{O}(\text{l}) \longrightarrow 2\text{HNO}_3(\text{aq}) + \text{NO}(\text{g})$

- ❖ The nitric oxide (NO) is recycled in Step 2.

Cont.

- ❖ The largest percentage of nitric acid is used to synthesize ammonium nitrate, a water soluble fertilizer.
- ❖ Large quantities are also used to make plastics, drugs, and explosives such as trinitrotoluene (TNT) and nitroglycerine.

Cont.

3. Sulphuric Acid (H₂SO₄)

- ❖ Sulphuric acid is the world's most important industrial chemical, and the rate of consumption of sulphuric acid is a measure of a country's industrialization.
- ❖ Pure H₂SO₄ melts at 10.5°C and boils at 338°C.

Cont.

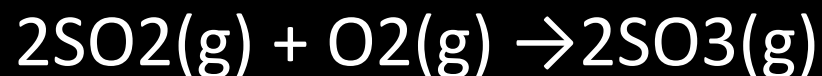
- ❖ H_2SO_4 mix with water in all proportions and release large amounts of heat energy (880 kJ/mol).
- ❖ If water is poured into concentrated acid, the heat evolved leads to boiling of the water and causes violent splashing.
- ❖ The safe way to dilute strong acids is to carefully pour the acid into the water while stirring.
- ❖ Concentrated H_2SO_4 has strong oxidizing properties

Cont.

Sulphuric acid is prepared industrially by the contact process, using four steps:

Step 1: Burning Sulphur in air: $\text{S(s)} + \text{O}_2\text{(g)} \longrightarrow \text{SO}_2\text{(g)}$

Step 2: Converting SO_2 to SO_3



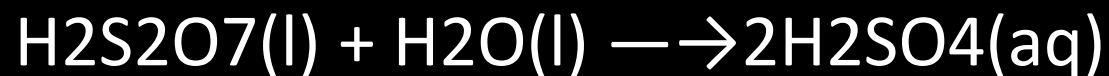
❖ The conversion of SO_2 to SO_3 is slow, but it is increased by heating the reaction mixture to 400°C in the presence of V_2O_5 catalyst. Because the SO_2 and O_2 molecules react on contact with the surface of V_2O_5 , the process is called **Contact process**.

Cont.

Step 3: Passing SO₃ into concentrated H₂SO₄:

$\text{SO}_3(\text{g}) + \text{H}_2\text{SO}_4(\text{l}) \longrightarrow \text{H}_2\text{S}_2\text{O}_7(\text{l})$ Pyrosulphuric acid (oleum or fuming sulphuric acid)

Step 4: Addition of water to pyrosulphuric acid



Cont.

Uses of sulphuric acid

- ❖ Sulphuric acid is used in the production of fertilizers, detergents, plastics and paints.
- ❖ It is used in the production of a number of explosives.
- ❖ Sulphuric acid is an oxidizing agent and a good dehydrating agent.
- ❖ It is often used to dry neutral and acidic gases such as nitrogen, oxygen, and carbon dioxide.
- ❖ It is also used as electrolyte in car batteries.
- ❖ It is also used as a catalyst in the manufacture of many chemicals.

Cont.

4. Diammonium monohydrogen phosphate (DAP), $(\text{NH}_4)_2\text{HPO}_4$

- ❖ Diammonium monohydrogen phosphate (DAP) is a white crystalline compound that is completely soluble in water.
- ❖ How is DAP produced industrially? It can be produced when ammonia reacts with phosphoric acid by the following two steps:
- ❖ Step 1: Anhydrous ammonia reacts with phosphoric acid to form mono ammonium dihydrogen phosphate and diammonium monohydrogen phosphate



Cont.

- ❖ Step2: Recycling mono ammonium dihydrogen phosphate for further reaction with anhydrous ammonia yields DAP:



Cont.

Use of DAP

- ❖ DAP is used as a fertilizer.
- ❖ When applied as plant food, it temporarily increases soil acidity, but over the long term, the soil becomes more acidic than before upon nitrification of the ammonium.
- ❖ DAP has the advantage of having both nitrogen and phosphorus, which are essential for plant growth.

Cont.

- ❖ DAP can be used as fire retardant.
- ❖ It lowers the combustion temperature of the
- ❖ material, decreases weight-loss rates, and causes an increase in the production of residue or char.
- ❖ DAP is also used as a yeast nutrient in wine making and beer brewing.

END OF CHAPTER 5