

INDUSTRIAL CHEMISTRY (COMMON FOR ALL BRANCHES)

GOVT. POLYTECHNIC DEBAGADA

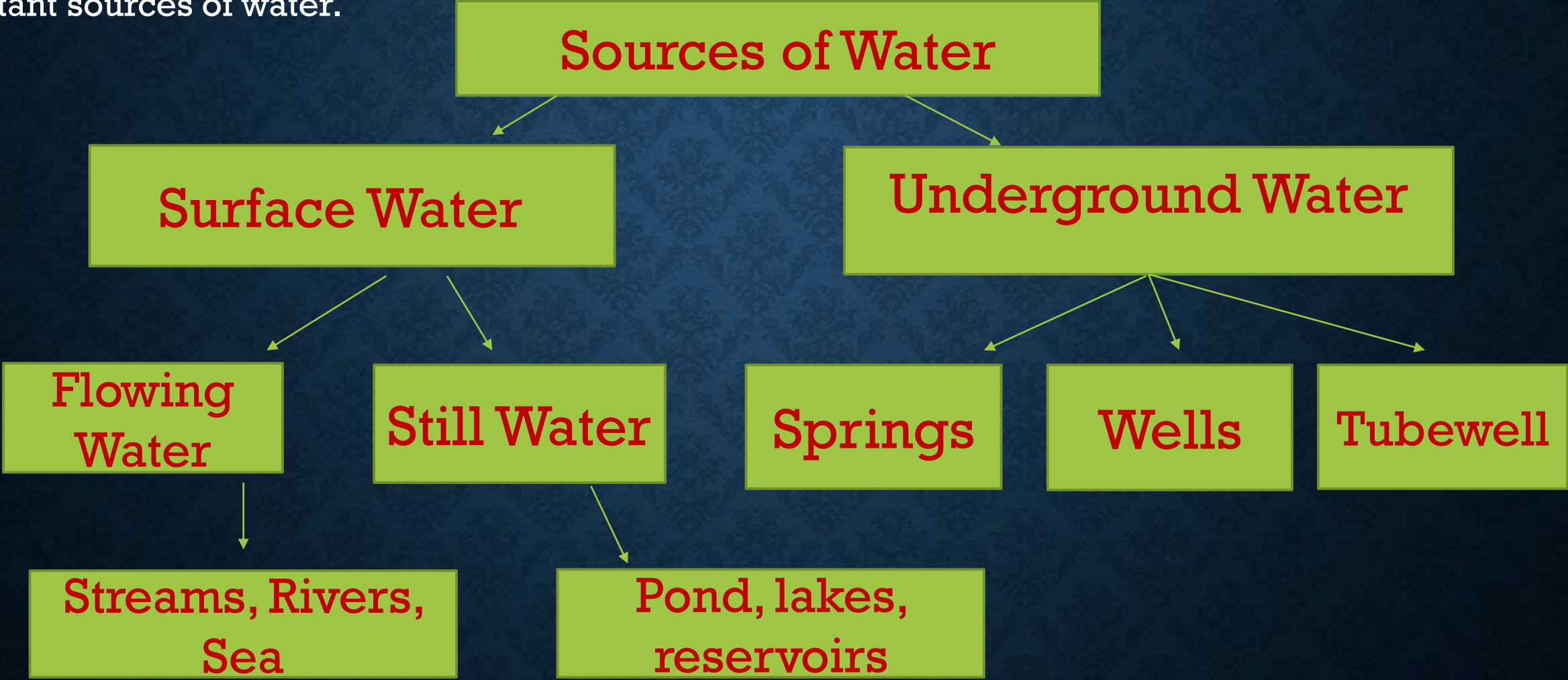
SR. LECTURER IN CHEMISTRY

Introduction:

- Water is nature's most abundant wonderful & useful compound. It is essential to all forms of life.
- Water is not essential for the animals & plants, but also occupies a unique position in industries.
- No industry can be established or run without adequate supply of water.
- The most important uses of water in the industries is in the steam generation.
- Water is widely used in power & chemical plants, production of steel, rayon, paper, atomic energy, textile & for air -conditioning etc.
- The earth constituting 75% of water in its surface. The human body contain 65% of water. It is present in air in the form of water vapour.

Sources of Water:

Rain water collects on the earth in the form of surface water & underground water. The following are the important sources of water.



APPLICATION OF WATER

- The application like washing, bathing, cooking, drinking,
- In textile industry, sugar industry, dyeing industry, paper industry, laundry, Bakeries,
- Concrete making, Pharmaceutical Industry.

TYPES OF IMPURITIES PRESENT IN WATER

The common impurities present in water are

- 1.Suspended Impurities(Clay, Sand)
- 2.Dissolved Gases(O_2 , CO_2 , H_2S)
- 3.Dissolved Mineral Salts(Carbonates,bicarbonates, Cl_2)
- 4.Sulphates,nitrates,Fluorides of Na, K, Mg, Ca, Fe .
- 5.Microscopic Matter like bacteria, micro-organisms like algae, fungi etc.

CLASSIFICATION OF WATER

- The water is classified into two types based on its action with soap
- These are
 - a) Soft water
 - b) Hard water
- Soft water: The water which forms (produces) lather easily with soap solution is called Soft water.
E.g: Rain water, distilled water, demineralised water.

Reason for formation of Lather easily

- Soap is a sodium or potassium salt of fatty acids like stearic acid, palmitic acid & oleic acid.
- Whenever soap is added to soft water, it ionises into anion of fatty acid & Na^+ .
- This anion involves in the cleaning action. So lather forms easily.
- $$\text{C}_{17}\text{H}_{35}\text{COONa} \xrightarrow{\text{H}_2\text{O}} \text{C}_{17}\text{H}_{35}\text{COO}^- + \text{Na}^+$$

Sodium Stearate(Soap)
Stearate anion

HARD WATER

- Hard Water :

The water which doesn't produces lather easily with soap solution is called Hard Water.

- It forms curdy white precipitate.

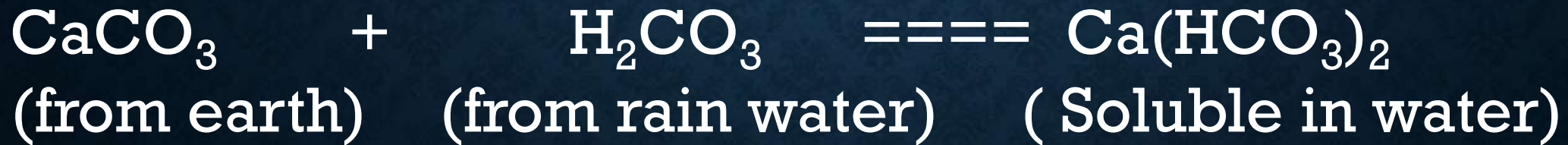
- E.g : Sea, River, Pond water.

WHY THIS HARDNESS?

- During first shower of rain, carbon dioxide of air dissolves in water to form carbonic acid (H_2CO_3).

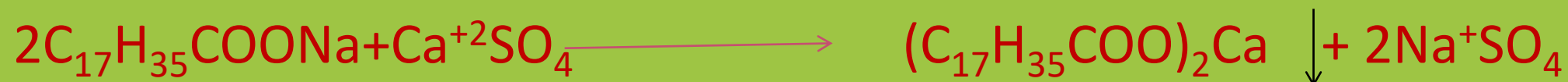


- The above water containing H_2CO_3 reacts with calcium carbonate present in earth to form soluble calcium bicarbonate.
- The presence of bicarbonates in water make its temporarily hard.



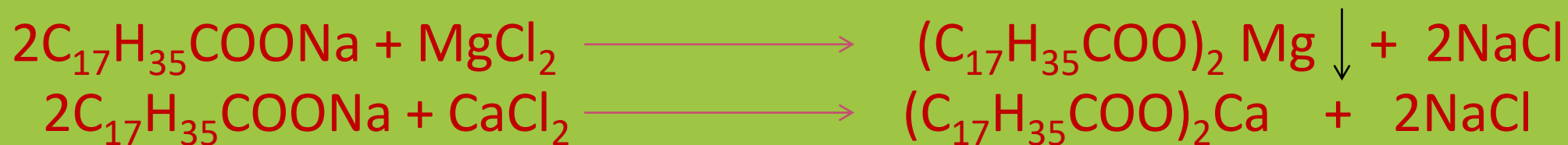
CAUSES OF HARDNESS

- Hardness :The lather preventing property of soap with water is called Hardness.
- The hardness of water is due to presence of dissolved salts like bi-carbonates, chlorides & sulphates of calcium & magnesium.
- When soap is treated with hard water, it forms insoluble calcium Or magnesium salt of fatty acid.
- It is precipitated as a white curdy substance.



Soap doesn't produce lather until all the Ca^{+2} & Mg^{+2} ions have been precipitated.

Hence, the salts should be removed from the hard water before its use.



TYPES OF HARDNESS

➤ The hardness of water is two types

1. Temporary Hardness (Carbonate Hardness)

2. Permanent Hardness (Non-carbonate Hardness)

➤ Temporary Hardness ::

“The hardness causes due to the presence of dissolved bicarbonates of calcium & magnesium is called Temporary Hardness (Carbonate Hardness) .”

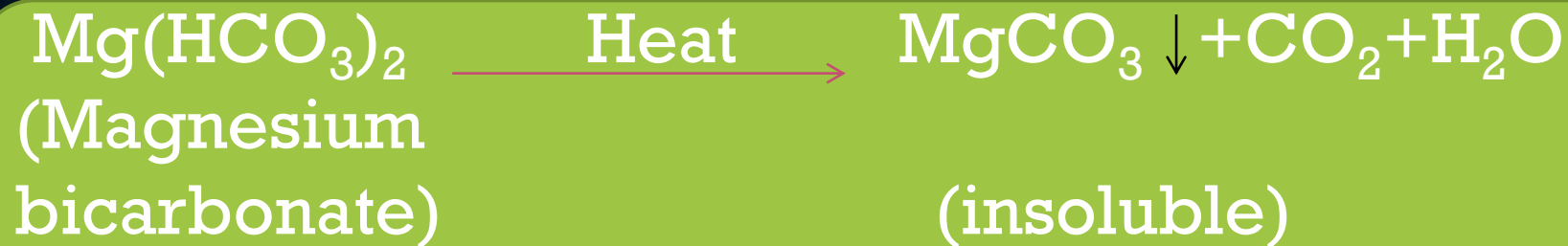
OR

“If water contain bicarbonates of Ca^{2+} & Mg^{2+} ions, then it is called as Temporary Hardness.”

➤ The formula of these compounds is $\text{Ca}(\text{HCO}_3)_2, \text{Mg}(\text{HCO}_3)_2$.

REMOVAL OF TEMPORARY HARDNESS FROM WATER

- This type of hardness can be removed by boiling of water or by adding lime.
- 1.By boiling method : Whenever water is boiled, the bicarbonates decompose to form insoluble carbonates which can be removed by filtration method.



b) By adding Slaked Lime , Ca(OH)_2 Clark's Method:

- In this method calculated amount of slaked lime (calcium hydroxide) is added to hard water.
- The bicarbonates of Ca & Mg react with lime & form insoluble carbonates, which are removed by filtration method.



(From hardwater)

PERMANENT HARDNESS

- *“The hardness cause due to the presence of chlorides & sulphides of calcium & magnesium is called Permanent Hardness.”*

OR

“If the water contain chloride & sulphide is of Ca^{2+} & Mg^{2+} ions then it is called Permanent Hardness.”

- The formula of these compounds are CaCl_2 , MgCl_2 , CaSO_4 & MgSO_4 .
- Permanent hardness can n't be removed by boiling. It is removed by special methods like ion-exchange process etc.

REMOVAL OF PERMANENT HARDNESS

- The permanent hardness of water can be removed by the following methods
 - a) By adding washing soda(Na_2CO_3)
 - b) Lime Soda Process
 - c) Ion-exchange Process
 - d) Zeolite process/Permutite Process

SOFTENING OF HARD WATER BY LIME-SODA PROCESS:

- Whenever lime $[\text{Ca}(\text{OH})_2]$ & washing soda $[\text{Na}_2\text{CO}_3]$ are added to water, the calcium & magnesium salts are converted into insoluble compounds of calcium carbonates $[\text{CaCO}_3]$ & Magnesium hydroxide $[\text{Mg}(\text{OH})_2]$.
- These are filtered off.
- The following reactions takes place in this process.

1. Calcium bicarbonate reacts with lime only.



2. Magnesium bicarbonate also reacts with lime only

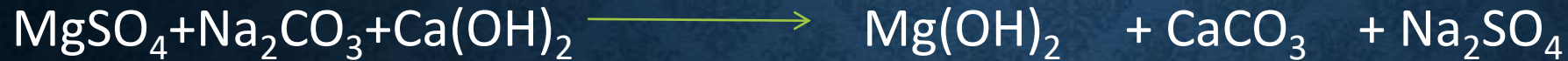


(From hard water)

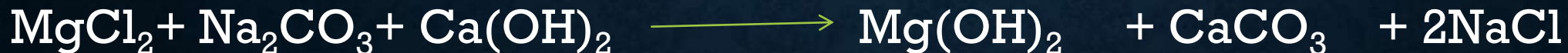


REMOVAL OF PERMANENT HARDNESS

➤ Magnesium sulphate reacts with lime & soda

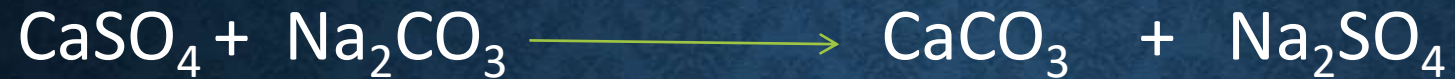


➤ Magnesium chloride also reacts with lime & soda.



REACTION WITH SODA

- Calcium sulphate reacts with soda only



- Calcium Chloride also reacts with soda only



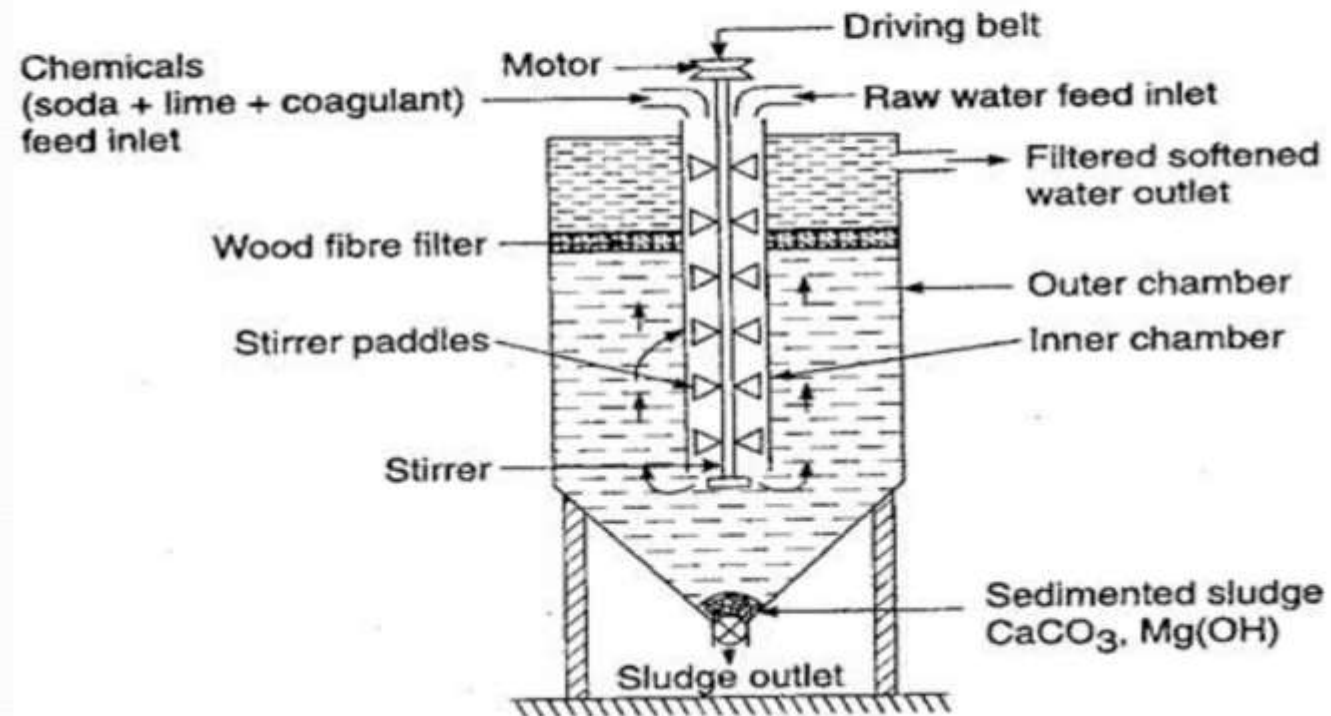
THE LIME-SODA PROCESS MAY BE CARRIED OUT EITHER IN COLD OR HOT WATER.

Cold –Lime Soda Process:

- In this method, calculated quantity of lime, soda & water with little quantity of coagulant like alum or aluminium sulphate are fed into the inner chamber.
- As the raw water & chemicals flow down, there is a vigorous stirring & continuous mixing take place.
- Due to chemical reaction all hardness causing chemicals are converted to low precipitation sludge, which is effectively settled with the help of coagulant.
- The soften water comes into the outer co-axial chamber & gradually rises upwards.
- The softened water then passes through a filtering medium for the complete removal of precipitate.
- This process provided water containing a residual hardness of 50-60 ppm.

DIAGRAM OF COLD -LIME SODA PROCESS:

Cold lime soda process



HOT-LIME SODA PROCESS:

➤ The plant used for this process essentially consists of three (3) parts.

1) "*Reaction Tank*" in which raw water, chemicals & steam are thoroughly mixed.

2) "*A conical Sedimentation Tank*" in which sludge settles down.

3) "*A Sand Filter*" which ensures complete removal of sludge from the softened water.

➤ Process:

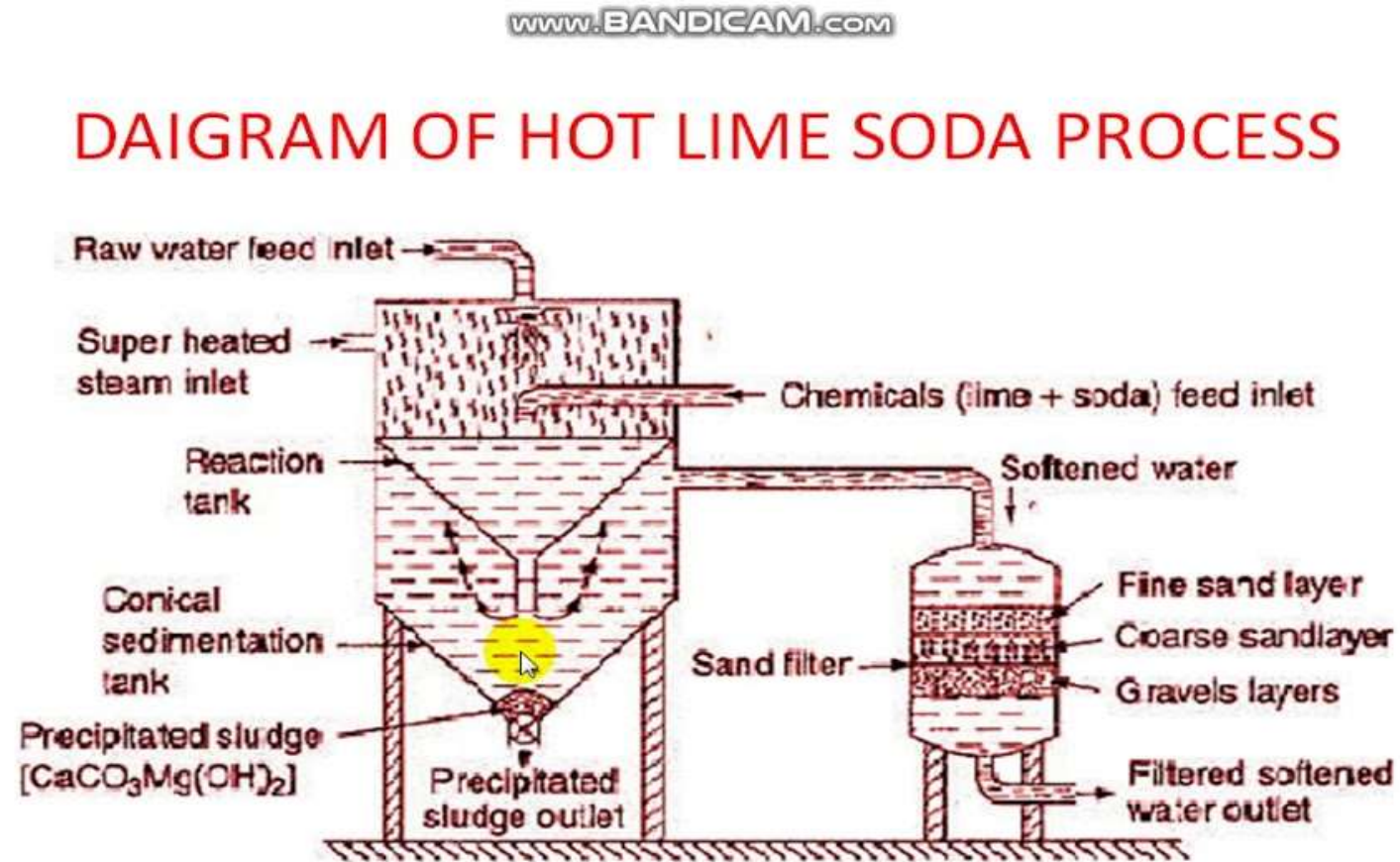
1. The hard water & chemicals (lime & soda) are fed into the reaction tank & heated to 80-150 °C by passing steam.

2. At this temp., the reactions proceed at a faster rate & the sludge formed settle down rapidly.

3. No coagulants are needed in this process.

4. This process produced water containing a residual hardness of 15-30ppm.

DIAGRAM OF HOT-LIME SODA PROCESS:



DIFFERENCES BETWEEN COLD LIME SODA PROCESS & HOT LIME SODA PROCESS

Cold lime Soda Process	Hot Lime soda Process
1.This process is carried out in room temperature(25 °c).	This process is carried out in the higher temperature (80-150 °c)
2. The reaction proceeds at a slower rate.	2.The reaction proceeds at a faster rate.
3.Coagulants are added.	3. Coagulants are not added.
4.It takes 24hours to complete.	4.It takes 15 minutes to complete.
5.It has low softening capacity.	5.It has high softening capacity.

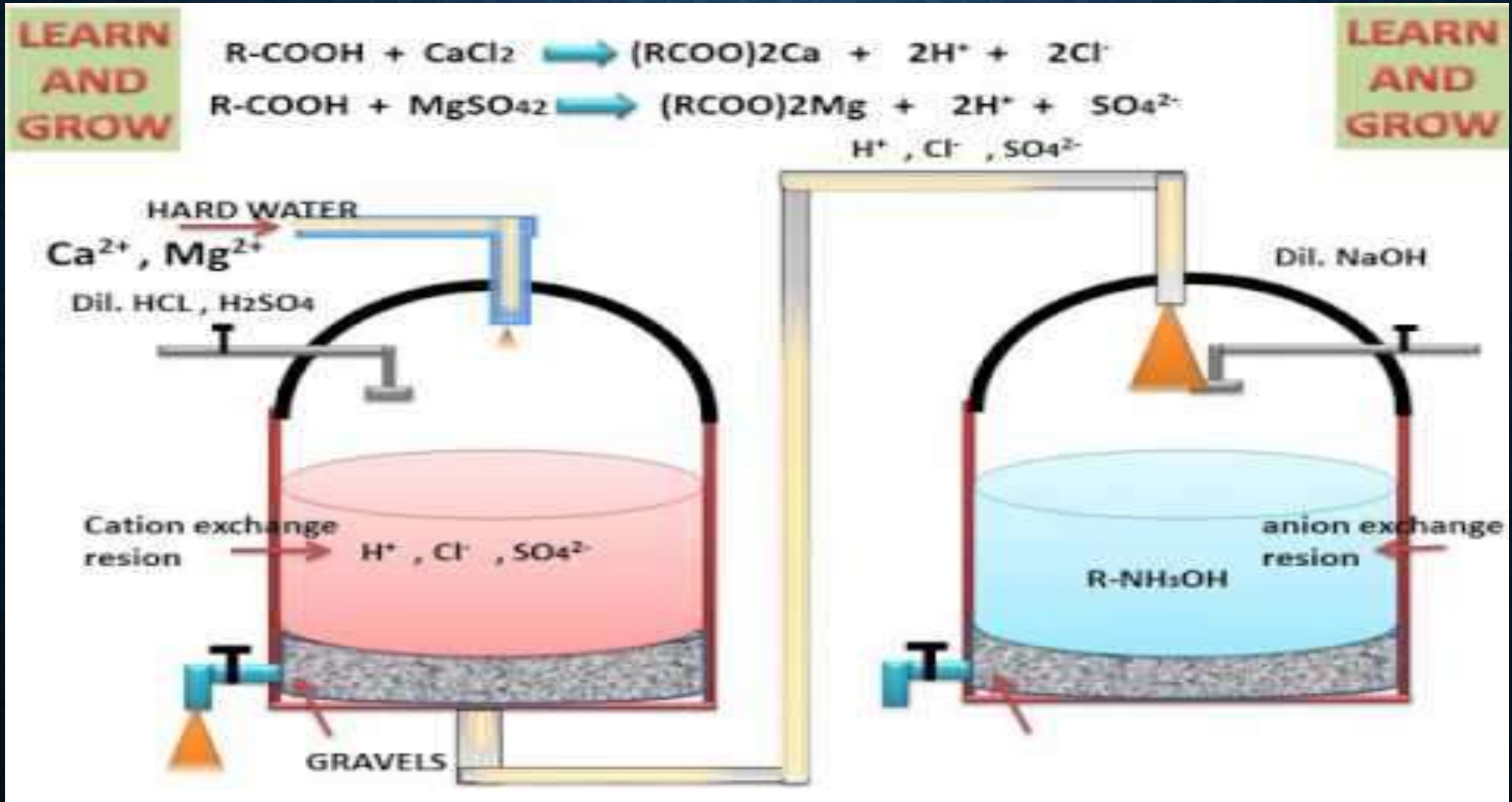
ADVANTAGES OF LIME-SODA PROCESS:

1. It is very cheap & most economical.
2. This process increases PH of water, which reduced the growth of pathogenic bacteria.
There by corrosion of the distribution pipes is reduced.
3. Mineral content of water is reduced.
4. Survival of microorganisms is prevented.
5. The water obtained in this process has more corrosion resistant.

SOFTENING OF HARD WATER BY ION EXCHANGE PROCESS

- Among all the methods of water softening , the ion –exchange process is the best & the most modern method . All the cations & anions present in the water are removed in this process . The water so obtained is demineralized water.
- In this method Ion – exchange resins are used.
- The resins are cross-linked organic polymers with micro-porous structure.
- The functional groups attached to the resins are responsible for the exchange of ions.
- The resins containing $-\text{COOH}$ or $-\text{SO}^3\text{H}$ group (acidic resin) can capable of exchange their H^+ with other cations. These are called *Cation exchange resins*.
- The resins containing $-\text{OH}^-$ or $-\text{NH}_2$ group (basic resin) can capable of exchange their OH^- or NH_2 with other Anions. These are called *Anion exchange resins*.

FIGURE FOR ORGANIC ION EXCHANGER.



➤ The organic ion-exchanger consists of two columns , namely

a) cation exchanger

b) anion exchanger

➤ The cation exchanger is filled with an acidic resin (R-COOH) & anion exchanger is filled with a basic resin (R-OH).

➤ The hard water is first sent through the cation exchanger.

➤ Here the acidic resin exchanges the H⁺ with Mg⁺² & Ca⁺² ions of water.



(acidic exhausted resin)

➤ The water is then passed through the anion exchanger. Here ,basic resin exchanges the OH⁻ with Cl⁻ HCO⁻³ & SO⁻²₄ of water.



(basic exhausted resin)

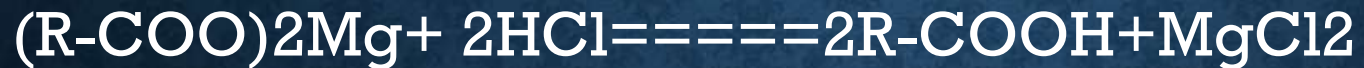
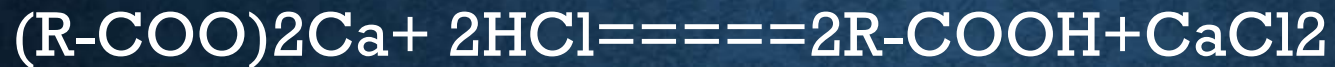


➤ The H⁺ & OH⁻ ions combine & form water.



REGENERATION OF RESINS

- After some time, the resins are exhausted.
- The exhausted acidic resin is regenerated by passing an acid like HCl or H₂SO₄.



- The basic exhausted resin is regenerated by passing alkali like NaOH.

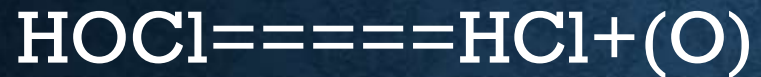


- After regeneration, the resins are ready for softening.

WHAT IS CHLORINATION?

➤ The addition of chlorine or bleaching power to water for sterilization is called chlorine.

➤ The following reactions occur in this process.



Bacteria + (O) $\rightleftharpoons$ Bacteria are killed.

➤ What is desalination? How it is carried out?

The process of removal of salts from water is called desalination.

Reverse osmosis is used to carry out desalination.

WHAT IS CALGON? STATE THE USES OF IT?

- Sodium hexamet phosphate is named as Calgon.
- It's formula is $(\text{NaPO}_3)_6$ or $\text{Na}_2[\text{Na}_4(\text{PO}_3)_6]$.
- It is used to remove permanent hardness of water.
- $\text{Na}_2[\text{Na}_4(\text{PO}_3)_6] + 2\text{CaCl}_2 \rightleftharpoons \text{Na}_2[\text{Ca}_2(\text{PO}_3)_6] + 4\text{NaCl}$

AIR POLLUTION & NOISE POLLUTION(COMMON FOR ALL BRANCHES)

GOVT. POLYTECHANIC DEBAGADA

NAME OF THE FACULTY:KUNI MAJHI,SR. LECTURER IN CHEMISTRY

The atmosphere of earth is made up of four principal layers.

- Troposphere
- Stratosphere
- Mesosphere
- Thermosphere

These layers are determined basing upon

- Variation in temperature that occurs vertically from the surface outward.

As per our syllabus we will discuss only about troposphere and stratosphere.

1) Troposphere

- It is the layer closest to the surface of the earth.
- It extends to a height from 8 km (near the poles) to 20 km (near the equator)
- It is the region where most of the water vapour and suspended particles in the atmosphere are collected and weather occurs in this region.
- It is the most important zone for the organisms and composed of mainly nitrogen and oxygen.
- It also contains Argon and Carbon dioxide and traces of He, Ne, CH₄, Kr, N₂O, CO, O₃, NH₃, NO₂, SO₂, etc.

2) Stratosphere

- Stratosphere is the layer next to the troposphere.
- This region of air extends up to 50 km above the earth's surface.
- It is about 62 km thick at the equator and about 72 km thick at the pole and extends up to 80 km above the earth's surface.
- As the minimum temperature of this sphere is very low, (minimum about -55°C and maximum about 5°C) so there is no cloud, dust or water vapours.
- This region is rich in ozone which absorbs harmful ultraviolet (UV) radiations from the Sun.
- Major gases present in this layer are N_2 , O_2 , O_3 and some water vapour.

POLLUTION

Definition

- i) When harmful substances contaminate the environment, it is called pollution.
- ii) When the condition of the environment becomes very bad in terms of both quantity and quality, it is called pollution.

POLLUTANT

Definition:

The materials present in greater quantity than the natural abundance which has some detrimental effect is known as pollutant.

Examples CO₂, CO, SO₂, Pb, Mg, As, Cd etc.

Types of pollutants

i) **Primary pollutant**: It is a harmful chemical substance that directly enters into the environment as a result of natural events or human activities.

Examples:

- a) Oxides of Carbon - (CO and CO₂)
- b) Oxides of Nitrogen- (NO)
- c) Oxides of Sulphur- (SO₂)
- d) Hydrocarbon- (CH₄)
- e) Suspended particles

ii) **Secondary pollutant**: It is a harmful substance derived from the primary pollutant

Examples:

SO₃, H₂SO₄, NO₂, N₂O, HNO₃, O₃, H₂O₂

- Air pollution and excessive noise harm our health and also our environment.
- Air pollution can mainly cause cardiovascular and respiratory related diseases.
- It is the leading environmental cause of premature death in many developed and developing countries.
- Air pollution also has negative impacts on the quality of water and soil.
- It damages ecosystems through eutrophication (excess nitrogen pollution) and acid rain. Hence, agriculture, forests, buildings etc. are also affected due to air pollution.
- Air pollution has many sources such as industry, transport, energy production, agriculture etc. In addition to the air pollution, noise pollution also effects our health. Environmental noise levels are rising in urban areas, mainly
due to increasing traffic volumes, intensifying industrial and recreational activities.
- This can lead to increased stress level, sleep disturbance and may adversely affect health and quality of life. Noise also has an impact on wildlife.
- This unit aims at introducing basic concepts of air and noise pollution with an emphasis on its effect on our health and environment. The unit include types of air pollutants, its effects and control, source of noise pollution, its measurement and effects. After completion of this unit, the students will develop basic concepts of air and noise pollution.
- The students will also know the pollution control mechanism which will give them an opportunity to protect our health and environment by minimising the air and noise pollution.

INTRODUCTION

- *“We still have too much air and water pollution and we still need to work to reduce it. But we also need to put the problem of pollution into a historical as well as scientific perspective”.*

(Ronald Reagan, Ex-president of United States of America)

- The air is composed of 78% nitrogen, 21% oxygen, and 0.9% argon. The remaining elements include carbon dioxide, water vapour, hydrogen, and other trace elements. The atmosphere is a delicate balance of elements and particles.
- Air pollution occurs when there is an alteration to the composition of air. The main sources of air pollution are transportation, factory emissions, biomass consumption, agriculture production etc.
- The air pollution is caused due to excessive concentration of suspended particulate matter (SPM), carbon dioxide, nitrogen oxide in the atmosphere emitted from the sources that burns fuel.
- Air pollution including noise pollution is a significant risk factor for human health conditions, causing allergies, respiratory and cardiovascular disease as well as lung damage.
- It is also a major contributors to global warming and climate change.

DEFINITION OF POLLUTION AND POLLUTANT

- The word pollution come from Latin word “**polluere**” that means **contamination**.
- Hence in layman terms, the pollution is something that **contaminates the environment**.
- It may be defined as the presence of harmful substances in the air, water and soil which can have adverse effect on living beings and on the environment.
- Due to pollution, undesirable changes occur in the physical, chemical or biological characteristics of air, water and soil that may be harmful for any living organism.
- Types of Pollution: There are mainly five types of pollution:
 - Air Pollution
 - Water pollution
 - Land pollution
 - Noise pollution
 - Radioactive pollution

Air Pollution

- Air pollution may be defined as the undesirable presence of one or more contaminants such as dust,
- fumes, gas, mist, odour, smoke, or vapour which are detrimental to human health in particular and
- the planet as a whole. Air pollution in many cases prevents photosynthesis process in plants which has
- serious consequences on the purification of air we breathe. It is a major contributor to global warming
- and climate change. Air pollution is indeed a significant risk factor for human health conditions, causing
- allergies, respiratory and cardiovascular diseases.

Water Pollution

- Water pollution can be defined as the contamination of a stream, river, lake, ocean or any other water body, degrading water quality and rendering it toxic for the environment and human.
- The main causes of water pollution include sewage and waste water, urbanisation and deforestation, agriculture, industries, marine dumping and radioactive waste. Water pollution harms biodiversity and ecosystem.
- It has very negative impacts on human health. Many diseases such as diarrhea, cholera, typhoid, dysentery and skin infection result from drinking or being in contact with contaminated water.

Land Pollution

- Land pollution refers to any physical or chemical changes in soil condition that may adversely affect the human health, plants and animals. Most soil pollutants are agricultural chemical, fertilisers and pesticides.
- Dumping of waste which may include municipal wastes, untreated sewage, industrial effluents etc. also pollutes the soil when harmful substances from dump leak into it.

Noise Pollution

- Noise pollution can be defined as any unwanted or disturbing sound that effects the health and wellbeing of humans and other organism.
- Sound is measured in decibels. Sound that reaches 85 decibels or more is considered harmful for human ear.
- Noise pollution has its impact on millions of people on daily basis.
- The most common health problem in human is hearing loss. Exposure to loud noise may also cause high blood pressure, heart disease, sleep disturbances and stress.
- The main sources of noise pollution include traffic noise, air traffic noise, construction noise, catering and night life, animals etc.

Radioactive Pollution

- Radioactive pollution is defined as increase in the natural radiation level in the environment caused mainly by human activities.
- The sources of radiation pollution involve any process that emanates radiation in the environment.
- Causes of radiation pollution include research and medical procedures and waste, nuclear power plants, TVs, computers, radio waves, cell phones, etc. However, the most common ones that can pose moderate to serious health risks are: Nuclear explosions and detonations of nuclear weapons, Defensive weapon production, Nuclear waste handling and disposal, Mining and Nuclear accidents.

Pollutants

- Pollutants are the harmful substances which brings undesirable and harmful changes in the physical,
- chemical or biological characteristics of air, water and soil. Smoke from industries and automobiles,
- domestic and commercial sewage, radioactive substances from nuclear plants and discarded household
- articles (tins, bottles, broken crockery etc.) comes under the category of pollutants.

Types of Pollutants:

Pollutants can be categorised into following five categories:

1.Water Pollutants: The runoff from industries, agriculture fields and even from urban areas contribute largely to the water pollution. In addition, raw sewage is a major pollutant of water.

2.Soil Pollutants: The main source of soil pollutant include municipal and industrial wastes, overdose of pesticides and herbicides etc.

3.Air Pollutants: The major source of air pollutant is burning fossil fuels and it happens due to factory emission and automobiles. Also acid rain has adverse effect on forests and their inhabitants.

4.Noise Pollutants: Major noise pollutant include horns of automobiles, loudspeakers, fire crackers, electrical appliances, traffic noise etc.

5.Radioactive Pollutants: Radioactive pollutant include radiation released in nuclear power plant accidents, use of nuclear weapons, mining, spillage of radioactive chemicals, cosmic and other natural sources like gamma rays, radiation used for the treatment of diseases like cancer etc.

Natural and manmade sources of air pollution

Air pollution may be caused by various processes and it may be natural or manmade (anthropogenic).

❖ Natural sources of air pollution

It is caused due to continuous and temporary natural events and it cannot be prevented. Natural sources of air pollution are described below:

1.Volcano Activities: Volcanic eruptions emit a series of toxic gases including sulphur and chlorine. It also emits particulate matter in the form of ash particles. Volcanic eruptions are restricted to localised area.

2.Winds and Air Current: It can mobilise soil and other pollutants and spread it over the large areas.

3.Wild Fires: It emit carbon monoxide and particulate matter into the atmosphere. It may affect significant areas although they can be restricted and contained to small area.

4.Microbial Decaying Process: Microorganisms present in the environment have a major role in natural decaying processes of living organisms. This activity results in the natural release of gases especially methane gas and causes air pollution.

5.Increasing Temperature: It contribute to an increase in the amounts of contaminants volatilizing from polluted soil and water into the air.

❖ Manmade sources of air pollution

It is caused due to human activities and it has huge impact on environment and also on all of us.

Manmade sources of air pollution are described below:

1. Mining and Smelting: Crushing & processing of mineralogical deposits emits a variety of metals into the atmosphere and creates pollution.

2. Foundry Activities: It emits a variety of metals into atmosphere due to processing of metallic raw materials (including the use of furnaces).

3. Various Industrial Processes: These may emit both organic and inorganic contaminants through accidental spills and leaks of stored chemicals or mis-handling and storage of chemicals—especially inorganic chemicals of volatile nature.

4. Transportation: Vehicles emits a series of air pollutants in the form of gases such as carbon monoxide, sulphur oxides, nitrogen oxides and particulate matter.

5. Construction and Demolition Activities: These activities pollute the air with various construction materials, specially demolition of old buildings which may contain a series of banned chemicals such as PCBs, PBDEs, Asbestos etc.

6. Coal Power Plants: Burning of coal in coal power plant may emit a series of gases as well as particulate matter with metals (such as As, Pb, Hg) and organic compounds (especially PAHs).

7. Waste Incineration: In this process, various toxic gases, and particulate matter is emitted into the atmosphere, depending on the composition of waste.

8. Landfill Disposal Practices: Due to the natural microbial decaying activity in the disposal area methane gas is generated and pollute the environment.

9.Agriculture: Agricultural activity pollute the air through emissions of ammonia gas and the application of pesticides/herbicides/insecticides which contain toxic volatile organic compounds.

10.Defence Activities: These activities may pollute the air by emitting toxic gases through practices and training.

11.Smoking: Smoking emits a series of toxic chemicals including a series of organic and inorganic chemicals, some of which may be carcinogenic also.

12.Storage and Use of Household Products: Household products such as paint, sprays, varnish, etc. that contains organic solvents which volatilize in the air and we feel smell while using them.

13.Refrigerants: It is used in various electronic equipment such as refrigerator, air-conditioner etc. These are mainly responsible for creating greenhouse effect in the atmosphere, that warms the planet.

14.I.C. Boilers: These are combustion devices used to heat water or to produce steam. I.C. Boilers create air pollution by emitting hazardous air pollutants in the atmosphere.

Air Pollutants

- *“Air pollution is the excessive concentration of foreign matter in the air which adversely affects the well-being of the individual or cause damage to property”.(- American Medical Association)*
- The foreign matter which causes air pollution are called air pollutants.
- Air pollutants include gasses, liquid droplets and solid particles.
- They are classified according to the source of emission into two main groups: (i) **Primary Pollutants** and (ii) **Secondary Pollutants**.
- **The Primary Pollutants** are emitted from a source directly into the atmosphere.
- The source can either be a natural processes such as sand storms, volcanic eruption or anthropogenic (by humans) such as industrial and vehicle emissions.
- The major primary pollutants are oxides of Sulphur, Nitrogen, Carbon, Particulate matter, Methane, Ammonia, Chlorofluorocarbons, Toxic metals etc.
- **The Secondary Pollutants** are not emitted directly. They are formed in the atmosphere when the primary pollutants react with themselves or with the other components of the atmosphere.
- Major secondary pollutants include photochemical oxidants and secondary particulate matter. Photochemical oxidants result from the photochemical reactions between sunlight and nitrogen oxides, sulphur dioxide, or volatile organic compounds.
- They mainly include acids, nitrogen dioxide, sulphur trioxide, and ozone.
- Ozone is considered as highly dangerous air pollutant. Exposure to ozone can cause many lung diseases such as asthma, emphysema, and bronchitis. Repeated and long exposures to ozone may even permanently scar the lung tissues.

Particulate Pollutant

- Air quality at any location is determined by the level of pollutants present in the air and it depends on the types and amount of pollutants released into the air. The level of pollutants in the air can vary greatly from one location to the other and from one hour to the next.
- **Particulate pollution** is one of the most complicated forms of air pollution. The pollutant responsible for particulate pollution is called particulate pollutant & also known as **particulate matter**. It is an amalgamation of different particles both solid and liquid, that behave in a similar ways and are of similar size.
- Particulate matter is **sub-divided** into different categories based on particle size i.e. **PM10, PM2.5 and PM0.1.**
- ❖ **PM10** also known as **coarse particles**, is defined as all particles with an aerodynamic diameter of 10 µm or smaller.
- PM10 also contains **PM2.5 and PM0.1**. These particles can pose significant health threat as it can penetrate into our lungs.
- Once these particles get into our lungs, it can irritate the lung tissue and can prompt asthma attacks. It can also irritate our airways, nose, throat and eyes. Its sources may include construction site dust, road dust or natural dust storm, agricultural processes, plant, insects , pollen grains as well as non-combustible materials released during the burning of fossil fuels.
- ❖ **PM2.5** also known as **fine particles**, is defined as all particles with an aerodynamics diameter of 2.5 µm or smaller. Fine particles can come from natural or human-made sources, like: vehicle exhaust, wildfires, power plant emissions and other combustion activities. Unlike PM10, PM2.5 can not only enter into our lungs but also permeate our bloodstream.
- PM10 particles get stuck up in our respiratory track and can't penetrate deep into our body, as PM2.5 does. PM2.5 can flow to other parts of our body like our brain and heart and can cause inflammation and damage.
- PM2.5 contributes to the same problems as PM10 and additional ones like, respiratory disease, reduced immune response, congenital disabilities.

- ❖ **PM0.1** also known as **ultrafine dust**, is defined as all particles with an aerodynamics diameter of 0.1 μm or smaller.
- It is smaller than fine dust and originates from the similar sources as PM2.5. Research indicates that ultrafine dust poses a worse threat than PM2.5, as the smaller particle size can infiltrate into our body to an greater extent.
- Recent studies show that PM0.1 displays enhanced cardiovascular toxicity and greater potential for oxidative stress. Overall, ultrafine dust is to be taken seriously and additional research will shed light on the further differences between it and PM2.5.
- Emission of particulate matter can be controlled or removed from a polluted stream by a variety of physical processes. Common types of equipment for collecting particulate matter include Bag filters , cyclone separators, electrostatic precipitators, and scrubbers. Once collected, particulates adhere to each other, forming agglomerates that can readily be removed from the equipment and disposed off, usually in a landfill.

❖ **Bag filters**

- Bag filters, commonly known as baghouse or dust collector is an pollution control device used to remove particulate matter from the contaminated gas stream by depositing the particles on bag filters.
- These bag filters are made up of fabric materials. The filter is usually in the form of cylindrical fabric bags but it may also be in the form of cartridges that are made up of fabric, sintered metal or porous ceramic.
- In general, bag filters are capable of collection efficiencies greater than 99 percent.
- There are following three types of bag filters and they differ from each other in the method of cleaning the filter material.
 1. Shaker bag filters
 2. Reverse air bag filters
 3. Pulse jet type bag filters

1. Shaker Bag Filters

- The shaker bag filters consists of vertical casing made up of cylindrical bags, bottom hopper and a tube sheet between the vertical casing and the hopper. The cylindrical bags are closed at the top.
- At the top of the casing, a shaking mechanism is attached. The contaminated gas stream enters into the hopper, flows through the holes of the vertical sheet and inside the vertical bags, leaving the dust cake on the
- inside surface of the bag filters.
- Periodically, the gas flow is stopped and bags are shaken to clean them.
- The dislodged dust cake falls into the hopper and finally removed from the collector.

2.Reverse Air Bag Filters

- These filters are similar to the shaker bag filters. The contaminated gas stream enters from the hopper, flows into and through the bags. The gas stream leaves out the dust cake on the inside bag surface.
- For cleaning the bags, the flow of contaminated gas stream is stopped and another clean gas flow is introduced which flows in the reverse direction. This gas flow is usually taken from the cleaned gas stream discharged from the bag filters.
- The dust cake, dislodged by the reverse airflow falls into the hopper and finally removed from the collector.

3.Pulse Jet Type Bag Filters

- The pulse jet type bag filters has a tube sheet located near top of the vertical casing, and the filter bags are hanged from the tube sheet. A wire mesh cage is fixed inside the bags to support and prevent them from collapsing.
- The contaminated gas stream enters through the hopper, flows into the bags and up through the tube sheet, leaving the dust cake on the bag surface. These bag surfaces are cleaned by applying short duration pulses of compressed air. The dust cake dislodged by the compressed air pulses falls into the hopper and finally removed from the collector.

Cyclone Separators

- Cyclone separators or simply cyclones are separation device used for removing the particulate matter from air or other gas stream. It works in the principle of inertia to remove particulate matter.
- The size of the cyclone may vary from 1.2 meters to 9 meters depending upon the volume of air or other gas stream to be filtered.
- Cyclone separators are basically centrifugal separators and work much like a centrifuge. It consists of an upper cylindrical part referred to as the barrel and a lower conical part referred to as cone.
- A vortex is generated in the cyclone body which simply transform the inertia force of flowing gas or air particle to a centrifugal force. The particle laden air stream enters tangentially at the top of the barrel and travels downward into the cone forming an outer vortex.
- The increasing air velocity in the outer vortex results in a centrifugal force on the particles separating them from the air stream. When the air reaches the bottom of the cone, it begins to flow radially inwards, reaches at the top and comes out as clean air/gas while the particulate matter fall into the dust collection chamber attached to the bottom of the cyclone.

Cyclone Separators

- Most cyclones are built to control and remove particulate matter that is larger than $10\mu\text{m}$. However, high efficiency cyclones are also available that are designed to remove the particles as small as $2.5\mu\text{m}$.
- Out of all of the particulate-control devices, cyclone separators are the least expensive device. They are often used as a pre-treatment before the contaminated gas enters more effective pollution control devices. Therefore, cyclone separators can be seen as “rough separators” before the air/ gas reaches the fine filtration stages.
- Cyclone separators are generally able to remove somewhere between 50-99% of particulate matter presents in the air/gas.
- There are several advantages associated with the cyclone separators such as (i) Less installation and maintenance cost (ii) Occupy very little space (iii) Separated particulate matter is collected in dry condition which makes it easier to disposed off. However, there are few disadvantage also, like standard models are not available to remove particulate matter smaller than $10\mu\text{m}$ effectively and also the equipment are unable to handle sticky materials.

Electrostatic Precipitators

- Electrostatic Precipitators are used to remove the fine particles like smoke and dust from the flowing gas.
- It is a commonly used device for air pollution control and mostly used in steel plants, thermal power plants etc.
- The operation of electrostatic precipitators is quite simple.
- It uses an electric charge to remove particulate matter either in the form of solid or liquid droplets from air or other gasses in smokestacks or other flues. The precipitators consists of a row of thin vertical wires and a stack of large vertical metal plates.
- The plates are spaced from 1 cm to 17 cm apart depending on the type of application. One of the electrode is charged with a high negative voltage whereas second electrode charged with high positive charge. The gas stream flows horizontally between the wires and through the stack of plates. The particulates present in the gas stream are charged with the negative charge as they pass through the negatively charged electrodes. The particulates thus charged with the negative charge are pulled towards the positive electrode (plate) and deposited on plates or other collection devices.
- The treated gas steam then passes out of the precipitators and through a stack to the atmosphere. When sufficient quantity of particles are accumulated on the collector devices, they are shaken off mechanically from the collectors.
- The particulates which can be dry or wet, fall into a hopper at the bottom of the unit and are transported to the disposal or recycling site through belt conveyer . The soot or ash collected from coal burning power plants in this manner is referred to as fly ash.
- Electrostatic precipitators are very important tool in the process of cleaning up contaminated gases.
- They are extremely effective and are capable of removing more than 99% of particulate matter of size smaller than 10 μm size. However, this level of effectiveness comes at a very high cost – about 2-4% of a
- power plant's electrical energy output.

GASEOUS POLLUTION CONTROL

- Gaseous pollution is created by; **primary and secondary pollutants**.
- **Primary gaseous pollutants** include Sulphur and Nitrogen dioxide, Nitrogen oxide, Carbon monoxide and VoCs etc., whereas **secondary gaseous pollutants** include Ozone and other photochemical oxidants, Sulphuric acid etc.
- These gaseous pollutants are removed by means of three basic techniques; **Absorption, Adsorption and Incineration or combustion**.
- Here, two methods namely, **Absorber and Catalytic converter** which comes under combustion method, are discussed.

1.Absorber

- Absorber is a process of removing gaseous pollutants by dissolving it into a solvent media. Most commonly used solvent media is a liquid phase, but it can also be a dry bulk solid in certain cases.
- The material that absorbs is called the solvent, and the gas that is to be absorbed is called solute.
- The common form of absorption is wet scrubbing.
- The types of scrubber include cross flow scrubber, bubble, plate and tray scrubbers, packed-bed counterflow scrubber etc. The most common type of wet scrubber is a packed-bed counterflow scrubber.
- The gas stream containing the pollutant enters from the bottom of the scrubber and moves upwards towards the exhaust provided at the top of the scrubber.
- The liquid scrubbing media or solvent enters from the top of the scrubber and gets distributed over the random packing. The gas stream also passes through the random packing which provides necessary surface area and facilitate contact between the two media.
- The liquid media absorbs the pollutants from the gas stream which are collected in the sump of the scrubber.
- Before exiting the gas stream passes through a mist eliminator and disperse to the atmosphere.
- Water is commonly used scrubbing fluids, but there are many processes or pollutants that require different fluids or solvent materials.

Catalytic converter

- There are enormous number of cars on the road in India specially in big cities like Mumbai, Kolkata, Bangalore, Pune etc. and each one is source of air pollution.
- To overcome this problem, an interesting device called a catalytic converter was invented by Eugene Houdry, a French mechanical engineer and expert in catalytic oil refining in mid 1950s.
- The car emissions contains harmful toxic by-products like nitrogen oxides, carbon monoxide and hydrocarbons.
- A catalytic converter is a simple device that uses oxidation and reduction reactions to covert these harmful fumes to less harmful fumes. It is composed of a metal housing with a ceramic honeycomb interior with insulating layers.
- This honeycomb interior is coated with precious metals like platinum, rhodium, and palladium. It is located near front portion of the car.
- There are mainly **two** types of catalysts used in the catalytic converter:

(i) Reduction catalyst (ii)Oxidation catalyst

- ❖ **Reduction catalyst:** It reduces nitrogen oxide pollution by removing oxygen. Nitrogen oxides are broken up into nitrogen and oxygen gases which are harmless.
- ❖ **Oxidation catalyst:** It converts carbon monoxide into carbon dioxide and hydrocarbons into carbon dioxide and water.

- **Based on the type of catalyst used, the converter is categorized into two category:**
- **Two-way type catalytic converter:** In this type of converter, only oxidation catalysts are used, which converts carbon monoxide to carbon dioxide and hydrocarbons to carbon dioxide and water by oxidation process.
$$\text{CO} + \text{O}_2 \rightarrow \text{CO}_2$$
$$\text{C}_x\text{H}_4x + 2x\text{O}_2 \rightarrow x\text{CO}_2 + 2x\text{H}_2\text{O}$$
- **Three-way type catalytic converter:** In this converter, both the catalysts, oxidation & reduction are used. Hence, it performs similar to the two-way converter with the addition of a reduction catalyst which reduces nitrogen oxide to nitrogen and oxygen gases by reduction process.
$$\text{NO}_x \rightarrow \text{N}_x + \text{O}_x$$
- In addition to the converters discussed above, an oxygen sensor is also located near the converter which helps to tell car's electronic control unit (ECU) about the availability of oxygen in the exhaust gases.
- It helps vehicle to run on a more efficient air/fuel ratio, allowing engine to supply the converter with enough oxygen to complete the oxidation process.

Effects of air pollution due to Refrigerants, I.C., Boiler

- Refrigerants are used in various electronic equipment such as refrigerator, air-conditioner etc. With the advancement of technology, there has been an immense change in the life style of people around the world. Specially, air-conditioner have become indispensable due to their existence almost everywhere be it home, office, school, railway station, airport etc.
- Initially, chlorofluorocarbons more widely known as CFCs were used as most common refrigerant. But after CFCs were found to be depleting the ozone layer, there was a worldwide effort to phase them out. The effort to get rid of CFCs resulted in two groups of chemicals but with a different problem, hydro fluorocarbons (HFCs) and hydro chlorofluorocarbons.
- These refrigerants break down Ozone molecules far less, but extremely potent greenhouse gases. This is because HFCs and HCFCs along with CFCs absorb infrared radiation, trapping heat inside the atmosphere rather than allowing it to escape into space, creating a greenhouse effect that warms the planet. I.C. Boilers are combustion devices used to heat water or to produce steam. Steam is produced in boilers by heating water until it vaporizes.
- The steam is then used to produce heat / electricity or to run machinery. I.C. Boilers emit a variety of hazardous air pollutant (HAPs), particle pollutant and volatile organic compounds. Some of the pollutants emitted are Nitrogen oxide, Sulfur dioxide, Carbon monoxide, Hydrogen chloride, cadmium, mercury etc.

Noise pollution

- Noise pollution can be defined as any unwanted or disturbing sound that effects the health and well-being of human and other organism.
- The sound is typically described in terms of loudness and it is measured in logarithmic units called decibels (dB). Not all sound is considered as noise pollution.
- According to World Health Organisation (WHO), noise above 65 dB can be considered as noise pollution. To be very precious, noise becomes harmful when it exceeds 75 dB and painful above 120 dB.

Sources of noise pollution

- Like any other pollution, the noise pollution is caused mainly due to industrialization, urbanization and modern civilization.
- The source of noise pollution can be categorised into two category: **Industrial sources and Non-industrial sources**.
- **Industrial sources** include noise from various industries and big machines working at very high speed and with very high noise intensity.
- **Non-industrial sources** include noise created by transport/vehicular traffic, loudspeaker, radio etc.
- However, the major source of noise pollution may be categorized as follows:

1.Industrial sources: The industries such as textile mills, engineering establishments, printing press, metal works etc. contribute heavily towards noise pollution. Many industrial cities in India like Kolkata, Kanpur etc. are more affected as industrial zones are not separated from residential zones specially in case of small scale industries. It is therefore advisable to keep industrial zone away from the residential zone and they may be separated by a sufficiently wide green belt.

2.Transport vehicles: Automobile revolution in urban areas turned out to be a big source of noise pollution. In the recent past, there is an enormous growth in traffic volume due to increase in number of vehicles such as busses, trains, trucks etc. resulting in increased noise pollution. Airport located in the vicinity of residential areas creates lots of noise pollution as the airplanes passes over the residential areas during its landing and taking off. Heavy trucks, busses, trains, motor bikes, mopeds etc. are also contribute to the noise pollution.

3.Household noise: The household activity is also a source of many indoor noises such as noise of playing children, infants crying, moving of furniture etc. Domestic gadgets like mixer-grinder, pressure cookers, exhaust fans, washing machines and entertainment equipment such as radio, music system, television sets are all indoor sources of noise pollution.

4.Public address system (PA system): Many public functions such as political rallies, strikes, elections, religious and other social events etc. use PA system normally in a very loud volume and thus are become the source of noise pollution.

5.Agriculture machines: Heavy types machinery and equipment such as tractors, thrashers, tube wells, powered tillers, harvesters etc. are being used in many agricultural farms. These machinery may create noise pollution of level more than 90 dB to 98 dB.

6.Defence equipment: A lot of noise pollution is created by artillery, tanks, explosions, shooting practices etc. by defence personnel. Noise created by jet engines and sonic booms have been known to shatter the window panes and old dilapidated buildings and also it has deafening impact on the ears.

7.Miscellaneous sources: The construction site, blasting, stone crusher etc. are some of the other sources of noise pollution

❖ Measurement of noise pollution level

- The sound can be described **physically as well as physiologically**.
- **Physically**, *sound is a mechanical disturbance propagated as a wave motion in air or other media such as water, steel etc.*
- **Physiologically**, *sound is an auditory sensation or perception evoked by this physical phenomenon.*
- The physical properties and perception of sound or noise are expressed and measured in different concepts and units.
- Sound pressure is used as the fundamental measure of sound (amplitude) as it can be measured directly by instruments.
- The weakest sound pressure disturbance that can be detected by an average person at 1000 Hz has been found to be $20 \mu\text{N/m}^2$ and the largest sound pressure perceived without discomfort is of the order of $10^7 \mu\text{N/m}^2$. Because of such a wide range, the use of a linear pressure scale has been found to be impractical.
- It has been found convenient to employ sound pressure level, a quantity, which is proportional to the logarithm of sound pressure. By this, the sound pressure range of interest is compressed between 0 to 130, a range convenient to use.
- The sound pressure level is expressed in the unit of decibel (dB).
- Sound pressure level is defined as: $L_p = 10 \log_{10} (P/P_r)^2$, Where L_p = sound pressure level, dB P = root mean square sound pressure, usually in $\mu\text{N/m}^2$, P_r = reference sound pressure, $\log_{10}$ = Logarithm to the base 10
- The reference sound pressure, P_r has an internationally agreed value of $20 \mu\text{N/m}^2$.
- Sound is measured with a sound level meter which is usually a portable, self-contained instrument incorporating a microphone, amplifier, a voltmeter and attenuators, the whole of which is calibrated to read sound pressure levels directly.

❖ Effects of Noise pollution

- Noise is more than a mere nuisance.
- Noise pollution may have deleterious effects on human health, wild life and environmental quality.
- Some of the major effects of noise pollution is discussed below:
 - **Hearing problems:** Our ears can take certain range of sounds without getting damaged. Constant exposure to loud levels of noise may result in loss of hearing. It may also reduce our sensitivity to sounds that our ears picks up unconsciously in our day-to-day life.
 - **Psychological issues:**
 - Our psychological health may get influenced by noise pollution in working areas such as offices, construction sites or even in homes. It may result in disturbance of sleep, constant stress, fatigue, anxiety, depression etc. These, in turn, may cause more severe and chronic health issue in the later stage of life.
 - **Physical problems:**
 - Excessive noise level may cause high blood pressure, headaches, respiratory problems, racing pulse etc.
 - **Cognitive issues:** Noise pollution may affect brain responses and ability to focus which may result in low performance levels over the time.
 - The study reveals that the school children residing near railway station or airport have problems in learning.
 - **Sleeping disorders:**
 - High level of noise likely to affect our sleeping pattern and it may lead to very uncomfortable and irritating situations.
 - It may result in early fatigue and affect our performance in office as well as in home.
 - **Cardiovascular issues:**
 - High level of noise may cause high blood pressure, cardiovascular disease and stress related heart problems.
 - **Communication barrier:** Noise pollution may act as a barrier in free communication among the people. This may lead to misunderstanding and also difficulty in understanding each other. It may affect badly the teaching learning process in the class room, laboratories and workshops.

➤ **Effect on wildlife:**

- Noise pollution affects wildlife more than the humans as they are more dependent on sound. Animals have better sense of hearing than humans as their survival depends on it.
- Animals gets disoriented more easily and face many behavioural problems. They may suffer from hearing loss and become inefficient in hunting which may lead to disturbing the balance of eco-system.

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Noise pollution (Regulation and Control) Rules, 2000

- The increasing ambient noise levels in public places from various sources, inter-alia, industrial activity, construction activity, fire crackers, sound producing instruments, generator sets, loud speakers, public address systems, music systems, vehicular horns and other mechanical devices have deleterious effects on human health and the psychological well-being of the people.
- It is considered necessary to regulate and control noise producing and generating sources with the objective of maintaining the ambient air quality standards in respect of the noise.
- In order to address above issues, the principal rules were published in the Gazette of India, vide S.O.123(E), dated 14.2.2000 and subsequently amended vide S.O.1046(E), dated 22.11.2000, S.O.1088(E), dated 11.10.2002, S.O.1569(E), dated 19.9.2006 and S.O.50(E), dated 11.01.2010 under the Environment (Protection) Act, 1986.

The main features of the Noise Pollution (Regulation and Control) Rules, 2000 is described under the sub-headings:

1. Short-title and commencement
2. Definitions
3. Ambient air quality standards in respect of noise for different areas/zones
4. Responsibility as to enforcement of noise pollution control measures.
5. Restrictions on the use of loud speakers/public address system and sound producing instruments
(5A) Restriction on the use of horns, sound emitting construction equipment and bursting of fire crackers.
6. Consequences of any violation in silence zone/area.
7. Complaints to be made to the authority.
8. Power to prohibit etc. continuance of music sound or noise.

UNIT SUMMARY

1. Pollution may be defined as the presence of harmful substances in the air, water and soil which can have adverse effect on living beings and on the environment.
2. Types of pollution mainly include air pollution, water pollution, land pollution, noise pollution and radioactive pollution.
3. Pollutants are the harmful substances which brings undesirable and harmful changes in the physical, chemical or biological characteristics of air, water and soil.
4. Manmade sources of air pollution may include mining and smelting, foundry activities, various industrial processes, construction and demolition activities, coal Power Plants, waste Incineration, landfill disposal practices, agriculture, defence activities, smoking, storage and use of household products, refrigerants and I.C. Boilers.
5. Natural sources of air pollution may include volcano activities, winds and air current, wild fires, microbial decaying process, increasing temperature.
6. Air quality at any location is determined by the level of pollutants present in the air and it depends on the types and amount of pollutants released into the air.
7. Particulate pollution is one of the most complicated forms of air pollution.
8. The pollutant responsible for Particulate Pollution is called particulate pollutant & also known as particulate matter.
9. Particulate matter is sub-divided into different categories based on particle size i.e. PM₁₀, PM_{2.5} and PM_{0.1}.
10. PM₁₀ also known as coarse particles, is defined as all particles with an aerodynamic diameter of 10 µm or smaller. Once these particles get into our lungs, it can irritate the lung tissue and can prompt asthma attacks.
11. PM_{2.5} also known as fine particles, is defined as all particles with an aerodynamics diameter of 2.5 µm or smaller. PM_{2.5} contributes to the same conditions as PM₁₀ and additional ones like, respiratory disease, reduced immune response, congenital disabilities etc.

12. PM_{0.1} also known as ultrafine dust, is defined as all particles with an aerodynamics diameter of 0.1µm or smaller. Recent studies show that PM_{0.1} displays enhanced cardiovascular toxicity and greater potential for oxidative stress.
13. Bag filters is a pollution control device used to remove particulate matter from the contaminated gas stream by depositing the particles on bag filters made up of fabric materials.
14. Bag filters are of three types namely, Shaker bag filters, Reverse air bag filters and Pulse jet type bag filters.
15. Absorber is a process of removing gaseous pollutants by dissolving it into a solvent media.
16. A catalytic converter is a simple device used in car to covert harmful emission fumes to less harmful fumes.
17. Mainly two types of catalysts are used in the catalytic converter, Reduction catalysts and Oxidation catalyst.
18. Refrigerants are used in various electronic equipment such as refrigerator, air-conditioner etc. It is responsible for creating a greenhouse effect that warms the planet.
19. Noise pollution is any unwanted or disturbing sound that effects the health and well-being of human and other organism.
20. Sound is measured in logarithmic units called decibels (dB). Sound becomes harmful when it exceeds 75 dB and painful above 120 dB.
21. Sources of sound pollution may include industrial sources, transport vehicles, household noise, public address system, agriculture machines, defence equipment etc.
22. Noise pollution may create major health issues such as hearing problems, psychological issues, physical problems, cognitive issues, sleeping disorders, cardiovascular issues, communication issues etc.
23. Noise pollution (Regulation and Control) Rules, 2000 can be downloaded from the website
““cpcbenvvis.nic.in/noisepollution/noise_rules_2000.pdf ”.

Subjective Questions

1. Define pollution and pollutant? classify different types of pollution.
2. Enumerate natural and manmade sources of air pollution.
3. Discuss different types of air pollutants and its effect.
4. Write short notes on:
 - (i) Bag Filters
 - (ii) Cyclone separators
 - (iii) Electrostatic precipitators
5. Explain working principle of Absorber and Catalytic converter.
6. Discuss Effects of air pollution due to Refrigerants and I.C., Boiler.
7. Discuss briefly the sources of noise pollution.
8. Enumerate effects of noise pollution on human health.
9. Write short note on measurement of noise pollution.
10. Discuss briefly pollution control rules 2000.

CONTAMINANT

Definition- It is defined as a material which does not occur in the nature but it is introduced by human activity into the environment.

Example: Chlorine gas. **RECEPTOR**

Definition: The medium which is affected by a pollutant is known as receptor.

Examples:

a) Man is the receptor of CO gas which causes cardiac arrest

b) Plant is the receptor of CO gas which causes destruction of chlorophyll.

PATHWAY OF POLLUTANT

Definition: It is the mechanism by which the pollutant is distributed from its source in to the environmental segments.

(C₂H₅)₄Pb Auto exhausts PbCl₂ + PbBr₂

Air

To food crops and food chains PbCl₂ + PbBr₂

AIR POLLUTION

Definition

- It is the introduction of particulates, biological molecules or other harmful materials into the earth's surface possibly causing disease, death to human, damage to other organisms such as food crops or the natural or built environment.
- **Sources**
 - a) **Stationary Sources:** smoke stacks of power plants, factories, other fuel burning heating devices, traditional biomass burning are major sources of air pollution.
 - b) **Mobile Sources:** motor vehicle, marine vessels and air crafts.
 - c) **Chemicals:** dust and controlled burn particles in agriculture and forest management.
 - d) **Fumes** from paint, hair spray, aerosol sprays and other solvents.

Types of air pollutants

- a) **Gases:** SO_2 , SO_3 , H_2S , CO , CO_2 , NO , NO_2 , O_3 , HF , etc. are the gases which mainly cause air pollution.
- b) **Particulates** :Dust, Smoke, Smog etc. are the particulates responsible for air pollution .
- c) **Deforestation:** Green plant (leaves) use CO_2 for manufacture of food by photosynthesis and give out O_2 , there by purifying atmospheric air. So, deforestation causes indirect air pollution.
- d) **Internal combustion engines:** Internal combustion engines are used for running motor cars, buses, planes, trucks, auto-rickshaws, scooters etc. when fuel in the I.C.E burns, lots of smoke are produced which causes air pollution.

Control of Air Pollution

1. **By using catalyst:** Emissions from the automobiles and vehicles
2. **chimney:** The use of long chimney reduces substantially the concentration of air pollutants at the ground level.
3. **By reducing Smoke:** By reducing smoke during combustion, air pollution be controlled.
4. **By eliminating dust totally:** For elimination of dust totally, extraction ventilation method is adopted .

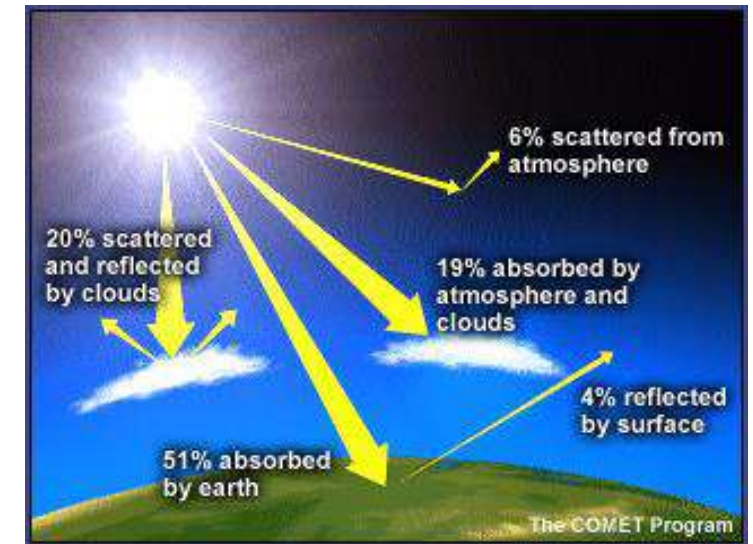
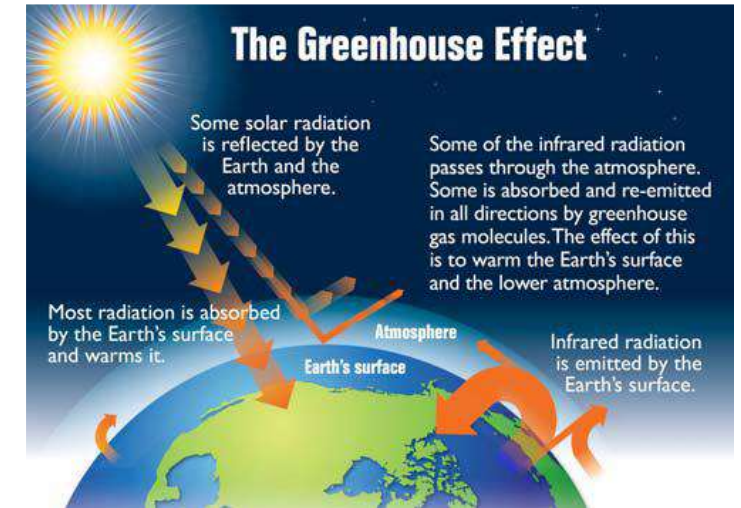
GREEN HOUSE EFFECT

What is the green-house effect?

- **Green-house effect** is a natural phenomenon which helps the earth to maintain an average temp of **15°C** for sustaining the life on the earth's surface.
- Without these gases, temp. of earth would be about -18°C. Thus, certain level of green house gases are important to maintain life. Certain human activities have intensified this effect resulting in an even warmer environment

Distribution of solar energy

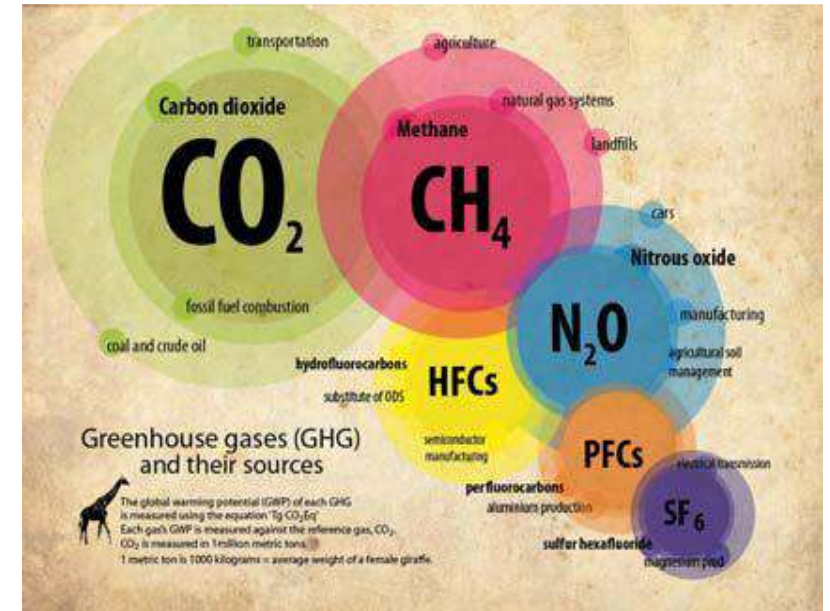
- **Solar energy** within the troposphere is transferred by radiation, conduction and convection.
- Out of the solar energy that reaches the earth's atmosphere **6%** scattered from atmosphere
- **19%** is absorbed by the clouds, dust and gases in the atmosphere,
- **51%** of it absorbed by the surface of the earth,
- **4%** is reflected back in to the space by the surface and
- **20%** is reflected back in to the space by clouds, dust and gases in the atmosphere.



❖ Different Types of greenhouse gases

- Water vapour (H₂O)
- Carbon Dioxide (CO₂)
- Methane (CH₄)
- Nitrogen Oxides (N₂O)
- Chlorofluorocarbon (CFC)
- HFCs, PFCs, SF₆

Among these gases CO₂ takes major part for heating up the earth's atmosphere.



Possible causes of Green House effects

- Deforestation
 - Burning of fossil fuels, gasoline, oil
 - Burning of wood and coal
 - Chlorofluorocarbons
 - Population growth
- ### **Facts about Greenhouse effect**
- When the concentration of CO₂ increases in the atmosphere, it forms a thick layer which acts like the glass panels of a green house or the windows of a closed car.
 - It allows the sun rays which consist of U.V., visible and I.R. radiation.
 - The ozone layers present in the stratosphere absorb most of the U.V. radiation and allow visible and I.R. radiation to pass through towards the earth.
 - The large amount of CO₂ present in the atmosphere on the earth, absorbs the I.R. radiation which increases the earth's atmospheric temperature. As a result of this, the earth goes on warming up more and more.

Effects

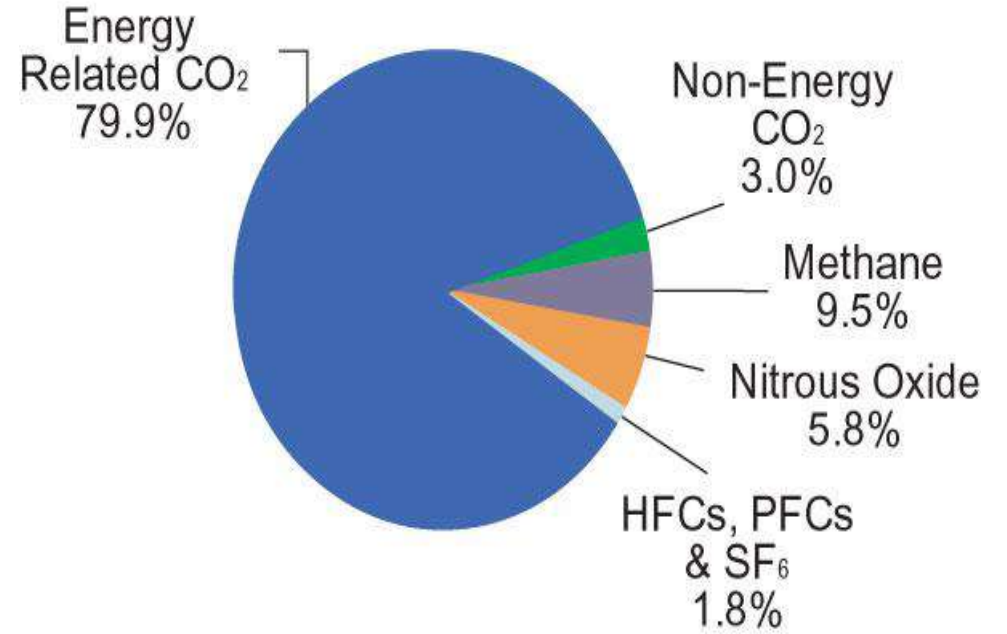
- Global Warming
- Endangered species
- Climate change

What is Global Warming?

- Heat trapped inside earth
- General warming effect created
- Increase in air and ocean temperature
- Vital issue in society

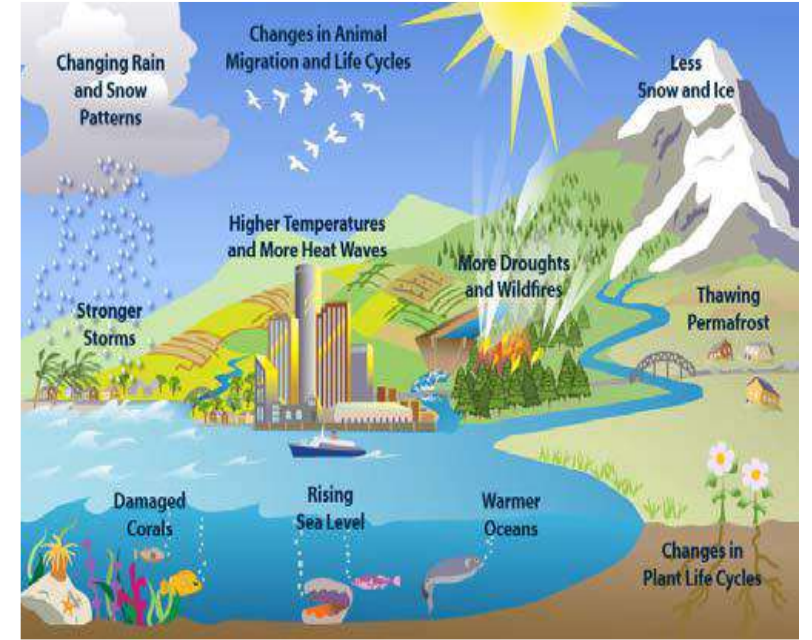
Causes of Global Warming

- Greenhouse gases increase through human activity
- Deforestation
- Use of fertilizer
- Burning of organic matter
- Burning of fossil fuels



Consequences of global warming

- Climate change
- Change in wild life adaptations and cycles
- Melting of polar ice caps
- Increase in sea level
- Flooding in coastal areas
- Ocean acidification
- Species becoming extinct
- Heavy drought
- Spread of Disease
- Rise in tides
- Change in weather pattern



Steps to be taken for controlling Global Warming

- Reforestation
- Personal actions like using public transport, Organic farming, Eco friendly buildings etc.

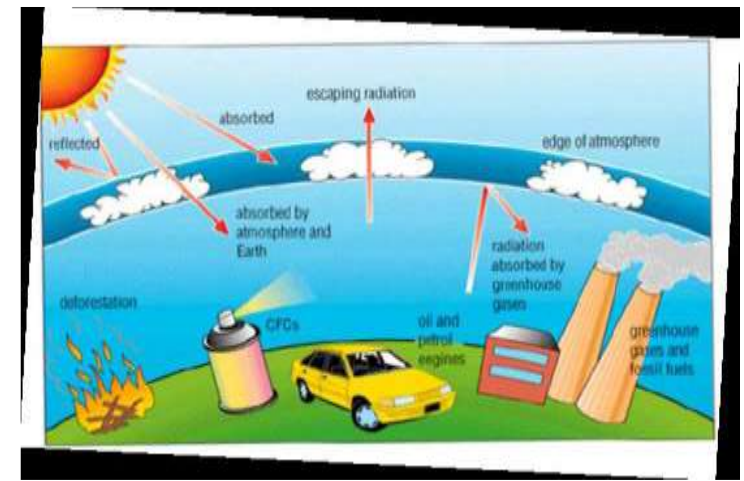
Depletion of ozone layer

What is ozone and the ozone layer?

- Ozone is a highly reactive form of oxygen.
- Ozone exists within both the troposphere and stratospheric zones of the earth's atmosphere
- In the troposphere, ground level ozone is a major air pollutant and primary constituent of photochemical smog.
- In the stratosphere, the ozone layer is an essential protector of life on earth, as it absorbs harmful UV radiation before it reaches the earth.

Ozone Depletion Process

- Main cause of ozone depletion-
Wide spread use of chlorofluorocarbon.
- 30% CFC used in fridge, freezers and air conditioners
- 25% used in spray cans
- 20% used for cleaning and other purposes.



Mechanism

- Chlorofluorocarbons are released from the above sources.

- CFCS are very stable on earth.

But as they rise in to the ozone layer,

UV radiation releases chlorine radical from CFCs



- Chlorine radical destroys ozone.



- Chlorine strips an atom from molecule of ozone turning it into nascent or atomic oxygen.



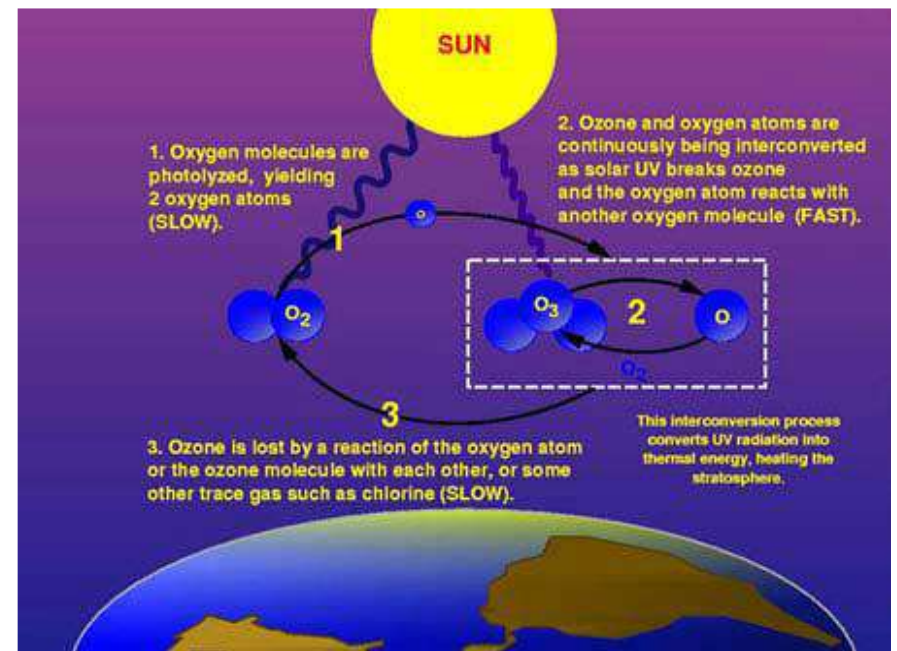
- Chlorine radical combines with fluorocarbon radical to form chlorofluorocarbon again.



Complete reaction



The chlorine goes on to repeat the process and in this way, one chlorine atom can destroy thousands of ozone molecules.



Side Effects of Ozone layer depletion

Ozone layer depletion can cause the following health problems.

- Skin cancer , Other skin problems like patches in skin and sunburns ,Immune suppression , Eye problem

Acid Rain

Definition: Acid rain is the mixture of some acids in excessive quantity in the rain water.

Major contributors

- i) H_2SO_4 (60-70%)
- ii) HNO_3 (30-40%)
- iii) HCl (Traces)

Causes

- Fuel (solid, Liquid) contains Sulphur and Nitrogen.
- These two elements when burn in atmospheric oxygen, get converted to SO_2 and NO_2 which are highly soluble in water.



In case of nitrogen, following reactions are involved.



Under the humid conditions of air, N_2O_5 invariably reacts with water vapour to form droplets of HNO_3



Some HNO_2 is also formed



- HNO_3 and HNO_2 then return to the earth's surface.

- SO_3 in humid atmosphere form droplets of H_2SO_4 .



• HNO_3 , H_2SO_4 thus formed combine with HCl (emitted from natural and man-made sources) to generate precipitation which is commonly referred as acid rain.

Adverse effects of acid rain

1. On aquatic system
2. On terrestrial ecosystem
3. On buildings
4. Human beings & plant kingdom



GOVT. POLYTECHNIC DEBAGADA

**SUB: APPLIED CHEMISTRY & EVS
(COMMON FOR ALL BRANCHES)**

TOPIC: ALLOY

YEAR: 1ST YEAR 2026-27

FACULTY NAME: KUNI MAJHI, SR. LECTURER IN CHEMISTRY

ALLOY

- Alloy
- TYPES OF ALLOY
- PURPOSE OF MAKING ALLOYS
- USES OF ALLOYS
- AMALGAM

ALLOY

- *A homogeneous mixture of two or more elements with metallic properties is called an Alloy.'*

OR

'An alloy is a homogeneous mixture of two or more elements with metallic properties.'

- Generally alloys contain two or more metals.

Sometimes a non-metal may be present.

ALLOY

Mostly ,metals are used commercially in the form of alloys due to the following properties.

The main purpose of making alloys are as follows :

1. Alloys are **harder** & more **malleable** (pressed into shape without breaking/cracking),sheet of metal & **ductile**(Drown out into a thin wire).
2. They have lower melting point than that of component metals.
3. They are less reactive & hence more corrosion resistance.
4. They have low electrical & thermal conductivity.
5. To get good casting.
6. To modify the chemical activity.

TYPES OF ALLOY

➤ Alloys are mainly classified into the following two types

a) Ferro Alloys

b) Non-Ferro Alloys (Non-Ferrous Alloys)

- Ferro Alloys :
- 1.The alloys which contain iron as major component are called Ferro Alloys
 - 2.The Ferro Alloys have high m.p, density (v/m) & hardness.
 - 3.The Ferro Alloys have high temp. strength & their special magnetic & thermal expansion properties.
 - 4.The Ferro Alloys are used for production of steel, cast iron, wrought iron.

Name	Composition	Uses
Ni steel	2.4 % Ni (Ni +Cu + Mn + Fe)	For making cables, cutting tools, automobile & aeroplane parts.
Chrome Steel	1.5-2% Cr	For cutting machinery & cutlery making surgical instruments, springs.
Stainless Steel	Fe=73%+Cr= 18%+ Ni= 7.7% +C =1.3%	For making utensils, machine parts, cycle & automobile parts.
Invar	36% Ni	For making measuring instruments, clock pendulum, survey instruments etc.

NICKLE STEEL



CROME STEEL



Stainless steel



Uses of Stainless
Steel in
Automotive
industry



Non-Ferrous Alloy

- The alloys which contain other than iron as major elements are called non-ferrous alloys.
- The melting point, hardness & density of non-ferrous alloys are low.
- Brass, bronze are heavy copper base Non-Ferrous alloys.
- Aluminium(Al) base & Mg base alloys are light alloys.
- The composition & uses of the various alloys are given below.

Name	Composition	Properties	Uses
Brass	Cu: 60-80% Zn: 40-20%	Hard,lustrous,easily cast, malleable, ductile	Electrical fittings, Medals, utensils, Cartridges , sheets
Bronze	Cu: 75-90% Sn :25-10%	Hard, brittle ,takes up polish	Statues, medals , coins, utensils
German Silver	Cu: 50%,Zn: 25%,Ni :25%	Hard, silvery, takes up polish	Decorative articles, utensils,ornaments
Gun Metal	Cu: 87%,Sn: 10%,Zn :3%	Hard, brittle ,easily cast.	Cannon,Barrels,casting, gears,guns.

Name	Composition	Properties	Uses
Bell Metal	Cu :80%,Sn: 20%	Brittle more, sonorous(ringing sound) than Cu or Sn.	Bells,gongs,(ghantaa), musical instruments
Stainless Steel	Fe: 73%,Cr: 18% Ni: 7.7% ,C: 1.3%	Lustrous, hard, corrosion resistant	Utensils, cutlery, cycle & automobile parts, surgical instruments.
Alnico	Steel 50%,Al: 20%,Ni :21%,CO: 9%	Light,shiny,corrosion resistant	Powerful magnet, microphones sensors, loudspeakers.
Duralumin	Al: 95%,Cu: 4%,Mn: 0.5%,Mg:0.5%	Very light, stronger than Al	Air craft frame, light tools,ships,automobile parts, speed boats, gun barrels, surgical instruments, making cables.

Amalgams

- **Amalgams is an alloy in which the base metal is Mercury.**
- **Amalgams : The alloys of Mercury & other metals are called amalgams.**
- Iron & platinum don't form amalgams.
- Example : Na/Hg(Liquid amalgam)
- **Zn/Hg** amalgam used in **voltaic cells**
- Metals like Sn, Zn, Ag, Au, Na etc. with mercury form amalgams.
- Amalgams of different metals are used for different purpose.

Different purpose of using amalgam

1. **Sodium amalgam(Na)**: is made to decrease the reactivity of sodium. Moreover ,it is used as a good reducing agent.
2. **Copper amalgam** is used for **filling dental cavities**.
3. **Tin amalgam** is used for **silvering cheap mirrors**.
4. **Amalgams of mercury (Cinnabar)** is a toxic mercury sulphide mineral, bright red colour used **as a pigment & carve it into jewellery, ornaments, decorate walls, pots, tattoos etc.**



GOVT. POLYTECHNIC DEBAGADA

**SUB: APPLIED CHEMISTRY & EVS
(COMMON FOR ALL BRANCHES)**

TOPIC: FUEL

YEAR: 1ST YEAR 2026-27

FACULTY NAME: KUNI MAJHI, SR. LECTURER IN CHEMISTRY

Fuel

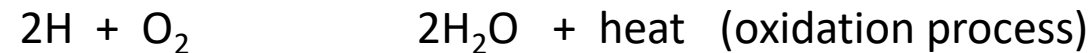
- Fuel
- Fossil fuel
- Classification of fuel(Primary Fuel, Secondary Fuel/Derived Fuel)
- Introduction
- Calorific value & its type , Units
- Choice of a good fuel
- Fractional Distillation Process
- Diesel(Gas Oil),Petrol(Gasoline)
- Kerosene, Producer Gas,
- Water Gas, LPG
- CNG, Coal Gas

Introduction

- Due to rapid industrialisation, the power requirement is increasing day-by-day.
- Power is essential for domestication & industrial requirements.
- Carbon compounds have been used for many centuries as the source of heat & energy.
- ***“The substance which are used for production heat energy for domestic & industrial purpose are termed as fuels.”***
- ***Fuel: “A substance which on combustion gives large amount of heat energy is called Fuel.” Or “The substance which on combustion release a large amount of heat energy without producing excess residue or by-products.”***
- ***Fuel + O₂ combustion Product(S) + Heat energy***

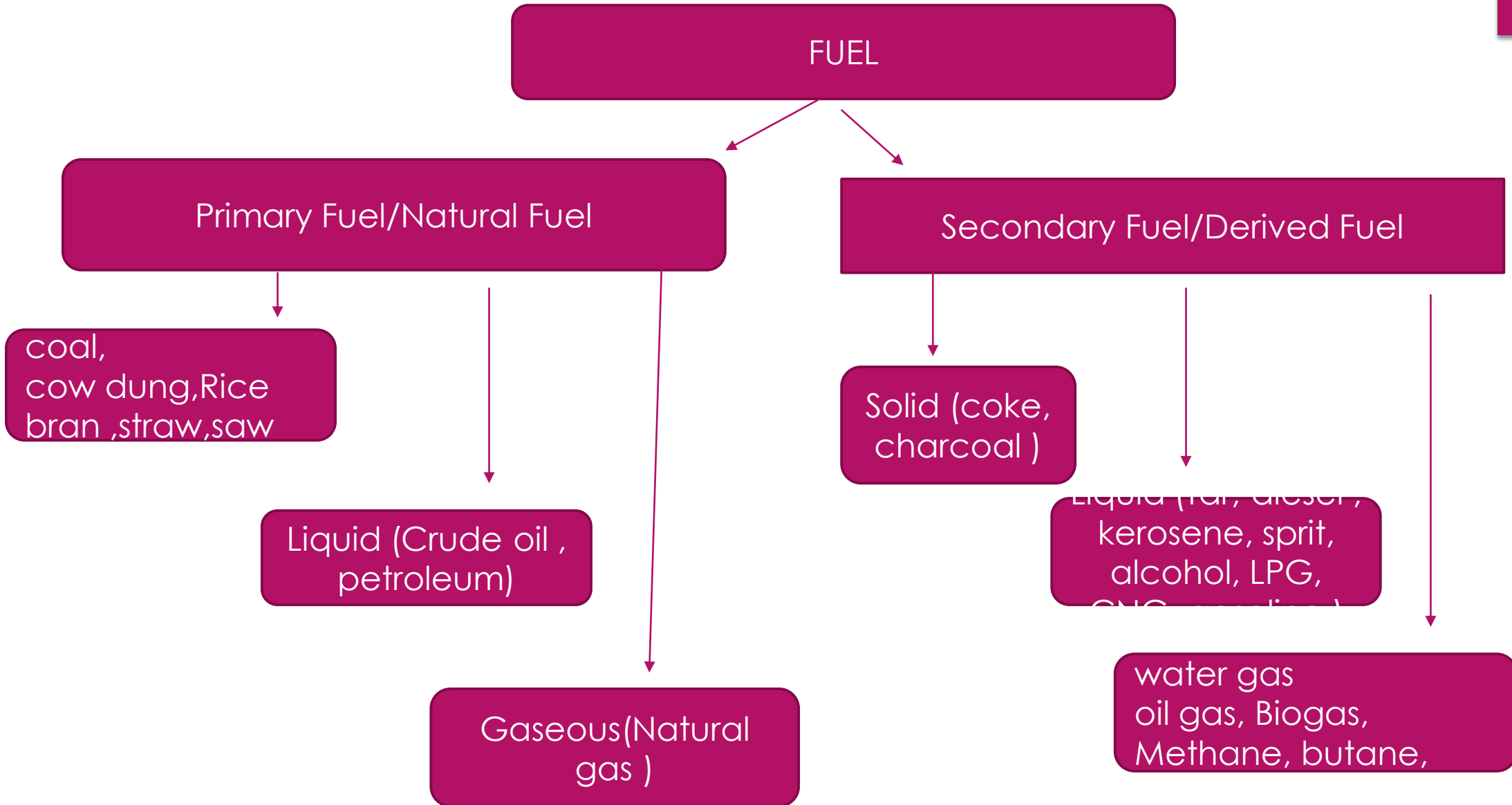
- 
- The fuel mainly contain **carbon & hydrogen**.

Carbon & hydrogen are oxidised to new compounds (CO₂, H₂O) with the liberation of heat energy.



- **Fossil fuels:** *“Fuels like Coal, petroleum oil, natural gas decreasing day –by-day which are stored in earth’s crust called fossil fuels.”*
- **Combustion :** *“The process in which heat energy is liberated by burning of a substance in excess of oxygen or air is called combustion.”*

Classification of Fuel



Primary Fuel, Secondary Fuel

- The fuels which occur in nature are called **Primary Fuel**.
- The fuels which are synthesized (prepared) from the primary fuels are called **Secondary Fuel**.

Calorific value:

- ***“The amount of heat energy released by the complete combustion of one gram of the fuel or food.”***
or
“The net amount of heat energy produced by the complete combustion of a unit mass or unit volume of fuel in air.”
- ***Calorie is used for measuring the quantity of heat.***
- ***Units of Calorific value are : cal/gm, kcal/kg, Kcal/m³ KJ/kg, British Thermal Unit(BTU). etc.***

Types of calorific value

There are two types of calorific value

Higher(gross) calorific value

1.It may be defined as the total amount of heat produced when unit mass or volume of the fuel has been burnt completely & the products have been cooled to 15°C temp.

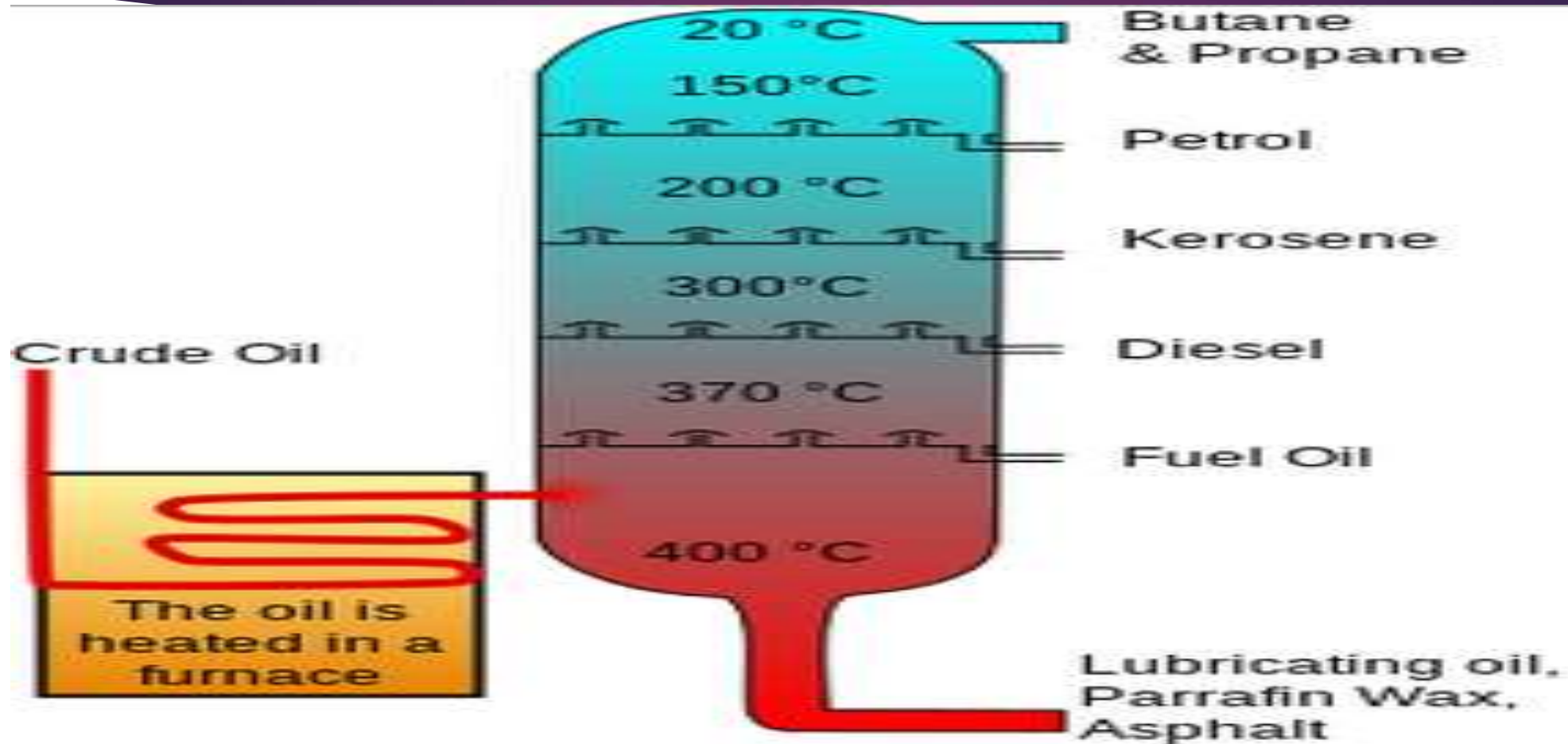
Lower (net) Calorific value

1.The heat produced when unit mass/volume of the fuel is burnt completely & the products are permitted to escape out.

Choice of a good fuel

1. A good fuel should have **high calorific value**.
2. It should have **low moisture content**.
3. It should have **cheap & readily available**.
4. It should **transport easily**.
5. It should have **moderate ignition temperature**.
6. It should **leave small amount of residue(ash)**.
7. It must be **easy to handle ,store & transport at a low cost**.
8. It should not undergo spontaneous combustion.
9. Combustion should be under controllable & stopped when required.
10. It should not Contain high percentage of moisture.
11. It should required low storage volume.
12. It should Contain low percentage of volatile matter.

Fractional Distillation Process



Fractional Distillation

As the each gas reaches a set different temperature that condenses it to liquid, the liquid is seperated into its own distilling column.

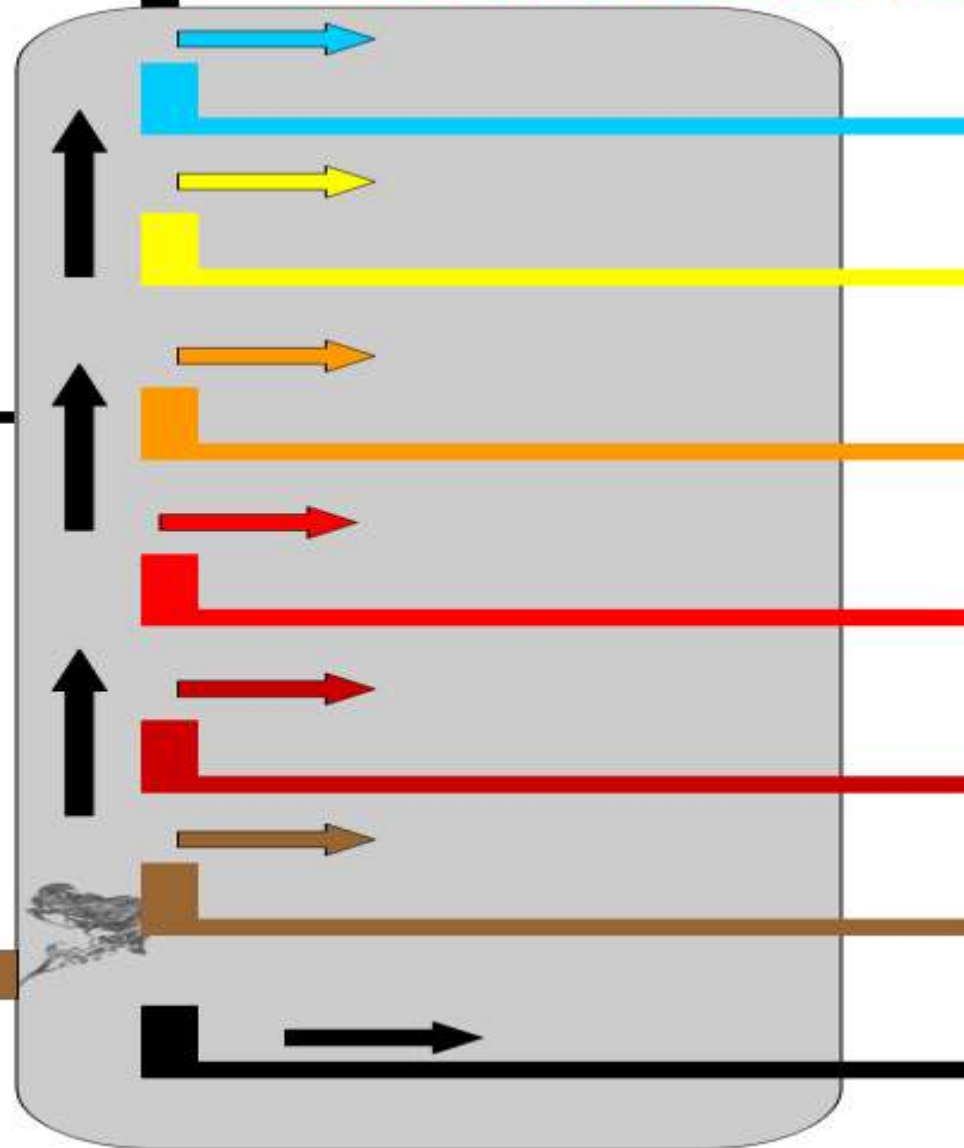
Distillation Column

Gas is passed through to the distillation column.

Crude Oil



Boiler
(Used to Change Crude Oil to Gas)



Butane and Lighter Products
($<85^{\circ}\text{F}$)

Gasoline
($85^{\circ}\text{F} - 185^{\circ}\text{F}$)

Naphtha
($185^{\circ}\text{F} - 350^{\circ}\text{F}$)

Kerosene
($350^{\circ}\text{F} - 450^{\circ}\text{F}$)

Diesel Oil
($450^{\circ}\text{F} - 650^{\circ}\text{F}$)

Fuel Oil
($650^{\circ}\text{F} - 1050^{\circ}\text{F}$)

Residue
($>1050^{\circ}\text{F}$)



Diesel(Gas Oil), Petrol(Gasoline)



Diesel(Gas Oil):

- It is obtained by fractional distillation of crude petroleum between **250-320 °C**.
- It consists of hydrocarbons between pentadecane to octadecane **$C_{15}H_{32}-C_{18}H_{38}$**
- Average composition **C = 85% H = 12% Rest = 3%**
- Its calorific value is **11,000 kcal/kg**

Uses:

- It is used as a fuel in diesel engines & in automobiles fuel.

Petrol(Gasoline):

- It is obtained between **40-120 °C** in the fractional distillation of petroleum.
- It is **highly volatile, inflammable fuel**.
- It consists of hydrocarbons between pentane to octane (**$C_5H_{12}-C_8H_{18}$** .)
- The average composition of petrol is **C = 84%, H = 15%, N + S + O = 1%**
- Its calorific value is **11,250 kcal/kg**.
- It is used as a fuel in **Internal combustion Engine of automobiles (petrol engine)**, aeroplanes.
- **It is used as a dry cleaning agent.**

Kerosene, Producer Gas



Kerosene:

- It is obtained by fractional distillation of crude petroleum between **180-250 °C**.
- It consists of hydrocarbons between decane to hexadecane (**$C_{10}H_{22}$ - $C_{16}H_{34}$** .)
- The average composition of kerosene is **C = 84 %**, **H=16 %** **S ≤ 0.1%**.
- Its calorific value is **11,100 kcal/kg**.
- It is used as **domestic fuel in stove ,jet engines fuel**.
- It is used **in making oil gas**.

Producer Gas:

- It is a mixture of **combustible gases of CO,H₂** associated with large percentage of **non-combustible gases of CO₂, N₂**.
- The average composition of Producer Gas is **CO = 22-30%**, **H₂ = 8-12%**,**N₂ = 52-55%** **CO₂ = 3%**.
- Its calorific value is **13,00 kcal/m³**.
- It is used as a **reducing agent in metallurgical operation for heating open hearth furnace (in steel & glass manufacture.)**

Diesel(Gas Oil), Petrol(Gasoline),Kerosene, Producer Gas

Diesel(Gas Oil):

- 1.The Average composition of diesel is **C = 85% H =12% Rest = 3%.**
- 2.It is used as a fuel in diesel engines & in automobiles fuel.

Petrol(Gasoline):

- 1.The average composition of petrol is **C = 84%,H =15%, N + S + O =1% .**
- 2.It is used as a fuel in **Internal combustion Engine of automobiles(petrol engine),aeroplanes.**
- 3.It is used as a **dry cleaning agent.**

Kerosene :

- 1.The average composition of kerosene is **C = 84 %, H=16 % S ≤ 0.1%.**
- 2.It is used as **domestic fuel in stove , jet engines fuel.**
- 3.It is used **in making oil gas.**

Producer Gas:

- 1.The average composition of Producer Gas is **CO = 22-30%, H₂ = 8-12%,N₂ = 52-55% CO₂ = 3%.**
2. It is used as a **reducing agent in metallurgical operation for heating open hearth furnace (In steel & glass manufacture).**

Water Gas, LPG, CNG, Coal Gas

Water Gas:

- 1.The average composition of water Gas is **CO = 41%, H₂ = 51%, N₂ = 4% , CO₂ = 4%.**
- 2.It is used for **welding purpose, fuel, illuminating gas.**
- 3.It is a **source of hydrogen gas.**

LPG(Liquified Petroleum Gas):

- 1.The average composition of LPG is **n-butane = 27%, iso-butane = 25%,Butane= 43% , propane = 2.5%, propene = 2.5%.**
- 2.It is used as **domestic fuel & industrial fuel , motor fuel.**
- 3.**The warning of gas leakage due to presence of Ethyl Mercaptan (C₂H₆S).**

CNG(Compressed Natural Gas):

- 1.The average composition of CNG is **CH₄ = 70-90%, C₂H₆(Ethane) = 4-9%,trace of propane & butane.**
- 2.It is used as fuel for **vehicles, domestic & industrial fuel.**
- 3.**A source of carbon used in tyre industry.**

Coal Gas :

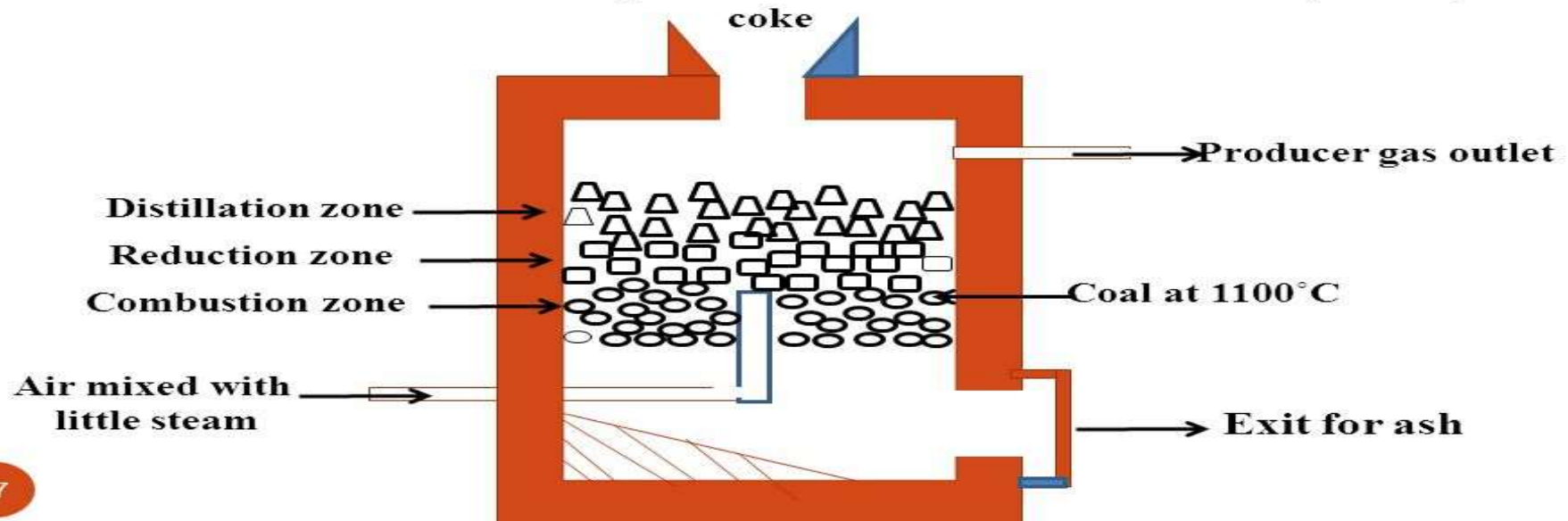
- 1.The average composition of Coal gas is **CH₄=32%,Ethene=3% C₂H₂(Ethyne)=2%, N₂=4%, H₂=40%, CO=7%, CO₂=1% ,rest=11%.**
- 2.It is used as a **fuel ,reducing agent in metallurgical operations , as an illuminants .**

PRODUCER GAS

Producer gas

Producer gas is essentially a mixture of combustible gases, CO , H_2 etc. associated with large percentage of non combustible gas like CO_2 , N_2 etc.

It is prepared by passing air mixed with little steam (about 0.35 kg/kg coal) over a hot coke maintained at 1100°C in special a reactor called 'gas producer'. It consists of steel vessels about 3m dia and 4 m in height. The vessel is lined inside with refractory bricks.



Water Gas, LPG



Water Gas:

- It is a mixture of **combustible gases of CO , H_2** with **a little quantity of non-combustible gases of CO_2 , N_2** .
- The average composition of water Gas is **$\text{CO} = 14\%$, $\text{H}_2 = 51\%$, $\text{N}_2 = 4\%$, $\text{CO}_2 = 4\%$** .
- Its calorific value is **$28,00 \text{ kcal/m}^3$** .
- It is used for **welding purpose, fuel, illuminating gas**.
- It is a **source of hydrogen gas**.

LPG(Liquified Petroleum Gas):

- It is a **colourless, odourless, flexible clean gas, flammable mixture of Hydrocarbons**.
- The average composition of LPG is
 $\text{n-butane} = 27\%$, $\text{iso-butane} = 25\%$, $\text{Butane} = 43\%$, $\text{propane} = 2.5\%$, $\text{propene} = 2.5\%$
- Its calorific value is **$27,800 \text{ kcal/m}^3$** .
- It is used as **domestic fuel & industrial fuel, motor fuel**.
- **The warning of gas leakage due to presence of Ethyl Mercaptan ($\text{C}_2\text{H}_6\text{S}$).**

CNG, Coal Gas



CNG(Compressed Natural Gas):

- It is a **colourless, odourless gases**.
- It is **very cheap gas**.
- The average composition of CNG is $\text{CH}_4 = 70\text{-}90\%$, C_2H_6 (Ethane) = 4-9%, trace of propane & butane.
- Its calorific value is **12500 kcal/m²**.
- It is used as fuel for **vehicles, domestic & industrial fuel**.
- **A source of carbon used in tyre industry.**

Coal Gas:

- It is a mixture of a number of lower hydro-carbons along with $\text{N}_2, \text{H}_2, \text{CO}, \text{CO}_2$.
- It is a **colourless gas** & burns with a **sooty flame**.
- The average composition of $\text{CH}_4=32\%$, Ethene=3%, C_2H_2 (Ethyne)=2%, $\text{N}_2=4\%$, $\text{H}_2=4\%$, $\text{CO}=7\%$, $\text{CO}_2=1\%$.
- It is used as a **fuel ,reducing agent in metallurgical operations , as an illuminant**.

Coal Gas

Coal Gas

- It is a mixture carbon monoxide, methane and hydrogen.
- It is obtained during the processing of coal to get coke.
- Used as a fuel in industries and lighting purpose.