MANONMANIAM SUNDARANAR UNIVERSITY

DEPARTMENT OF CHEMISTRY

TIRUNELVELI- 627 012

APPLIED CHEMISTRY

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APPLIED CHEMISTRY

UNIT-I FUEL CHEMISTRY Fuels- Definition-Classification - Combustion and Chemical Principles – Calorific Value, Characteristics of a good fuel. Solid fuel: Coal - Types - Cross and Net colorific values. Proximate and Ultimate analysis of coal - High and low temperature of carbonization - Uses. Liquid fuels: Petroleum and its Chemical Composition- Cracking of heavy oil residues- Thermal and catalytic cracking, Knocking, Anti-knocking and Chemical structure, Octane and Cetane numbers - Significance - Petroleum products and their applications. Gaseous fuels: Preparation and Specific uses of Producer gas, Water gas. LPG and Gobar gas. Advantages and Disadvantages of Solid, Liquid and Gaseous fuels. Rocket fuels- Classification of Solid Propellants, Liquid Propellants'- Combustion -Spontaneous ignition temperature (SIT) - Combustion calculation.

UNIT-II: PAINTS, LUBRICANTS, ADHESIVES AND PIGMENTS Paints: Classification- Primary constituents, Manufacturing of paints, Emulsion paint, Constituent and advantages-Latex paints and Fire retardant paints, Solvents and Thinners. Lubricants: Functions of lubricants-Properties and Classifications - Additives for lubricating oil, Lubricants of mineral origin. Lubricating grease and Solid lubricants. Adhesives: Classification and preparation of adhesives. Synthetic resin adhesives and Rubber based adhesives -Uses of adhesives. Pigments: Characteristics and uses of TiO2, Ultramarine Blue and Red lead.

UNIT-III: AGRICULTURAL CHEMISTRY Fertilizers: Raw material, manufacture (flow chart)- Chemical process (with equation) of ammonium nitrate, ammonium sulphate, urea, ammonium phosphate, super phosphate, triple super phosphate, NPK fertilizers. Pesticides: Classification of pesticides, examples. Insecticides: Stomach poisons, Contact insecticides, Fumigants, Manufacture and uses of Insecticides: DDT, BHC, Pyrethrin, Aldrin and Pentachlorophenol. Fungicides: Bordeaux mixture, Lime Sulphur, Creosote oil.

UNIT-IV: OILS, SOAPS AND DETERGENTS Oils: Definition: Fats and Oils- Constituents-Sources- Difference between oils and fats, Manufacture of Cottonseed oil, Sunflower oil and Soyabean oil. Soaps: Definition, Manufacture of soaps- Types of soaps - Specific uses. Detergents: Difference between soaps and detergents, Synthetic detergents- Surface active agents and their classification. Anionic, Cationic and Non - ionic detergents - Applications including cleaning action.

UNIT-V: MATCH AND SILICATE INDUSTRIES Match Industry; Types of Matches-Composition of match head and strikening surface. Manufacture of safety matches-Coloured matches- Pyro techniques and explosives, Classification of good explosives TNT, RDX, Gun powder, Ammonium nitrate. Silicate industry; Cement: Types of cements, composition, manufacture of Portland cement and setting of cement. Ceramics: Introduction, Types, Manufacture, and Applications, Refractory materials. Glass: Definition, Composition, Types, Manufacturing of glass products, Physical and Chemical properties, Applications.

UNIT-I

FUEL CHEMISTRY

FUEL CHEMISTRY:

Fuel chemistry deals with the composition, properties, production, and combustion of fuels, and the chemical principles governing energy release.

Definition of Fuel

A fuel is a substance that, when burned in the presence of oxygen, produces a large amount of heat energy which can be used for domestic, industrial, or power-generation purposes.

Classification of Fuels

1. Classification Based on Physical State

a) Solid Fuels

- Examples: **Coal, coke, wood, charcoal**
- Characteristics:
  - Easy to store
  - Produce smoke and ash
- Uses: Boilers, furnaces

b) Liquid Fuels

- Examples: **Petrol, diesel, kerosene, alcohol**
- Characteristics:
  - High calorific value
  - Easy transport through pipelines
- Uses: Internal combustion engines

c) Gaseous Fuels

- Examples: **Natural gas, LPG, CNG, biogas**
- Characteristics:
  - Clean and efficient combustion
  - High thermal efficiency
- Uses: Cooking, power generation

2. Classification Based on Origin

a) Primary (Natural) Fuels

- Fuels available directly from nature
- Examples: **Coal, petroleum, natural gas, wood**

b) Secondary (Artificial) Fuels

- Fuels derived from primary fuels
- Examples: **Coke, petrol, diesel, producer gas, coal gas**

3. Classification Based on Renewable Nature

a) Non-Renewable Fuels

- Limited in supply
- Examples: **Coal, petroleum, natural gas**

b) Renewable Fuels

- Can be replenished naturally
- Examples: **Biogas, bioethanol, biodiesel**

Combustion and Chemical Principles

Combustion of Fuels

Combustion is a chemical process in which a fuel reacts rapidly with oxygen, producing heat energy along with combustion products such as CO_2 and H_2O.

General equation:

$Fuel+O_2 \rightarrow CO_2+H_2O+Heat$

Chemical Principles of Combustion

1. Oxidation–Reduction Reaction

- Combustion is a **redox reaction**
- Fuel → oxidized
- Oxygen → reduced

Example:

$CH_4+2O_2 \rightarrow CO_2+2H_2O$

2. Ignition Temperature

- The **minimum temperature** at which a fuel starts burning
- Below this temperature, combustion will not occur

3. Calorific Value

- Amount of heat released by complete combustion of a unit quantity of fuel

- Higher calorific value → better fuel

4. Types of Combustion

a) Complete Combustion

- Occurs in excess oxygen
- Products: **CO_2 and H_2O**
- Produces maximum heat

b) Incomplete Combustion

- Occurs in limited oxygen
- Products: **CO, soot**
- Produces less heat and causes pollution

5. Combustion Efficiency

- Depends on:
  - Proper fuel–air ratio
  - Nature of fuel
  - Temperature
  - Mixing of fuel and air

6. Flame Temperature

- Maximum temperature attained during combustion
- Higher flame temperature → better thermal efficiency

7. Combustion Products and Pollution

- **CO_2** → greenhouse effect
- **CO** → poisonous gas
- **SO_2, NO_x** → acid rain

8. Chemical Kinetics of Combustion

- Combustion rate depends on:
  - Activation energy
  - Surface area of fuel
  - Concentration of oxygen

9. Role of Catalysts

- Catalysts (e.g., platinum in catalytic converters) lower activation energy and reduce harmful emissions

Combustion of fuels is governed by chemical principles such as oxidation–reduction reactions, ignition temperature, calorific value, and reaction kinetics, which determine fuel efficiency and environmental impact.

Calorific Value:

Definition

The calorific value of a fuel is the amount of heat energy produced when a unit quantity of the fuel is completely burned in the presence of oxygen.

- Unit:
    - Solid & liquid fuels → kJ/kg
    - Gaseous fuels → kJ/m^3

Types of Calorific Value:

1. Higher Calorific Value (HCV)

Also called Gross Calorific Value (GCV)

- Total heat released when combustion products are cooled and water formed is condensed
- Includes latent heat of condensation of water vapor

2. Lower Calorific Value (LCV)

Also called Net Calorific Value (NCV)

- Heat released when water remains in vapor state
- Does not include latent heat of water vapor

Relationship between HCV and LCV

$LCV = HCV - (9H \times L)$

Where:

- HHH = percentage of hydrogen in fuel
- LLL = latent heat of steam (≈ 587 kcal/kg)

Significance of Calorific Value

- Higher calorific value → better fuel
- Helps in:
    - Fuel selection

- Engine efficiency
- Cost comparison of fuels

Measurement of Calorific Value

- Bomb calorimeter (for solid and liquid fuels)
- Gas calorimeter (for gaseous fuels)

Typical Calorific Values of Common Fuels

Fuel	Calorific Value
Coal	25,000–33,000 kJ/kg
Coke	28,000 kJ/kg
Petrol	45,000 kJ/kg
Diesel	43,000 kJ/kg
LPG	50,000 kJ/kg
Natural Gas	55,000 kJ/kg
Biogas	20,000 kJ/m^3

Characteristics of a Good Fuel

A good fuel should have the following characteristics:

1. High Calorific Value
    - Produces a large amount of heat per unit mass or volume.
2. Moderate Ignition Temperature
    - Ignites easily but does not catch fire spontaneously.
3. Low Moisture Content
    - Moisture reduces heating efficiency.
4. Low Ash Content
    - Leaves minimal residue after combustion.
5. Clean Combustion
    - Produces little smoke and fewer harmful gases.
6. High Combustion Efficiency
    - Burns completely, releasing maximum heat.

7. Easy Availability
    - Should be readily obtainable.
8. Economical
    - Low cost in relation to energy produced.
9. Safe to Handle and Store
    - Should not be highly toxic or explosive.
10. Easy Storage and Transportation
    - Should be convenient to store and transport.

Solid Fuels

Definition

Solid fuels are fuels that exist in the solid state and produce heat energy when burned.

Examples

- Wood
- Coal
- Coke
- Charcoal
- Peat

Classification of Solid Fuels

1. Primary (Natural) Solid Fuels

- Obtained directly from nature
- Examples: Wood, coal, peat

2. Secondary (Manufactured) Solid Fuels

- Produced from primary fuels
- Examples: Coke, charcoal, briquettes

Characteristics of Solid Fuels

- Easy to store and handle
- Low cost
- Produce ash after combustion
- Generally lower combustion efficiency than liquid and gaseous fuels

Advantages

- Easily available
- Simple technology required for use
- Suitable for large-scale heating

Disadvantages

- Smoke and air pollution
- Ash disposal problem
- Lower thermal efficiency
- Difficult temperature control

Uses

- Domestic cooking and heating
- Industrial boilers and furnaces
- Power generation

Coal

Coal is a solid fossil fuel formed from plant remains subjected to high pressure and temperature over millions of years. It is mainly composed of carbon along with hydrogen, oxygen, nitrogen, and sulphur.

Types of Coal

Coal is classified based on carbon content and calorific value:

1. Peat

- Lowest rank of coal
- High moisture content
- Low calorific value
- Least efficient fuel

2**. Lignite (Brown Coal)**

- Moderate carbon content
- High moisture
- Used in thermal power plants

3. Bituminous Coal

- High carbon content
- Widely used for industrial purposes

- High calorific value

4. Anthracite

- Highest rank of coal
- Very high carbon content
- Smokeless and hardest coal
- Highest calorific value

Calorific Value of Coal

1. Gross Calorific Value (GCV)

(Also called Higher Calorific Value – HCV)

- Total heat produced when 1 kg of coal is completely burned
- Includes latent heat of condensation of water vapor formed during combustion

2. Net Calorific Value (NCV)

(Also called Lower Calorific Value – LCV)

- Heat available when water remains as vapor
- Excludes latent heat of condensation

Relation Between GCV and NCV

NCV=GCV−(9H×L)\text{NCV} = \text{GCV} - (9H \times L)NCV=GCV−(9H×L)

Where:

- HHH = percentage of hydrogen in coal
- LLL = latent heat of steam (≈ 587 kcal/kg)

Typical Calorific Values of Coal

Type of Coal	Calorific Value (kJ/kg)
Peat	**8,000 – 15,000**
Lignite	**15,000 – 25,000**
Bituminous	**25,000 – 35,000**
Anthracite	**32,000 – 36,000**

Coal – Proximate & Ultimate Analysis, Carbonization and Uses

1. Proximate Analysis of Coal

Proximate analysis gives the percentage composition of coal in terms of moisture, volatile matter, ash, and fixed carbon.

Components

1. Moisture
    - Water present in coal
    - Reduces calorific value
2. Volatile Matter
    - Gases and vapours released on heating
    - High volatile matter → easy ignition
3. Ash
    - Non-combustible residue
    - Causes disposal problems
4. Fixed Carbon
    - Solid combustible portion
    - Responsible for heat generation

Significance:

- Determines coal quality
- Helps in selecting coal for industrial use

2. Ultimate Analysis of Coal

Ultimate analysis gives the elemental composition of coal.

Elements Determined

- Carbon (C)
- Hydrogen (H)
- Oxygen (O)
- Nitrogen (N)
- Sulphur (S)

Significance:

- Used to calculate calorific value
- Helps in combustion calculations
- Predicts pollution potential

3. Carbonization of Coal

Carbonization is the heating of coal in the absence of air to produce coke.

A. Low-Temperature Carbonization (500–700°C)

Products:

- Soft coke
- Coal tar
- Coal gas

Characteristics:

- Coke contains more volatile matter
- Lower calorific value
- Smoky flame

Uses:

- Domestic fuel
- Gas production

B. High-Temperature Carbonization (900–1200°C)

Products:

- Hard coke
- Coal tar
- Coke oven gas

Characteristics:

- Coke is hard, porous, and strong
- Low volatile matter
- High calorific value

Uses:

- Metallurgical processes
- Blast furnaces

4. Uses of Coal

- Fuel for thermal power plants
- Manufacture of coke
- Production of coal gas and coal tar

- Metallurgical industries
- Domestic heating

Liquid Fuels

Definition

Liquid fuels are fuels that exist in the liquid state and produce heat energy when burned. Most liquid fuels are obtained from petroleum.

Examples

- Petrol (Gasoline)
- Diesel
- Kerosene
- Fuel oil
- Alcohols (ethanol, methanol)
- Biodiesel

Classification of Liquid Fuels

1. Natural Liquid Fuels

- Obtained directly from nature
- Example: Crude petroleum

2. Artificial (Refined) Liquid Fuels

- Obtained by refining petroleum
- Examples: Petrol, diesel, kerosene

Properties of Liquid Fuels

- High calorific value
- Easy ignition and controlled combustion
- Less ash compared to solid fuels

Advantages

- Easy transportation and storage
- High combustion efficiency
- Clean burning compared to solid fuels

- Precise control of fuel supply

Disadvantages

- Fire and explosion hazards
- Costlier than solid fuels
- Environmental pollution
- Limited resources (non-renewable)

Uses

- Petrol and diesel → automobiles
- Kerosene → cooking and lighting
- Fuel oil → boilers and furnaces
- Alcohols and biodiesel → alternative fuels

Petroleum and Its Chemical Composition

Petroleum (crude oil) is a naturally occurring liquid fossil fuel found beneath the earth's surface. It is a complex mixture of hydrocarbons with small amounts of non-hydrocarbon compounds.

Chemical composition:

- Paraffins (alkanes) – straight-chain and branched-chain hydrocarbons
- Naphthenes (cycloalkanes)
- Aromatic hydrocarbons
- Minor constituents: sulphur, nitrogen, oxygen compounds and traces of metals

Cracking of Heavy Oil Residues

Cracking is the process of breaking high-molecular-weight hydrocarbons into smaller, more useful hydrocarbons such as petrol, diesel, and LPG.

1. Thermal Cracking

- Carried out at high temperature (450–750°C) and pressure
- No catalyst is used
- Produces petrol with low octane number

Merits: Simple process

Demerits: Lower yield, poor fuel quality

2. Catalytic Cracking

- Uses catalysts like silica–alumina or zeolites
- Lower temperature and pressure than thermal cracking
- Produces petrol with high octane number

Advantages:

- Higher yield of petrol
- Better fuel quality
- More economical and efficient

Knocking

Knocking is an undesirable phenomenon in internal combustion engines where fuel burns unevenly or explodes suddenly, producing a metallic sound and reducing engine efficiency.

Anti-Knocking

Anti-knocking agents prevent knocking and ensure smooth combustion.

Examples:

- Tetraethyl lead (TEL) *(now restricted due to pollution)*
- Alcohols and aromatic hydrocarbons

Effect of Chemical Structure on Knocking

- Straight-chain hydrocarbons → maximum knocking
- Branched-chain hydrocarbons → less knocking
- Aromatic hydrocarbons → excellent anti-knock properties

Octane Number

- Measures anti-knocking quality of petrol
- Reference fuels:
    - Iso-octane = 100
    - n-Heptane = 0

Significance

- Higher octane number → smoother engine performance
- Used to grade petrol quality

Cetane Number

- Measures ignition quality of diesel

- Reference fuels:
    - n-Hexadecane (cetane) = 100
    - α-Methylnaphthalene = 0

Significance

- Higher cetane number → shorter ignition delay
- Ensures efficient diesel engine operation

Petroleum Products and Their Applications

Petroleum Product	Applications
LPG	Domestic cooking
Petrol	Motor fuel
Kerosene	Cooking, lighting
Diesel	Heavy vehicles, generators
Lubricating oil	Machinery lubrication
Paraffin wax	Candles, polishes
Bitumen	Road construction

Gaseous fuels

Definition

Gaseous fuels are fuels that exist in the **gaseous state** and produce heat energy when burned in the presence of oxygen.

Examples

Natural gas

LPG (Liquefied Petroleum Gas)

CNG (Compressed Natural Gas)

Coal gas

Producer gas

Water gas

Biogas

Classification of Gaseous Fuels

1. Natural Gaseous Fuels

- Obtained directly from nature
- Example: **Natural gas**

2. Artificial (Manufactured) Gaseous Fuels

- Prepared from solid or liquid fuels
- Examples: **Coal gas, producer gas, water gas**

Composition of Important Gaseous Fuels

- **Natural gas:** Methane (80–95%)
- **LPG:** Propane and butane
- **Producer gas:** $CO + N_2$
- **Water gas:** $CO + H_2$
- **Biogas:** Methane + CO_2

Properties of Gaseous Fuels

- High calorific value
- Easy ignition
- Clean and smokeless combustion
- No ash residue
- High thermal efficiency

Advantages

- Complete and uniform combustion
- Easy control of flame temperature
- Low air pollution
- Easy transportation through pipelines

Disadvantages

- Storage and transportation difficulties
- Fire and explosion hazards
- Expensive storage equipment

Uses

- Domestic cooking (LPG, PNG)

- Power generation
- Industrial heating
- Motor fuel (CNG)

1. Producer Gas

Preparation

Producer gas is prepared by passing a **limited supply of air** over **red-hot coke** in a gas producer.

Reaction:

$2C+O2+4N_2 \rightarrow 2CO+4N_2$

Composition: CO (25–30%), N_2 (60–65%), small amounts of CO_2 and H_2

Specific Uses

- Fuel in furnaces
- Glass and ceramic industries
- Metallurgical processes

2. Water Gas

Preparation

Water gas is produced by passing **steam over red-hot coke**.

Reaction:

$C+H_2O \rightarrow CO+H_2$

Composition: CO (50%) and H_2 (50%)

Specific Uses

- Industrial fuel
- Manufacture of hydrogen
- Synthesis of methanol and ammonia

3. LPG (Liquefied Petroleum Gas)

Preparation

LPG is obtained during petroleum refining and natural gas processing. It is a mixture of propane and butane stored under pressure.

Specific Uses

- Domestic cooking fuel
- Industrial heating
- Automobile fuel (auto-LPG)

4. Gobar Gas (Biogas)

Preparation

Gobar gas is produced by **anaerobic fermentation** of cattle dung in a biogas plant.

Main constituent: Methane (55–65%)

Specific Uses

- Cooking and lighting
- Power generation
- Organic manure from slurry

5. Advantages and Disadvantages of Fuels

A. Solid Fuels

Advantages

- Cheap and easily available
- Simple technology required

Disadvantages

- Low efficiency
- Smoke and ash pollution
- Difficult temperature control

B. Liquid Fuels

Advantages

- High calorific value
- Easy handling and transport
- Controlled combustion

Disadvantages

- Fire hazard
- Costlier than solid fuels
- Environmental pollution

C. Gaseous Fuels

Advantages

- Clean and smokeless
- High combustion efficiency
- Easy flame control

Disadvantages

- Storage difficulty
- High initial cost
- Explosion risk

Rocket Fuels (Propellants)

Definition

Rocket fuels (propellants) are chemical substances that, on combustion, produce a large volume of high-temperature gases which provide thrust to rockets.

A rocket propellant consists of:

- Fuel
- Oxidizer

Classification of Rocket Propellants

1. Solid Propellants

Classification of Solid Propellants

a) Homogeneous (Single-base & Double-base) Propellants

- **Single-base:** Nitrocellulose
- **Double-base:** Nitrocellulose + nitroglycerine

Characteristics:

- Uniform composition
- Smooth combustion

b) Composite (Heterogeneous) Propellants

- Fuel: **Aluminium powder**
- Oxidizer: **Ammonium perchlorate / ammonium nitrate**
- Binder: **Polyurethane or rubber**

Characteristics:

- High thrust

- Used in large rockets

Combustion of Solid Propellants

- Burn on the **surface**
- Combustion rate depends on:
    - Composition
    - Grain geometry
    - Pressure and temperature

2. Liquid Propellants

Classification of Liquid Propellants

a) Monopropellants

- Single chemical acts as fuel and oxidizer
- Example: **Hydrogen peroxide, hydrazine**

b) Bipropellants

- Fuel and oxidizer stored separately
- Examples:
    - Liquid hydrogen + liquid oxygen
    - Kerosene + liquid oxygen

Combustion of Liquid Propellants

- Fuel and oxidizer injected into combustion chamber
- High combustion efficiency
- Can be controlled or stopped as required

Spontaneous Ignition Temperature (SIT)

Definition

The spontaneous ignition temperature is the minimum temperature at which a propellant ignites automatically without external ignition.

Significance

- Lower SIT → hypergolic propellants
- Ensures reliable ignition
- Important for rocket safety and design

Example: Hydrazine + nitrogen tetroxide ignite spontaneously.

Combustion Calculations (Rocket Propellants)

Combustion calculations involve:

- Determination of **stoichiometric fuel–oxidizer ratio**
- Amount of heat released
- Quantity of combustion products

Example:

$2H_2 + O_2 \rightarrow 2H_2O$ + Energy

Importance:

- Determines thrust
- Predicts flame temperature
- Ensures efficient fuel utilization

Advantages of Rocket Fuels

- Very high energy release
- Capable of operation in vacuum
- High thrust-to-weight ratio

UNIT-II

PAINTS, LUBRICANTS, ADHESIVES AND PIGMENTS

Paints

Paints are liquid or semi-liquid coatings applied to surfaces to protect, decorate, and preserve them.

Classification

Paints can be classified in several ways based on **composition, application, and purpose**.

1. Classification Based on Composition / Nature

1. **Oil Paints**
   - Made using drying oils (linseed oil)
   - Used for wood and metal surfaces
2. **Enamel Paints**
   - Oil-based paints with glossy finish
   - Hard and durable coating
3. **Emulsion Paints**
   - Water-based paints
   - Used for interior and exterior walls
4. **Cement Paints**

    - Cement-based paints
    - Used for exterior surfaces
5. **Plastic Paints**
    - Synthetic resin-based paints
    - Smooth decorative finish
6. **Bituminous Paints**
    - Made from bitumen
    - Used for corrosion protection
7. **Aluminium Paints**
    - Contain aluminium powder
    - Heat and corrosion resistant

2. Classification Based on Purpose

1. **Decorative Paints**
    - Provide colour and appearance
2. **Protective Paints**
    - Protect surfaces from corrosion and weather
3. **Industrial Paints**
    - Used in factories, machines, and structures

3. Classification Based on Surface

1. **Wood Paints**
2. **Metal Paints**
3. **Concrete / Masonry Paints**

Primary Constituents of Paints

Paints are composed of several essential components, each performing a specific function.

1. Base

- Main body of the paint
- Provides **opacity, durability, and protection**
- Examples: **White lead, zinc oxide, titanium dioxide**

2. Pigment

- Imparts **colour and hiding power**
- Improves appearance and corrosion resistance
- Examples: **Red oxide, chrome green, carbon black**

3. Vehicle (Binder)

- Liquid portion that carries pigment and base
- Forms a **continuous film** on drying
- Examples: **Linseed oil, alkyd resins, acrylic resins**

4. Solvent / Thinner

- Adjusts viscosity for easy application
- Evaporates after application
- Examples: **Turpentine oil, mineral spirits, water**

5. Driers

- Accelerate the **drying process** by oxidation
- Examples: **Cobalt, manganese, lead salts**

6. Extenders (Fillers)

- Increase volume and reduce cost
- Improve surface finish
- Examples: **Calcium carbonate, silica, barytes**

Manufacturing of Paints

The manufacture of paints involves a **series of well-defined steps** to obtain a uniform, stable, and smooth product.

Steps Involved in the Manufacturing of Paints

1. Selection of Raw Materials

Base

Pigments

Vehicle (binder)

Solvent (thinner)

Driers and additives

2. Grinding of Pigments

Pigments and base are ground with a part of the vehicle

Done using **ball mills or roller mills**

Purpose: to obtain **fine particles** and uniform dispersion

3. Mixing

Ground paste is mixed with remaining vehicle

Extenders and additives are added

Ensures **homogeneous mixture**

4. Thinning

Solvents or thinners are added

Adjusts viscosity for easy application

5. Addition of Driers

Driers like cobalt or manganese salts are added

Helps in faster drying of paint film

6. Filtration

Removes impurities and coarse particles

Improves smoothness and quality

7. Tinting (Optional)

Colour pigments are added to obtain desired shade

8. Packing

Finished paint is packed in air-tight containers

Ready for storage and use

Flow Chart of Paint Manufacturing

Raw materials → Grinding → Mixing → Thinning → Addition of driers → Filtration → Packing

Emulsion Paint

Definition

Emulsion paint is a water-based paint in which finely divided pigment particles are dispersed in an emulsion of water and synthetic resin (binder). It is widely used for interior and exterior walls.

Constituents of Emulsion Paint

1. **Pigment**
    - Provides colour and hiding power
    - Example: **Titanium dioxide**
2. **Binder (Resin)**
    - Forms a continuous film on drying
    - Examples: **Acrylic resin, vinyl resin**
3. **Solvent**
    - Acts as the dispersing medium

    - **Water** is used

4. **Emulsifying Agent**
    - Maintains stable dispersion of pigment and resin

5. **Additives**
    - Improve properties such as:
        - Preservatives
        - Fungicides
        - Plasticizers
        - Stabilizers

Advantages of Emulsion Paint

- Quick drying
- Odourless and eco-friendly
- Easy to apply
- Washable and durable
- Smooth and attractive finish
- Resistant to moisture and fungus
- Non-flammable

Latex Paints and Fire-Retardant Paints

1. Latex Paints

Definition

Latex paints are **water-based paints** in which the binder is a **latex (polymer emulsion)** such as acrylic, vinyl, or styrene-butadiene.

Constituents of Latex Paints

- **Pigments** – titanium dioxide, colour pigments

- **Binder (latex polymer)** – acrylic, vinyl, styrene-butadiene
- **Solvent** – water
- **Additives** – thickeners, preservatives, anti-fungal agents

Properties

- Quick drying
- Good adhesion
- Flexible paint film
- Low odour

Uses

- Interior and exterior walls
- Concrete, plaster, wood, and brick surfaces

2. Fire-Retardant Paints

Definition

Fire-retardant paints are special paints that **resist ignition and slow down the spread of fire** by forming a protective layer when exposed to high temperatures.

Constituents of Fire-Retardant Paints

- **Binder** – synthetic resin or silicone resin
- **Fire-retardant chemicals** – ammonium phosphate, borates
- **Pigments** – inert pigments
- **Additives** – intumescent agents

Mechanism of Action

- On heating, the paint:
    - Releases non-flammable gases

    - Forms a **char or foam layer**
    - Insulates the surface from heat and oxygen

Properties

- High fire resistance
- Reduces flame spread
- Provides thermal insulation

Uses

- Buildings and public structures
- Steel structures and wood
- Electrical installations

Advantages of Fire-Retardant Paints

- Enhances fire safety
- Protects structural integrity
- Reduces fire damage

Solvents and Thinners in Paints

Solvents in Paints

Definition

A **solvent** is a liquid that **dissolves the binder (vehicle)** of the paint and helps maintain the paint in a **liquid state** for easy application.

Functions of Solvents

- Dissolve the binder completely
- Control viscosity of paint
- Aid in smooth and uniform application
- Evaporate after application, leaving a dry film

Examples of Solvents

- **Turpentine oil**
- **Mineral spirits**
- **Xylene**
- **Toluene**
- **Water** (in emulsion paints)

Thinners in Paints

Definition

A **thinner** is a liquid added to paint to **reduce viscosity** and improve **flow and leveling**, but it may not dissolve the binder completely.

Functions of Thinners

- Adjust consistency of paint
- Improve spreading and brushing
- Prevent brush marks

Examples of Thinners

- **Turpentine**
- **Petroleum spirit**
- **Naphtha**
- **Alcohols**

Difference between Solvents and Thinners

Solvents	Thinners
Dissolve the binder	Reduce viscosity

Solvents	Thinners
Essential part of paint	Added when required
Example: Turpentine	Example: Naphtha

Lubricants – Functions

Lubricants are substances introduced between moving surfaces to reduce friction and wear. Their main functions are:

1. **Reduce Friction**
   - Form a thin film between moving parts, minimizing direct contact.
2. **Reduce Wear and Tear**
   - Prevents metal-to-metal contact, increasing the life of machine parts.
3. **Cooling Effect**
   - Carries away heat generated due to friction.
4. **Prevent Corrosion**
   - Forms a protective layer that prevents oxidation and rusting.
5. **Seal Gaps**
   - Acts as a seal between moving parts (e.g., piston and cylinder).
6. **Reduce Power Loss**
   - Smooth motion lowers energy loss due to friction.
7. **Dampen Shock and Noise**
   - Absorbs vibrations and reduces operating noise.
8. **Clean Moving Parts**
   - Removes dirt, metal particles, and sludge by carrying them away.

Lubricants – Properties and Classification

Properties of Lubricants

A good lubricant should possess the following properties:

1. **High Viscosity Index**
   - Viscosity should not change much with temperature.
2. **Suitable Viscosity**
   - Should be thick enough to maintain a lubricating film, but not too thick to cause power loss.
3. **High Flash and Fire Points**
   - Should not ignite at operating temperatures.
4. **Low Pour Point**
   - Should remain fluid at low temperatures.
5. **Thermal Stability**
   - Should not decompose at high temperatures.
6. **Oxidation Stability**
   - Should resist oxidation and formation of sludge.
7. **Corrosion Resistance**
   - Should protect metal surfaces from rust and corrosion.
8. **Good Oiliness**
   - Ability to adhere to metal surfaces.

Classification of Lubricants

1. Liquid Lubricants

- Mineral oils
- Synthetic oils
- Vegetable and animal oils

Uses: Engines, turbines, compressors

2. Semi-Solid Lubricants

- Greases (oil + thickener)

Examples: Calcium grease, sodium grease

Uses: Bearings, gears

3. Solid Lubricants

- Graphite
- Molybdenum disulphide (MoS_2)

Uses: High temperature and vacuum conditions

4. Emulsion Lubricants

- Oil-in-water or water-in-oil emulsions

Uses: Cutting and machining operations

Additives for Lubricating Oil & Lubricants of Mineral Origin

1. Additives for Lubricating Oils

Additives are chemicals added in small quantities to lubricating oils to **improve their performance and service life**.

Types of Additives and Their Functions

1. **Viscosity Index Improvers**
    - Reduce change in viscosity with temperature
    - Examples: Polyisobutylene, polymethacrylates
2. **Antioxidants**
    - Prevent oxidation and sludge formation
    - Examples: Phenols, amines
3. **Anti-wear Agents**
    - Reduce wear under high load

    - Example: Zinc dialkyldithiophosphate (ZDDP)
4. **Extreme Pressure (EP) Additives**
    - Protect surfaces under heavy load and high temperature
    - Examples: Sulphur, chlorine, phosphorus compounds
5. **Detergents and Dispersants**
    - Keep engine parts clean
    - Prevent sludge deposition
6. **Pour Point Depressants**
    - Lower the pour point of oil
    - Examples: Alkylated naphthalenes
7. **Corrosion and Rust Inhibitors**
    - Protect metal surfaces from corrosion
8. **Anti-foaming Agents**
    - Prevent foam formation
    - Examples: Silicone oils

2. Lubricants of Mineral Origin

Definition

Lubricants of mineral origin are oils **obtained from petroleum (crude oil)** by refining and purification.

Preparation

- Fractional distillation of crude oil
- Solvent refining
- Dewaxing and finishing processes

Characteristics

- Good lubricating properties
- Economical and widely available
- Moderate oxidation stability

Examples

- Engine oils
- Gear oils
- Turbine oils

Advantages

- Low cost
- Easily available
- Suitable for most machinery

Limitations

- Poor performance at very high or very low temperatures
- Lower viscosity index compared to synthetic oils

Lubricating Grease and Solid Lubricants

1. Lubricating Grease

Definition

Lubricating grease is a **semi-solid lubricant** consisting of a **lubricating oil thickened with a soap or other thickener**.

Composition of Lubricating Grease

- **Base oil** – mineral or synthetic oil
- **Thickener** – metal soaps (calcium, sodium, lithium)

- **Additives** – antioxidants, anti-wear agents, corrosion inhibitors

Types of Greases

1. **Calcium grease** – water resistant
2. **Sodium grease** – good at high temperatures
3. **Lithium grease** – multipurpose grease

Properties

- High adhesiveness
- Good sealing property
- Stays in position for long time

Uses

- Bearings
- Gears
- Chassis lubrication
- Machinery operating at moderate speeds

2. Solid Lubricants

Definition

Solid lubricants are solid substances that reduce friction by forming a **thin film** between moving surfaces.

Examples

- **Graphite**
- **Molybdenum disulphide (MoS_2)**

- **Boron nitride**
- **PTFE (Teflon)**

Mechanism of Lubrication

- Layer lattice structure allows easy sliding
- Reduces direct metal-to-metal contact

Properties

- Work at high temperatures
- Effective under high loads
- Suitable in vacuum and extreme conditions

Uses

- Aerospace and space equipment
- High-temperature machinery
- Vacuum systems
- Heavy-load bearings

Adhesives – Classification and Preparation

Definition

Adhesives are substances used to **join two surfaces together** by surface attachment, forming a strong bond.

1. Classification of Adhesives

A. Based on Origin

1. Natural Adhesives

- Obtained from natural sources
- Examples: **Starch glue, animal glue, casein glue**

2. Synthetic Adhesives

- Manufactured chemically
- Examples: **Epoxy resins, phenol–formaldehyde, urea–formaldehyde**

B. Based on Chemical Nature

1. **Thermoplastic Adhesives**
    - Soften on heating and harden on cooling
    - Examples: **Polyvinyl acetate (PVA), acrylic adhesives**
2. **Thermosetting Adhesives**
    - Harden permanently on heating
    - Examples: **Epoxy, phenolic resins**

C. Based on Method of Setting

1. **Drying Adhesives**
    - Set by evaporation of solvent
    - Examples: **Rubber cement, PVA glue**
2. **Hot-melt Adhesives**
    - Applied in molten state and set on cooling
    - Examples: **Polyethylene, EVA**
3. **Reactive Adhesives**
    - Set by chemical reaction
    - Examples: **Epoxy adhesives**

2. Preparation of Adhesives

1. Starch Adhesive

- Prepared by heating **starch with water**
- Used for paper and cardboard

2. Animal Glue

- Prepared by boiling **bones, skins, and hooves**
- Used in woodworking

3. Casein Adhesive

- Prepared by mixing **casein with lime or alkali**
- Used in plywood and furniture

4. Synthetic Resin Adhesives

Epoxy Adhesive

- Prepared by reacting **epichlorohydrin with bisphenol-A**
- Mixed with hardener before use

Phenol–Formaldehyde Adhesive

- Prepared by condensation of **phenol and formaldehyde**
- Used in waterproof plywood

Synthetic Resin Adhesives and Rubber-Based Adhesives – Uses of Adhesives

1. Synthetic Resin Adhesives

Definition

Synthetic resin adhesives are man-made polymer adhesives that develop **strong and durable bonds** by chemical reaction or curing.

Types and Examples

1. **Epoxy Resins**
   - Two-component system (resin + hardener)
2. **Phenol–Formaldehyde Resins**
   - Thermosetting adhesives
3. **Urea–Formaldehyde Resins**
   - Widely used wood adhesive

4. **Polyvinyl Acetate (PVA)**
    - Thermoplastic adhesive

Properties

- High bond strength
- Good chemical and heat resistance
- Water-resistant (especially epoxy and phenolic resins)

Uses of Synthetic Resin Adhesives

- Manufacture of **plywood and laminates**
- Bonding **metals, plastics, glass, ceramics**
- Electrical and electronic components
- Construction and structural bonding
- Automobile and aircraft industries

2. Rubber-Based Adhesives

Definition

Rubber-based adhesives are prepared using **natural or synthetic rubber** dissolved in suitable organic solvents.

Types

- **Natural rubber adhesives**
- **Synthetic rubber adhesives** (neoprene, nitrile rubber)

Properties

- Flexible bond
- High tackiness
- Good resistance to vibration

Uses of Rubber-Based Adhesives

- Footwear industry
- Adhesive tapes and labels
- Bonding rubber, leather, fabrics
- Upholstery and packaging

3. General Uses of Adhesives

- Woodworking and furniture making
- Construction and building materials
- Packaging and labeling
- Automobile and aerospace industries
- Electrical and electronic equipment
- Household and office applications

Pigments

Definition

Pigments are finely divided, insoluble coloured substances used in paints, inks, plastics, and coatings to provide colour, opacity, and protection.

Characteristics and Uses

1. Titanium Dioxide (TiO_2)

Characteristics

- Pure white pigment
- Very **high opacity and covering power**
- High **refractive index**
- Chemically inert and non-toxic
- Excellent resistance to light and weather

- Available in **rutile and anatase** forms

Uses

- White paints and emulsion paints
- Plastic and rubber industries
- Paper and ink manufacture
- Cosmetics and pharmaceuticals

2. Ultramarine Blue

Characteristics

- Bright blue pigment
- Good colouring power
- Resistant to light and alkalis
- Insoluble in water and oils
- Decomposed by acids
- Non-toxic and stable

Uses

- Blue paints and distempers
- Laundry bluing agent
- Paper and textile colouring
- Printing inks

3. Red Lead (Pb_3O_4)

Characteristics

- Bright red-orange pigment

- High density and good covering power
- Anti-corrosive in nature
- Toxic due to lead content
- Reacts with acids

Uses

- Anti-corrosive primers for iron and steel
- Protective coatings on steel structures
- Manufacture of lead-based paints
- Storage batteries and glass industry

UNIT-III

AGRICULTURAL CHEMISTRY

Agricultural Chemistry

Definition

Agricultural chemistry is the branch of chemistry that deals with the application of chemical principles to agriculture for improving soil fertility, crop yield, and quality of agricultural produce.

Scope of Agricultural Chemistry

1. Soil Chemistry
    - Chemical composition of soil
    - Soil pH and nutrient availability
    - Soil fertility and soil testing
2. Plant Nutrition
    - Essential nutrients for plant growth
    - Macro and micronutrients
    - Nutrient deficiency symptoms
3. Fertilizers
    - Classification of fertilizers
    - Manufacture and application
    - Chemical fertilizers and biofertilizers
4. Manures
    - Organic manures and green manures
    - Role in improving soil structure
5. Pesticides and Agrochemicals
    - Insecticides, herbicides, fungicides
    - Safe use and environmental impact
6. Soil Amendments
    - Lime, gypsum, and other conditioners

    - Reclamation of acidic and alkaline soils

Importance of Agricultural Chemistry

- Increases crop yield
- Improves soil fertility
- Enhances food quality
- Controls pests and diseases
- Promotes sustainable agriculture

Role in Modern Agriculture

- Development of eco-friendly fertilizers
- Precision farming
- Integrated nutrient management
- Environmental protection

Fertilizers

Definition

Fertilizers are chemical or natural substances added to soil or plants to **supply essential nutrients** required for healthy plant growth and increased crop yield.

Functions of Fertilizers

- Supply essential plant nutrients
- Improve crop productivity
- Correct nutrient deficiencies
- Enhance soil fertility

Classification of Fertilizers

1. Based on Nutrients Supplied

a) Nitrogenous Fertilizers

- Supply nitrogen
- Examples: **Urea, Ammonium sulphate, Ammonium nitrate**

b) Phosphatic Fertilizers

- Supply phosphorus
- Examples: **Single superphosphate (SSP), Triple superphosphate (TSP)**

c) Potassic Fertilizers

- Supply potassium
- Examples: **Muriate of potash (KCl), Sulphate of potash (K_2SO_4)**

2. Based on Number of Nutrients

a) Straight Fertilizers

- Contain one major nutrient
- Example: **Urea**

b) Compound / Complex Fertilizers

- Contain two or more nutrients chemically combined
- Example: **NPK fertilizers**

c) Mixed Fertilizers

- Physical mixture of fertilizers
- Example: **NPK mixtures**

3. Based on Source

a) Chemical Fertilizers

- Manufactured industrially
- Examples: **Urea, DAP**

b) Biofertilizers

- Contain living microorganisms
- Examples: **Rhizobium, Azotobacter**

Advantages of Fertilizers

- Quick nutrient availability
- Easy to apply
- High crop response

Disadvantages

- Overuse causes soil degradation
- Water pollution (eutrophication)
- Reduced soil microbial activity

Raw Materials

Definition

Raw materials for fertilizers are natural or industrial substances used in the manufacture of nitrogenous, phosphatic, and potassic fertilizers.

1. Raw Materials for Nitrogenous Fertilizers

Raw Material	Source
Atmospheric nitrogen (N_2)	Air
Natural gas / coal / naphtha	Source of hydrogen
Water (H_2O)	Hydrogen source
Ammonia (NH_3)	Basic intermediate

Used for manufacturing

- Urea

- Ammonium sulphate
- Ammonium nitrate

2. Raw Materials for Phosphatic Fertilizers

Raw Material	Source
Rock phosphate	Mineral deposits
Sulphuric acid (H_2SO_4)	Industrial chemical
Phosphoric acid (H_3PO_4)	From rock phosphate

Used for manufacturing

- Single superphosphate (SSP)
- Triple superphosphate (TSP)
- Diammonium phosphate (DAP)

3. Raw Materials for Potassic Fertilizers

Raw Material	Source
Potash minerals	Sylvite, Carnallite
Potassium chloride (KCl)	Muriate of potash
Potassium sulphate (K_2SO_4)	Sulphate of potash

4. Raw Materials for Complex Fertilizers

- Ammonia
- Phosphoric acid
- Potash salts

5. Raw Materials for Biofertilizers

- Microbial cultures

- Carrier materials (peat, lignite)

Fertilizers – Manufacture Flow Charts

1. Manufacture of Urea

Raw materials: Ammonia (NH_3) and Carbon dioxide (CO_2)

Natural gas / Coal / Naphtha
↓
Hydrogen
↓
Atmospheric Nitrogen + Hydrogen
↓
Ammonia (NH_3)
↓
NH_3 + CO_2 (High pressure & temperature)
↓
Ammonium Carbamate
↓
Dehydration
↓
Urea
↓
Prilling / Granulation

2. Manufacture of Single Superphosphate (SSP)

Raw materials: Rock phosphate and Sulphuric acid

Rock Phosphate
+
Sulphuric Acid
↓
Chemical Reaction
↓
Monocalcium Phosphate
+
Calcium Sulphate (Gypsum)
↓
Curing
↓
Single Superphosphate (SSP)

3. Manufacture of Triple Superphosphate (TSP)

Raw materials: Rock phosphate and Phosphoric acid

Rock Phosphate
+
Phosphoric Acid
↓
Monocalcium Phosphate
↓
Curing
↓
Triple Superphosphate (TSP)

4. Manufacture of Diammonium Phosphate (DAP)

Raw materials: Ammonia and Phosphoric acid

Rock Phosphate
↓
Phosphoric Acid
+
Ammonia
↓
Neutralization
↓
Slurry
↓
Granulation
↓
Drying & Cooling
↓
Diammonium Phosphate (DAP)

5. Manufacture of Ammonium Sulphate

Ammonia
+
Sulphuric Acid
↓
Ammonium Sulphate Solution
↓
Crystallization
↓
Ammonium Sulphate Fertilizer

Manufacture of Ammonium Nitrate – Chemical Process (with Equations)

Raw Materials

- **Ammonia (NH_3)**
- **Nitric acid (HNO_3)**

Chemical Process

Step 1: Neutralization Reaction

Ammonium nitrate is manufactured by **neutralizing ammonia with nitric acid**.

$$NH_3 + HNO_3 \rightarrow NH_4NO_3 + \text{Heat}$$

- The reaction is **highly exothermic**
- Carried out in a **neutralizer**
- Produces ammonium nitrate solution

Step 2: Concentration

- The ammonium nitrate solution is **concentrated by evaporation** to about **95–99%**

Step 3: Solidification

- Concentrated melt is converted into solid form by:
  - **Prilling**, or
  - **Granulation**

Overall Reaction

$$NH_3 + HNO_3 \rightarrow NH_4NO_3$$

Uses of Ammonium Nitrate

- Nitrogenous fertilizer
- Manufacture of explosives (industrial use)

Manufacture of Ammonium Sulphate – Chemical Process (with Equation)

Raw Materials

- **Ammonia (NH_3)**
- **Sulphuric acid (H_2SO_4)**

Chemical Process

Neutralization Reaction

Ammonium sulphate is manufactured by **neutralizing ammonia with sulphuric acid**.

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

- The reaction is **exothermic**
- Carried out in a **neutralizer**
- Forms ammonium sulphate solution

Crystallization

- The solution is **concentrated by evaporation**
- On cooling, **ammonium sulphate crystals** are formed

Drying and Packing

- Crystals are dried and packed for use as fertilizer

Overall Reaction

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

Uses

- Nitrogenous fertilizer (contains ~21% nitrogen)
- Suitable for alkaline soils

1. Manufacture of Urea

Raw materials: Ammonia (NH_3) and Carbon dioxide (CO_2)

Step 1: Formation of Ammonium Carbamate

$2\,NH_3 + CO_2 \rightarrow NH_2COONH_4$ (High pressure, temp)

Step 2: Dehydration to Urea

$NH_2COONH_4 \rightarrow NH_2CONH_2 + H_2O$

Overall Reaction

$2\ NH_3 + CO_2 \rightarrow NH_2CONH_2 + H_2O$

2. Manufacture of Ammonium Phosphate (DAP / MAP)

a) Diammonium Phosphate (DAP)

Raw materials: Ammonia and Phosphoric acid

$2\ NH_3 + H_3PO_4 \rightarrow (NH_4)_2HPO_4$

b) Monoammonium Phosphate (MAP)

$NH_3 + H_3PO_4 \rightarrow NH_4H_2PO_4$

3. Manufacture of Superphosphate (Single Superphosphate – SSP)

Raw materials: Rock phosphate and Sulphuric acid

(Rock phosphate ≈ $Ca_3(PO_4)_2$)

$Ca_3(PO_4)_2 + 2\ H_2SO_4 \rightarrow Ca(H_2PO_4)_2 + 2\ CaSO_4$

Products: **Monocalcium phosphate + gypsum**

4. Manufacture of Triple Superphosphate (TSP)

Raw materials: Rock phosphate and Phosphoric acid

$Ca_3(PO_4)_2 + 4\ H_3PO_4 \rightarrow 3\ Ca(H_2PO_4)_2$

Product: **Concentrated monocalcium phosphate**

NPK Fertilizers

Definition

NPK fertilizers are **complex or mixed fertilizers** that contain the three primary plant nutrients:

- **N – Nitrogen**
- **P – Phosphorus**

- **K – Potassium**

These nutrients are present in **specified ratios** to meet crop requirements.

Role of N, P and K

- **Nitrogen(N):**
  Promotes leafy growth and chlorophyll formation
- **Phosphorus(P):**
  Helps root development, flowering, and seed formation
- **Potassium(K):**
  Improves disease resistance, water regulation, and crop quality

Types of NPK Fertilizers

1. Complex (Compound) NPK Fertilizers

- Nutrients are **chemically combined**
- Manufactured in fertilizer plants
- Examples: **15:15:15, 20:20:0, 10:26:26**

2. Mixed NPK Fertilizers

- Physical mixture of straight fertilizers
- Examples: Urea + SSP + MOP mixtures

Composition (Grade)

NPK fertilizer grade is expressed as:

N : P_2O_5:K_2O

Example:

15:15:15 →

15% Nitrogen, 15% Phosphorus (as P_2O_5), 15% Potassium (as K_2O)

Manufacture (General Outline)

Ammonia + Phosphoric Acid + Potash

↓

Neutralization

↓

Slurry Formation

↓

Granulation

↓

Drying & Cooling

↓

NPK Fertilizer

Advantages

- Balanced nutrient supply
- Higher crop yield
- Easy application
- Efficient nutrient use

Uses

- Field crops (rice, wheat, maize)
- Horticultural crops
- Plantation crops

Pesticides – Classification with Examples

Definition

Pesticides are chemical substances used to **prevent, destroy, repel, or control pests** that damage crops, stored products, and public health.

Classification of Pesticides

1. Based on the Type of Pest Controlled

a) Insecticides

Used to control insects

- Examples: **DDT, Malathion, Carbaryl, Chlorpyrifos**

b) Herbicides

Used to control weeds

- Examples: **2,4-D, Atrazine, Glyphosate**

c) Fungicides

Used to control fungal diseases

- Examples: **Bordeaux mixture, Mancozeb, Carbendazim**

d) Rodenticides

Used to control rats and mice

- Examples: **Zinc phosphide, Warfarin**

e) Nematicides

Used to control nematodes

- Examples: **Aldicarb, Carbofuran**

2. Based on Chemical Nature

a) Inorganic Pesticides

- Examples: **Sulphur, Copper sulphate, Arsenic compounds**

b) Organic Pesticides

i) Organochlorines

- Examples: **DDT, BHC, Aldrin**

ii) Organophosphates

- Examples: **Malathion, Parathion**

iii) Carbamates

- Examples: **Carbaryl, Aldicarb**

iv) Synthetic Pyrethroids

- Examples: **Cypermethrin, Permethrin**

3. Based on Mode of Entry

- **Contact pesticides:** DDT
- **Systemic pesticides:** Dimethoate
- **Stomach poisons:** Lead arsenate

Insecticides – Classification Based on Mode of Action

Insecticides are chemicals used to **kill or control insects**. Based on how they enter the insect body, they are classified as **stomach poisons, contact insecticides, and fumigants**.

1. Stomach Poisons

Definition

Stomach poisons are insecticides that **enter the insect body through the mouth** when the insect feeds on treated plant parts.

Mode of Action

- Insect eats poisoned food
- Poison affects the digestive system
- Leads to death of the insect

Examples

- Lead arsenate
- Paris green
- Cryolite
- Zinc arsenate

Uses

- Effective against **chewing insects** like caterpillars and beetles

2. Contact Insecticides

Definition

Contact insecticides kill insects when they **come in contact with the insect body**, without being ingested.

Mode of Action

- Penetrate through insect cuticle
- Affect nervous system or respiration

Examples

- DDT
- BHC
- Malathion
- Pyrethrum

Uses

- Used against **sucking insects** like aphids, mosquitoes, and lice

3. Fumigants

Definition

Fumigants are insecticides applied in the **gaseous or vapour form**.

Mode of Action

- Enter insect body through **respiratory system**
- Cause suffocation or nervous system failure

Examples

- Methyl bromide
- Aluminium phosphide
- Carbon disulphide

Uses

- Control pests in **stored grains, warehouses, and closed spaces**

Comparison Table

Type	**Mode of Entry**	**Examples**
Stomach poisons	Through mouth	Paris green, Cryolite
Contact insecticides	Through body surface	DDT, Malathion
Fumigants	Through respiration	Aluminium phosphide

Manufacture and Uses of Important Insecticides

1. DDT (Dichloro-diphenyl-trichloroethane)

Manufacture

DDT is prepared by **condensation of chloral with chlorobenzene** in the presence of concentrated sulphuric acid.

$CCl_3CHO + 2\ C_6H_5Cl \rightarrow DDT + H_2O$ (conc. H_2SO_4)

Uses

- Control of mosquitoes (malaria, typhus)
- Agricultural insecticide
- Household pest control *(Use restricted/banned in many countries due to persistence)*

2. BHC (Benzene Hexachloride / Lindane)

Manufacture

Prepared by **chlorination of benzene in the presence of sunlight**.

$C_6H_6 + 3\ Cl_2 \rightarrow C_6H_6Cl_6$ (sunlight)

Uses

- Control of soil insects and pests
- Treatment of seeds
- Public health insecticide

3. Pyrethrin

Manufacture

- Extracted from **dried flowers of Chrysanthemum cinerariaefolium**
- Obtained by solvent extraction

Uses

- Household insect sprays
- Control of flies, mosquitoes, and lice
- Safe insecticide due to low toxicity to humans

4. Aldrin

Manufacture

Prepared by **Diels–Alder reaction** between hexachlorocyclopentadiene and norbornadiene.

Hexachlorocyclopentadiene+Norbornadiene→Aldrin

Uses

- Control of soil insects
- Termite control *(Highly toxic; now banned/restricted)*

5. Pentachlorophenol (PCP)

Manufacture

Prepared by **chlorination of phenol** in the presence of catalysts.

$C_6H_5OH + 5\ Cl_2 \rightarrow C_6Cl_5OH + 5\ HCl$

Uses

- Wood preservative

- Fungicide and herbicide
- Control of termites and insects

Fungicides – Bordeaux Mixture, Lime Sulphur and Creosote Oil

Definition

Fungicides are chemical substances used to **prevent or destroy fungal diseases** affecting crops, seeds, and timber.

1. Bordeaux Mixture

Composition

- Copper sulphate ($CuSO_4$)
- Quick lime [$Ca(OH)_2$]
- Water

Preparation

Prepared by mixing **aqueous copper sulphate solution** with **milk of lime** in the correct proportion.

$CuSO_4 + Ca(OH)_2 \rightarrow Cu(OH)_2 + CaSO_4$

- Copper hydroxide formed acts as the fungicide.

Uses

- Control of fungal diseases in **grapes, potatoes, tomatoes**
- Protection against **downy mildew**
- Used in orchards and plantations

2. Lime Sulphur

Composition

- Calcium polysulphides

Preparation

Prepared by boiling **quick lime and sulphur** with water.

$Ca(OH)_2 + S \rightarrow CaS_x + H_2O$

(where x=2–5)

Uses

- Control of **powdery mildew**
- Acts as fungicide and insecticide
- Used on fruit trees and vegetables

3. Creosote Oil

Composition

- Mixture of phenols and aromatic hydrocarbons
- Obtained from **coal tar distillation**

Preparation

- Extracted as a fraction during **fractional distillation of coal tar**

Uses

- Fungicide for **wood preservation**
- Protection of timber from **fungi and insects**
- Used for railway sleepers, poles, and fences.

Comparison Table

Fungicide	Main Component	Major Use
Bordeaux mixture	Copper hydroxide	Crop disease control
Lime sulphur	Calcium polysulphide	Mildew control
Creosote oil	Phenolic compounds	Wood preservation

UNIT-IV

OILS, SOAPS AND DETERGENTS

Oils

Definition

Oils and fats are naturally occurring organic substances belonging to the class of lipids. They are mainly esters of glycerol with fatty acids, known as triglycerides.

- **Oils** → liquid at room temperature
- **Fats** → solid at room temperature

Fats and Oils

Property	**Fats**	**Oils**
Physical state	Solid	Liquid
Fatty acids	Saturated	Unsaturated
Melting point	High	Low

Constituents of Oils and Fats

1. Glycerol

- A trihydric alcohol ($C_3H_5(OH)_3$)

2. Fatty Acids

Long-chain carboxylic acids

a) Saturated Fatty Acids

- Palmitic acid
- Stearic acid

b) Unsaturated Fatty Acids

- Oleic acid
- Linoleic acid
- Linolenic acid

General Structure of Oils and Fats

Triglyceride=Glycerol+3Fatty acids

Sources of Oils and Fats

1. Vegetable Sources

- Groundnut oil
- Coconut oil
- Mustard oil
- Sunflower oil
- Soybean oil

2. Animal Sources

- Butter
- Ghee
- Lard
- Fish oil

Uses

- Cooking and food preparation
- Soap and cosmetic manufacture
- Lubricants and pharmaceuticals

Difference between Oils and Fats

Basis	Oils	Fats

Basis	Oils	Fats
Physical state	Liquid at room temperature	Solid or semi-solid at room temperature
Nature of fatty acids	Contain more **unsaturated fatty acids**	Contain more **saturated fatty acids**
Melting point	Low melting point	High melting point
Source	Mostly **vegetable origin**	Mostly **animal origin**
Iodine value	High (more unsaturation)	Low (less unsaturation)
Examples	Groundnut oil, coconut oil, sunflower oil	Butter, ghee, lard

Manufacture of Vegetable Oils

(Cottonseed Oil, Sunflower Oil and Soyabean Oil)

The manufacture of these edible oils follows similar basic steps, with minor variations depending on the seed.

1. Manufacture of Cottonseed Oil

Steps Involved

1. Cleaning
    - Cottonseeds are cleaned to remove dirt, hulls, and foreign matter.
2. Decortication
    - Removal of seed coats (hulls) to obtain kernels.
3. Cooking / Conditioning
    - Kernels are heated to coagulate proteins and release oil.
4. Oil Extraction
    - Done by:
        - Mechanical pressing, or

        - Solvent extraction (using hexane)

5. Refining
    - Crude oil is refined to remove gossypol, free fatty acids, colour and odour.
6. Bleaching and Deodorization
    - Improves colour, taste, and shelf life.

2. Manufacture of Sunflower Oil

Steps Involved

1. Cleaning and Dehulling
    - Removal of impurities and seed hulls.
2. Crushing
    - Seeds are crushed into flakes.
3. Cooking
    - Flakes are heated to rupture oil cells.
4. Extraction
    - Mechanical pressing or solvent extraction (hexane).
5. Refining
    - Neutralization, washing, and drying.
6. Bleaching and Deodorization
    - Produces clear, odourless edible oil.

3. Manufacture of Soyabean Oil

Steps Involved

1. Cleaning
    - Removal of dust, stones, and broken seeds.
2. Cracking and Dehulling

- Seeds are cracked and hulls removed.

3. Flaking
    - Cracked seeds are rolled into thin flakes.
4. Solvent Extraction
    - Oil extracted using hexane.
5. Desolventization
    - Removal of solvent from oil and meal.
6. Refining
    - Removal of gums (degumming), free fatty acids, colour, and odour.

Soaps

Definition

Soaps are **sodium or potassium salts of higher fatty acids** (like palmitic, stearic, or oleic acid) prepared by the **saponification of fats or oils** with alkalis.

Manufacture of Soaps

Saponification Process

Fats or oils are boiled with **sodium hydroxide (NaOH)** or **potassium hydroxide (KOH)**.

Chemical Reaction

Fat (Triglyceride)+3 NaOH→Glycerol+3 Sodium fatty acid (Soap)

Steps in Soap Manufacture

1. **Boiling**
    - Oils/fats heated with alkali in large kettles.
2. **Salting Out**
    - Common salt (NaCl) added to separate soap from glycerol.
3. **Washing**

- Removes excess alkali and impurities.

4. **Finishing**
   - Addition of perfume, colour, and fillers.
   - Soap is moulded and cut into bars.

Types of Soaps

1. Hard Soaps

- Sodium salts of fatty acids
- Example: Toilet soap

2. Soft Soaps

- Potassium salts of fatty acids
- Example: Liquid soaps

3. Toilet Soaps

- Contain perfumes and antiseptics

4. Medicated Soaps

- Contain germicidal agents
- Example: Sulphur soap

5. Laundry Soaps

- Used for washing clothes

6. Transparent Soaps

- Contain glycerol and alcohol

Specific Uses of Soaps

Type of Soap	**Uses**
Toilet soap	Bathing and personal hygiene

Type of Soap	Uses
Laundry soap	Washing clothes
Medicated soap	Skin diseases
Liquid soap	Hand wash and shampoos
Shaving soap	Producing lather for shaving

Detergents

Definition of Detergents

Detergents are synthetic cleansing agents made from petroleum products, which are capable of removing dirt and grease from surfaces even in hard and acidic water.

1. Difference between Soaps and Detergents

Basis	Soaps	Detergents
Chemical nature	Na^+ / K^+ salts of fatty acids	Salts of sulphonic acids or sulphates
Action in hard water	Form scum, less effective	Effective, no scum formation
Source	Natural fats and oils	Synthetic chemicals
Biodegradability	Biodegradable	Some are non-biodegradable
Cleansing efficiency	Lower in hard water	High in all types of water
Examples	Sodium stearate	Sodium alkyl benzene sulphonate

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2. Synthetic Detergents

Definition

Synthetic detergents are cleansing agents prepared from **petroleum products**, capable of cleaning even in **hard and acidic water**.

3. Surface Active Agents (Surfactants)

Definition

Surface active agents are substances that **reduce surface tension** of water and enhance wetting, emulsification, and cleaning.

Structure

- **Hydrophobic tail** → dissolves grease
- **Hydrophilic head** → dissolves in water

4. Classification of Detergents

A. Anionic Detergents

Nature

- Negatively charged hydrophilic group

Examples

- Sodium alkyl benzene sulphonate
- Sodium lauryl sulphate

Uses

- Household washing powders
- Shampoos and dishwashing liquids

B. Cationic Detergents

Nature

- Positively charged hydrophilic group

Examples

- Cetyl trimethyl ammonium bromide (CTAB)
- Quaternary ammonium salts

Uses

- Fabric softeners
- Germicides and disinfectants

C. Non-ionic Detergents

Nature

- No electrical charge

Examples

- Fatty alcohol ethoxylates
- Alkyl phenol ethoxylates

Uses

- Dishwashers
- Textile and cosmetic industries

5. Cleaning Action of Detergents

- Detergent molecules form **micelles** in water
- **Hydrophobic tails** attach to grease
- **Hydrophilic heads** remain in water
- Grease is emulsified and washed away

Applications of Detergents

- Household cleaning
- Textile processing
- Food and dairy industries
- Pharmaceuticals and cosmetics
- Industrial cleaning

UNIT-V

MATCH AND SILICATE INDUSTRIES

Match Industry

Definition

The **match industry** deals with the **manufacture of safety matches**, which produce fire by friction and are used for lighting stoves, lamps, candles, and fireworks.

Raw Materials Used

- **Wood** (splints): soft wood like poplar or aspen
- **Match head chemicals**:
  - Potassium chlorate (oxidizing agent)
  - Antimony trisulphide (fuel)
  - Sulphur or paraffin wax
  - Glue or starch (binder)
- **Striking surface**:
  - Red phosphorus
  - Powdered glass
  - Binder (resin or glue)

Manufacture of Safety Matches

1. Preparation of Splints

- Wood logs are cut into thin splints

- Dried and treated with **ammonium phosphate** (fire retardant)

2. Paraffin Dipping

- Splints dipped in molten paraffin wax
- Helps smooth ignition

3. Preparation of Match Head

- Mixture of:
    - Potassium chlorate
    - Antimony trisulphide
    - Sulphur
    - Binder and colouring agents

4. Dipping of Splints

- Ends of splints dipped into match head paste

5. Drying

- Matches are dried under controlled conditions

6. Preparation of Striking Surface

- Made from **red phosphorus + powdered glass + binder**

7. Packing

- Matches are packed into matchboxes

Chemical Principle of Safety Match

- On striking, **red phosphorus → white phosphorus**
- White phosphorus reacts with **potassium chlorate**
- Produces heat and flame

Uses

- Domestic lighting and cooking
- Industrial and laboratory use
- Fireworks and ignition purposes

Types of Matches – Composition of Match Head and Striking Surface

Types of Matches

1. Safety Matches

- Ignite **only when rubbed on the prepared striking surface**
- Safer to handle and store

2. Strike-Anywhere Matches

- Can be ignited on **any rough surface**
- More sensitive and less safe than safety matches

Composition of Match Head

A. Safety Match Head

- **Potassium chlorate** → Oxidizing agent
- **Antimony trisulphide (Sb_2S_3)** → Fuel
- **Sulphur / paraffin wax** → Helps ignition
- **Glue or starch** → Binder
- **Colouring agents** → Appearance

B. Strike-Anywhere Match Head

- **Potassium chlorate** → Oxidizer
- **White phosphorus** → Ignition material
- **Antimony trisulphide** → Fuel

- **Glue** → Bind

Composition of Striking Surface (Safety Matches)

- **Red phosphorus** → Converts to white phosphorus on friction
- **Powdered glass / sand** → Provides friction
- **Antimony trisulphide** → Fuel
- **Binder (resin or glue)** → Holds materials together

Chemical Principle

- Friction converts **red phosphorus to white phosphorus**
- White phosphorus reacts with **potassium chlorate**
- Heat produced ignites the match

Comparison Table

Feature	Safety Match	Strike-Anywhere Match
Ignition	Only on box	Any rough surface
Phosphorus location	On box	In match head
Safety	High	Low

Manufacture of Coloured Matches

Coloured matches are **safety matches** in which the **match head is coloured** (red, green, blue, etc.) by adding suitable pigments. The **basic manufacturing process is similar to safety matches**, with an additional colouring step.

Steps in the Manufacture of Coloured Matches

1. Preparation of Wooden Splints

- Soft wood (poplar/aspen) is cut into thin splints
- Splints are dried and treated with **ammonium phosphate** (fire retardant)

2. Paraffin Dipping

- Splints are dipped in **molten paraffin wax**
- Helps smooth and easy ignition

3. Preparation of Coloured Match Head Paste

The paste contains:

- **Potassium chlorate** – oxidizing agent
- **Antimony trisulphide** – fuel
- **Sulphur** – ignition aid
- **Glue or starch** – binder
- **Colouring pigments** – iron oxide (red), ultramarine (blue), chrome green, etc.

4. Dipping of Match Heads

- Paraffin-coated splints are dipped into the **coloured match head paste**
- Ensures uniform coating

5. Drying

- Matches are dried in controlled chambers
- Prevents cracking and improves strength

6. Preparation of Striking Surface

- Made from:
    - **Red phosphorus**
    - **Powdered glass**
    - **Binder (glue/resin)**
- Applied to the sides of matchboxes

7. Packing

- Dried coloured matches are filled into matchboxes
- Packed and sealed for distribution

Pyrotechnics and Explosives

Pyrotechnics

Definition

Pyrotechnics is the science and technology of producing **heat, light, sound, smoke, or gas** by controlled chemical reactions, mainly used for **fireworks, signals, and entertainment**.

Applications

- Fireworks and crackers
- Signal flares and distress signals
- Military illumination and smoke screens

Explosives

Definition

Explosives are substances which, on application of heat, shock, or friction, undergo **rapid chemical decomposition** producing **large volumes of gases, heat, and pressure**.

Classification of Explosives

1. Low Explosives

- Burn rapidly (deflagration)
- Used as propellants

Example: Gun powder

2. High Explosives

- Detonate with very high velocity
- Used in military and mining

Examples: TNT, RDX, Ammonium nitrate (when sensitized)

Characteristics of a Good Explosive

- High explosive power

- Controlled sensitivity
- High detonation velocity
- Chemical stability
- Safe storage and handling

Important Explosives

1. TNT (Trinitrotoluene)

Chemical Name

2,4,6-Trinitrotoluene

Characteristics

- Yellow crystalline solid
- Low sensitivity to shock
- High explosive power

Uses

- Military explosives
- Mining and demolition

2. RDX (Cyclotrimethylene Trinitramine)

Chemical Name

Hexogen

Characteristics

- Very high detonation velocity
- More powerful than TNT
- Sensitive but stable with additives

Uses

- Military explosives
- Plastic explosives (C-4)

3. Gun Powder (Black Powder)

Composition

- Potassium nitrate (KNO_3) – oxidizer
- Charcoal (C) – fuel
- Sulphur (S) – ignition aid

Characteristics

- Low explosive
- Burns rapidly

Uses

- Firearms
- Fireworks
- Fuses

4. Ammonium Nitrate (NH_4NO_3)

Characteristics

- White crystalline solid
- Powerful oxidizer
- Low sensitivity

Uses

- Fertilizer
- Explosives (ANFO)
- Mining and blasting

Comparison Table

Explosive	Type	Major Use
TNT	High explosive	Military
RDX	High explosive	Plastic explosives
Gun powder	Low explosive	Firearms, fireworks
Ammonium nitrate	High (with fuel)	Mining, blasting

Silicate Industry

Definition

The **silicate industry** deals with the manufacture and use of **silicate-based materials** such as **glass, ceramics, cement, refractories, and enamels**, which are produced mainly from **silica (SiO_2)** and silicate compounds.

Important Raw Materials

- **Silica (sand)** – main constituent
- **Alumina (Al_2O_3)** – strength and durability
- **Lime (CaO)** – flux
- **Soda ash (Na_2CO_3)** – flux
- **Magnesia (MgO)** – refractory property

Main Products of the Silicate Industry

1. Glass Industry

Composition (Soda-lime glass)

- Silica (SiO_2)
- Soda ash (Na_2CO_3)
- Lime ($CaCO_3$)

Manufacture (Brief)

- Mixing → Melting → Fining → Shaping → Annealing

Uses

- Bottles, window panes, laboratory glassware

2. Cement Industry

Raw Materials

- Limestone
- Clay or shale

Manufacture

- Crushing → Grinding → Burning in rotary kiln → Clinker formation → Grinding with gypsum

Uses

- Construction of buildings, roads, dams

3. Ceramics Industry

Raw Materials

- Clay, feldspar, quartz

Products

- Bricks, tiles, porcelain, sanitary ware

4. Refractories

Definition

Materials that withstand **very high temperatures** without deformation.

Examples

- Silica bricks

- Fire clay bricks

5. Enamels

Definition

Vitreous coatings applied on metals.

Uses

- Utensils
- Chemical vessels
- Decorative articles

Importance of Silicate Industry

- Backbone of construction industry
- Essential for household and industrial products
- Supports infrastructure and manufacturing sectors

Cement

Cement – Definition

Cement is a finely powdered inorganic binding material which, when mixed with water, forms a paste that sets and hardens due to chemical reactions (hydration) and binds other materials such as sand and aggregates into a solid mass. It hardens both in air and under water, hence it is called a hydraulic binder.

1. Types of Cement

1. **Ordinary Portland Cement (OPC)**
   - General construction work
2. **Portland Pozzolana Cement (PPC)**
   - Contains pozzolanic materials (fly ash)
3. **Rapid Hardening Cement**
   - Gains strength quickly

4. **Low Heat Cement**
    - Used in dams and massive structures
5. **Sulphate Resistant Cement**
    - Resists sulphate attack
6. **White Cement**
    - Decorative purposes

2. Composition of Portland Cement

Oxide Composition

Constituent	**Percentage**
Lime (CaO)	60–65%
Silica (SiO_2)	20–25%
Alumina (Al_2O_3)	5–10%
Iron oxide (Fe_2O_3)	2–5%
Magnesia (MgO)	1–3%
Gypsum ($CaSO_4 \cdot 2H_2O$)	3–5%

Main Compounds Formed

- Tricalcium silicate (C_3S)
- Dicalcium silicate (C_2S)
- Tricalcium aluminate (C_3A)
- Tetracalcium aluminoferrite (C_4AF)

3. Manufacture of Portland Cement

Steps Involved

1. **Crushing and Grinding**
   - Limestone and clay crushed and ground to fine powder
2. **Mixing**
   - Raw materials mixed in correct proportion (dry or wet process)
3. **Burning**
   - Mixture fed into a **rotary kiln** (1400–1500°C)
   - Forms hard nodules called **clinker**
4. **Cooling**
   - Clinker cooled rapidly
5. **Grinding**
   - Clinker ground with **3–5% gypsum**
   - Produces Portland cement

Flow Chart

Crushing → Grinding → Mixing → Burning (Kiln)

→ Clinker → Cooling → Grinding + Gypsum → Cement

4. Setting of Cement

Definition

Setting of cement is the process by which cement paste **loses plasticity and gains hardness** after mixing with water.

Chemical Reactions Involved

1. **Hydration of Tricalcium Silicate**

$$2(3CaO\cdot SiO_2)+6H_2O\rightarrow 3CaO\cdot 2SiO_2\cdot 3H_2O+3Ca(OH)_2$$

2. **Hydration of Dicalcium Silicate**

$$2(2CaO\cdot SiO_2)+4H_2O\rightarrow 3CaO\cdot 2SiO_2\cdot 3H_2O+Ca(OH)_2$$

Role of Gypsum

- Prevents **flash setting**
- Controls setting time

Ceramics

1. Introduction

Ceramics are **inorganic, non-metallic materials** produced by shaping and firing **clay or other mineral substances** at high temperatures. They are generally **hard, brittle, heat-resistant, and chemically stable**.

2. Types of Ceramics

A. Traditional Ceramics

- Made from natural raw materials
- Examples: **Bricks, tiles, pottery, porcelain, sanitary ware**

B. Advanced (Engineering) Ceramics

- Made from high-purity compounds
- Examples: **Al_2O_3, SiC, Si_3N_4, ZrO_2**
- Used in aerospace, electronics, cutting tools

3. Manufacture of Ceramics

Steps Involved

1. **Preparation of Raw Materials**
   - Clay, silica, feldspar are crushed and ground
2. **Mixing**
   - Raw materials mixed with water to form plastic mass
3. **Shaping**
   - Moulding, extrusion, or pressing
4. **Drying**

    - Removes free moisture

5. **Firing (Kiln)**
    - Heated at **900–1600°C**
    - Gives strength and hardness
6. **Glazing (Optional)**
    - Improves appearance and waterproofing

4. Applications of Ceramics

- Building materials (bricks, tiles)
- Electrical insulators
- Tableware and sanitary ware
- Heat-resistant components
- Biomedical implants

5. Refractory Materials

Definition

Refractories are ceramic materials that **withstand very high temperatures** without softening, melting, or reacting chemically.

Characteristics of Refractories

- High melting point
- Thermal shock resistance
- Chemical stability
- Low thermal conductivity

Types of Refractories

1. **Acidic Refractories**
    - Silica bricks

    - Used in glass furnaces

2. **Basic Refractories**
    - Magnesite, dolomite
    - Used in steel making furnaces

3. **Neutral Refractories**
    - Chromite, alumina
    - Used in various industrial furnaces

Applications of Refractories

- Lining of furnaces and kilns
- Metallurgical industries
- Cement and glass industries

Glass

1. Definition

Glass is an **amorphous, transparent or translucent inorganic solid** produced by **melting silica with suitable fluxes and stabilizers** and then **cooling rapidly without crystallization**.

2. Composition of Glass

Basic Constituents

1. **Glass Former**
    - **Silica (SiO_2)** – main constituent (≈70–75%)

2. **Flux**
    - **Soda ash (Na_2CO_3)** or **Potash (K_2CO_3)**
    - Lowers melting point of silica

3. **Stabilizer**
    - **Lime (CaO)** or **Magnesia (MgO)**

    - Improves durability and hardness

4. **Other Additives (Optional)**
    - **Al_2O_3** – increases strength
    - **B_2O_3** – heat resistance
    - **Metal oxides** – colour

3. Types of Glass

1. Soda–Lime Glass

- Composition: $SiO_2 + Na_2O + CaO$
- Uses: Window panes, bottles

2. Potash–Lime Glass

- Composition: $SiO_2 + K_2O + CaO$
- Uses: Laboratory glassware

3. Lead Glass (Flint Glass)

- Composition: $SiO_2 + PbO$
- Uses: Optical lenses, decorative items

4. Borosilicate Glass

- Composition: $SiO_2 + B_2O_3$
- Uses: Heat-resistant glassware (Pyrex)

5. Coloured Glass

- Contains metal oxides (CoO, Cr_2O_3, MnO_2)
- Uses: Decorative and signal lamps

Glass – Manufacturing, Properties, and Applications

1. Manufacturing of Glass Products

Raw Materials

- **Silica (SiO_2)** – glass former
- **Soda (Na_2CO_3)** – flux
- **Lime ($CaCO_3$)** – stabilizer
- Optional: Metal oxides for colouring, B_2O_3 for heat resistance

Steps in Glass Manufacture

1. **Batching**
   - Raw materials weighed and mixed in correct proportion
2. **Melting**
   - Mixture heated in a furnace at **1400–1600°C** to form molten glass
3. **Fining**
   - Removal of bubbles and impurities
4. **Shaping / Forming**
   - Techniques:
     - **Blowing** – bottles, vases
     - **Pressing** – tableware
     - **Drawing / Rolling** – window panes and sheets
5. **Annealing**
   - Slowly cooled in **annealing lehr** to relieve internal stresses
6. **Cutting / Polishing / Decoration**
   - Finished products are cut, polished, and optionally coloured or decorated

2. Physical Properties of Glass

- Transparent or translucent
- Brittle and hard
- Non-crystalline (amorphous)

- High melting point (≈1400–1600°C)
- Poor conductor of heat and electricity

3. Chemical Properties of Glass

- Chemically **inert to water**
- Resistant to most acids (except **HF**)
- Can react with **alkalis** slowly at high temperatures
- Insoluble in common solvents

4. Applications of Glass

1. **Household and Kitchenware**
    - Bottles, jars, tableware
2. **Construction**
    - Window panes, glass doors
3. **Laboratory Equipment**
    - Beakers, test tubes, burettes
4. **Decorative and Optical**
    - Mirrors, lenses, stained glass
5. **Electronics and Communication**
    - Fiber optic cables, TV screens, smartphone displays
6. **Chemical Industry**
    - Storage containers for acids and solvents
