III YEAR – V SEMESTER
COURSE CODE: 7BCHE2A

ELECTIVE COURSE II (A) INDUSTRIAL CHEMISTRY

Unit I

1.1.**Paints:** Paint definition classification of paints based on their applications – constituents Requisites of a good paint

1.2.**Pigments:** Definition composition, characteristics and uses of white lead. Zinc oxide Lithopone and TiO2 – Blue pigments Ultra marine blue – characteristics – uses. Red pigments – red lead –characteristics and uses. Green pigments – chrome green, Guigwet's green and chromium oxide characteristics and their uses.

1.3.**Varnishes:** Definition – constituents of varnish – characteristics of a good varnish – uses – Japans varnish. Enamel – definition – Types – Ingredients and uses.

Unit II

2.1.**Ceramics:** Definition, classification of ceramics, general properties of ceramics – permeable (porous) and impermeable (non porous wares) – Basic raw material – Manufacture – applications of colour to pottery.

2.2.**Glass:**Definition - physical and chemical properties of glass – raw materials – Manufacture – types of glasses.

2.3.**Cement:** Raw materials – Portland cement – composition – types of Portland cement – Manufacture – Uses of Cement - Cement Raw Materials in India – Growth of Cement Industry in India. Chemistry of setting of cements.

Unit III

3.1.**Soap:** Definition – General consideration in soap making – manufacture of soap – toilet and transparent soaps.

3.2.**Detergents:** Definition – classification of face active agents – anionic detergents – cationic detergents – shampoo – raw materials

3.3.**Refractories:-** Introduction, Classification – Properties – Manufacture – Fire clay bricks – manufacture – Uses

Unit IV

4.1.**Fertilizers:** Definition – manufacture of Ammonium sulphate, CAN. Manufacture of urea and estimation of urea. Manufacture of phosphoric acid. Manufacture of superphosphates and uses of phosphate as fertilizer. Mixed fertilizers (NPK) – Fertilizer industries in India.

4.2.**Sugar Industry:** Manufacture of sugar from molasses and beetroot – sugar industries in India. Fermentation: Manufacture of spirits and wines. Distillation: Manufacture of vinegar and ethyl alcohol.

4.3.**Match industries:** Manufacture – chemistry of lighting and pyrotechny

Unit V

5.1.**Adhesives:** definition – classification of adhesives – animal glue – preparation – uses– protein adhesives – starch adhesives – preparation – uses.

5.2.**Enamels:** Introduction – Raw Materials – Manufacture and Applications

5.3.**Explosives:** Definition – Classification – Characteristics of explosives – Nitro cellulose, T.N.T. Picric acid, Gun Powder, Cordite and Dynamite.

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SUBJECT CODE: 7BCHE2A

SUBJECT NAME: INDUSTRIAL CHEMISTRY

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PAINTS. PIGMENTS & VARNISHES

PAINTS :

Definition :

Paint is a mechanical dispersion of one or more pigments in medium (liquid, non-volatile, drying oil and thinner) when a metalic surface is painted. The Thinner evaporates while the drying oil forms a dry pigmented film after oxidised itself.

Classification of paints :

Paints are classified into several types are given below :

1) Emulsion paints :

Emulsion paint is a dispersion of rubber-like resin in water. It contains film-forming vehicle, pigment and extender. The main constituent of emulsion paint is stabilizer, drier and antifoaming agent. Emulsion paint provide.

(i) easy to apply on surface of metal or wood.
(ii) quick drying
(iii) more durable and
(iv) more impermeable and to dust and dirt.

2) Luminescent paints :

It contains luminor pigment which flurosec under the influence of UV light. Such pigments absorb UV and emit radiation in the visible region of the specturm.
Example : ZnS. sulphides of zn, cd, titania with a small amounts of colour modifier like Cu, Ag, Mn and B. called activators.

3) Heat-resistant paints :

Heat-resistance paints are paints that withstand temperature, even upto red heat.
composition : lamp-black-3kg, graphite -3kg, black oxide of Mn- 1kg - Japan gold zinc-1lit, turpentine -1.5 lit, boiled linsed oil -1 lit.

Heat-resistant paint is suitable for space technology. It is developed by NASA.

composition : TiO_2 (pigment) + water solution of an alkali metal silicates (vechicle), aluminium orthophosphate (wetting agent) and water (thinner)

uses : It is used as finishes of ovens, furnace, stills, air craft combustion chambers, diesel engine exhaust pipes, smoke-stacks.

4) Distempers :

Distempers are water paints.

ingredients : i) chalk powder (base) ii) glue (binder) iii) colouring pigments and iv) water (thinner)

uses : Distempers are used as finishing coat on:

i) white-washed surface on interior walls

ii) plastered surfaces of interior walls

iii) External surfaces of brick-works, concrete etc. after adding a weather resisting compound, at the time of mixing.

5) water repellent paints :

water repellent paints are made by hydrolysis and condensation of organoethoxy silianes and organo chloro silanes It is more durable. It can last for more

than 5 years.

b) coal-tar paints :

It consists of mixt of coal tar and spirit. It is applied on the surface at hot condition.

uses : It is used for protecting iron and steel surfaces and meterials, used under the ground.

7) Anti fouling paints :

Anti fouling agents : mercuric oxide, oxide, pentachloro Phenol, Phenyl mercury napthenate etc.

uses :

i) Antifouling paints are used in marine constructions.

ii) It retards the fouling of ships pies etc marine worm, fungi etc.

Consituents of paint :

1) pigment :

pigment are various Inorganic and organic Insoluble substance which of

different colours depanding upon the composition. it is used for surface coating

Example :

1. zinc oxide, white lead, lithophone, titanium dioxide are white pigments.

2. Red lead, ferric oxide, chrome red are red pigments.

3. chromium oxide is green pigments

4. carbon black is black pigments.

pigments provide :

i) strength to paint ii) protection to the film by reflecting harmful ultraviolet light iii) resistance against abrasion / wear iv) impermeability to moisture and v) Easthetic appeal to the paint film.

A good pigment should be :

i) opaque ii) chemicaly inert iii) non-toxic so that there is no bad effect on the health of painter as well as inhabitant iv) cheap and v) mixable with film forming constituent oils.

2) Extenders or fillers :

Extenders or fillers reduce the cost and increase the durability of the paint. Hence, it improves consistency, leveling and setting of paint they serve to fill voids in the film and act as carriers for pigment colour.

e.g : barite ($BaSO_4$) talc, asbestos, gypsum($CaSO_4$) etc.

3) Drying oil or film forming meterials :

Drying oil is also called vehicle. It is a film forming constituent. They are glycerides of higher fatty acids (saturated or unsaturated) dying oil may be vegetable oil. Drying oil absorbs oxygen and forms peroxides hydroperoxides etc. and forms tough coherent, insoluble and highly cross-linked structure on the surface.

They provide toughness, durability adhesion and water proofness to the film when paint is applied in the form of a film the dying oil absorbs oxygen form

air and forms peroxides and hydroperoxides at double bonds. These peroxides isomerise polymerise and condense to form a tough elastic, insoluble, infusible polymer film.

4) Driers :

The Driers acts as an oxygen carrier catalyst and accelerate the drying of the film through oxidation and polymerization processes.

Example : formarely, pbo are used as drier. modern dries are Co, Mn, Pb, Zn, resinleate, linoleate and naphthalenates.

5) Thinner :

Thinner is highly volatile liquid. It reduced viscosity of the paint and increases its elasciy. It increases the pentration power of drying oil. The common thinner is turpentine oil. Other thinners are benzene, mineral, spirit, xylol, kerosene etc.

6) plasticisers :

Plasticisers are used to increase elasticity and to minimise cracking.

Example : dibutyl phosphate, tricresyl phosphate, dibutyl tartrate etc.

7) Anti- skinning agent :

Anti-skinning agents prevent skinning and gelling of paint film.

example : polyhydroxy phenols.

Requirements or characteristic of good paint :

A good paint has the following qualities.

(i) It should be opaque and chemically inert.

(ii) It should have high covering power

(iii) It should form a tough, uniform and adherent film.

(iv) The coating of paint should not crack after drying.

(v) The ~~coat~~ should be non-toxic, stable and long life.

(vi) It should neither be oxidized nor reduced in environment.

(vii) The colour due to paint should be shining and stable.

(viii) various requirements of paints are controlled by pigment volume concentration (PVC) which is defind as.

PVC = (volume of pigment in paint / total volume of the constituent) x 100.

The PVC range of various paints are.

i) flat paints - 50 - 75%
ii) Exterior House paint - 28 - 36%
iii) metal primers - 25 - 40%
iv) wood primers - 35 - 40%

PIGMENTS :

Definition :

pigments are various inorganic and organic insoluble substances which are different colours depending upon the composition. It is used for surface coating.

Example :

1. zinc oxide, white lead, lithophone, titanium di oxide are white pigments.

2. Red lead, ferric oxide, chrome red are red pigments.

3. chromium oxide is green pigments.

4. carbon black is black pigments.

White pigments :

White lead :

white lead is basic lead carbonate. It is white pigment. The formula of white lead is $2PbCO_3 . Pb(OH)_2$.

Percentage composition :

$PbCO_3$ = 80.2 – 68.9 % and $Pb(OH)_2$ = 31.1%

Characteristics :

i) Covering powder : 38 sq. m/10 kg

ii) Refractive index : 1.94 – 2.09

iii) Oil absorption: 8 - 15 gm oil / 100g pigment

iv) tinting strength : 120 – 220

v) specific gravity : 6.7 - 6.8

vi) white lead is soluble in alkali.

uses :

i) white lead is used for the manufacture of paints.

ii) it has high covering power due to its high refractive index.

zinc oxide :

zinc oxide is white pigment. The chemical formula of zinc oxide is ZnO.

characteristics :

i) It is pure white

ii) covering power : 42 sq. m / 10kg

iii) Refractive index : 2 - 2105

iv) Oil absorption : 13 gm oil / 100g pigment

v) Tinting strength : 210

vi) specific gravity : much less than white lead

vii) Its colour is unaffected by gases in the atmosphere.

viii) it is soluble in acids.

ix) it is insoluble in oil and solvents.

x) it is opaque to UV-light

xi) its film is hard and bright

xii) it reacts with the linseed oil harden the film.

uses :

i) It is used as white pigment

ii) Its covering power is greater than white lead

iii) It is opaque to UV-light. Hence it protects the vehicles and prevents the chalking

Lithopone :

Lithopone is white pigment. It is a mixture of barium, sulphate and zinc sulphide.

percentage of composition:

The chemical composition of lithopone is

$BaSO_4$ - 71·5-72·5 %.

ZnS - 27·5-28

ZnO - below 1%

characteristics :

i) covering power - 95 sq·m/10kg

ii) oil absorption - 12-18 gm oil/100g pigment

iii) tinting strength - 280

iv) It turns temporarily grey on exposure to sun light.

uses :

i) It is a valuable white pigment

ii) It is used for cold water paints, traffic paints, floor covering and oil cloth industry.

Titanium dioxide :

Titanium dioxide is the whitest of white pigments. It replaces the other white pigment such as white lead. lithopone etc. due to its superior properties. Its chemical formula is TiO_2.

Characteristics :

1) Anatase variety,

i) covering power : 230 Sq·m/10kg

ii) Refractive index : 2.55

iii) oil absorption : 20-27 gm oil/100g pigment

iv) Tinting strength.

2) Rutile variety :

i) covering power : 363 Sq·m/10kg

ii) Refractive index : 2.07.

iii) oil absorption : 20-27 gmoil/100 g pigment

iv) Tinting strength : 1500 - 1650.

Uses : It finds applications in paints, paper, textiles etc, industries.

Blue pigments - ultramarine blue :

Ultramarine is a dark blue pigment. It is a complex silicate of aluminium

and sodium associated with about 12% sulphur.

composition:

The chemical formula of ultramarine blue is $Na_8 \cdot Al_6 Si_6 S_3 O_{12}$. The composition of ultramarine is not stoichiometric because the degree of exchange that takes place depends upon the various factors, such as concentration of solution time of heating etc.

Characteristics:

i) ultramarine blue is used as bluing is laundering to neutralize the yellowish tone in cotton and linen fabrics

ii) it is used for whitening paper and other products.

Red - pigment - Redlead.

The chemical formula of read lead is Pb_3O_4

Characteristics:

i) Read lead has a brilliant ~~red~~ colour

ii) it is stable to light.

iii) it has corrosion inhibition properties.

uses:

i) Red lead is used as a primary coat for structural steel.

iii) It is used for imparting red colours to the paste for making bangles

Green pigments

Chrome green or chromium oxide green:

Chrome green contains chromium sesquioxide (Cr_2O_3)

Characteristics:

i) chrome green is unaffected by acids and alkalies.

ii) It is stable in light and heat fast

iii) it has higher oil absorption

iv) it is more expensive.

Uses:

i) It is used as green pigments

ii) It is used in certain glazes, alkali proof, printing inks, cement, colours, rubber compounds, bridge paints etc.

Guignet's green:

guignet's green is hydrated chromium oxide. The chemical formula is $[Cr_2O(OH)_4]$.

Characteristics:

i) Guignet's green is much more brilliant green than the chromium oxide green.

(7) It is used in ceramic glazes, alkaliproof, printing inks, cements, colours, rubber compounds, bridge paint etc.

VARNISHES :

Definition :

A varnish is a homogeneous colloidal dispersion - solution of natural or synthetic resin in oil or thinner or both. When it is applied on surface, it gives a transparent crack free film. The film dries by evaporation, oxidation and polymerization of some portion of its constituents.

Constituents of varnishes :

1) Resins :

Resins may be natural or synthetic, natural resins are shellac, copal, kauri, manila, etc. synthetic resins are phenolic aldehydes, alkyd resins, mannitol esters, melamine, urea formaldehyde, chlorinated rubber, vinyl resins etc.

Resin in varnish provides in element of hardening, resistance to weathering, durability, resistance to chemical action and

water - proofness.

2) Drying oils :

principle oils used are linseer or undergo dehydrated castor oil, castor oil, fish oil, cottonseed oil, coconut oil, etc. They dry by oxidation or polymerization.

3) solvents or thinners :

Thinners is highly volatile liquid, it reduces viscosity of the varnishes and increases its elasticity it increases the peneration power of drying oil.

Example : turpentine oil, kerosene, napththas, xylene, toluene, alcohols etc.

4) Driers :

Driers are increased the rate of drying or hardening of varnish film. Example : ~~gaaroo~~, co, Mn, pb, zn, resinaleate, linoleate and naphthalenates.

5) Anti - skinning agents :

Anti - skinning agents prevent skinning and getting of varnish film.

Example : guaicol, tertiary amylphenol.

Characteristic of good varnishes :

A good varnish should possess the following characteristics.

i) It should be soft and tender

ii) It should adapt itself to the contraction or expansion of coated material like wood. due to the temperature variation.

iii) It dries quickly.

iv) It produces a protective film.

v) It produces glossy and shining film on drying.

vi) It should yield asthetical appealing film.

vii) It should yield elastic film.

viii) The colour of the film is not fade or change on exposure to atmospheric weather.

ix) it should not shrink or crack after drying.

Uses :

i) varnishes are used for protection of articles against corrosion.

ii) It is used as a brightening coat to painted surface

iii) It is used for improving the apperence and intensifying of the ornamental grains of wood surfaces.

Japans varnish :

Japans are special type varnishes They are added to the paint which gives a good colour and luster.

types of Japans :

Japans are two types They are painter's japan and decorative japan(opaque varnish).

1) painter's japan :

The painter's japan are made up of a resin dissolved in a drying oil containing drier and thinner. They give more luster of the paint

2) Decorative ~~paint~~ japan :

Linseed oil is heated with litharge at 230°c for about 5-6 h. the solid mass lead oil is obtained. The lead oil is

mixed with asphaltum and thinner like kerosene to obtain decorative japan.

uses :

Japan varnishes are used for such product as bicycles, bed steads and electrical devices.

ENAMELS :

Definition :

Enamel is an initimate dispersion of pigments in varnish. They dry into a very lustrous and glossy finish. Enamels have got very good flow. The object of preparing enamels is to get good gloss.

Types of enamels :

Enamels are classified into two types. They are oleoresinous enamel and resin enamel.

1) Oleoresinous enamel :

The following ingredients are used for making of oleoresinous enamel

i) Titanium - calcium pigments (30% TiO_2 and 70% of $CaSO_4$)

ii) Fine particle size $CaCO_3$

iii) Heat bodied linseed oil.

iv) Ester gum solution

v) cobalt naphthalenate (6% Co)

vi) Lead naphthalenate (24% Pb)

vii) mineral spirits.

pigment volume concentration of oleoresinous enamel is 35-5%. The non-volatile vehicle portion contains 52% oil and 48% of resin.

2) Resin enamel:

The following ingredients are used for making of white resin enamel.

i) Titanium dioxide

ii) fine particle size zinc oxide

iii) long - oil alkyd.

iv) Mineral spirit

v) cobalt naphthalenate (6% Co)

vi) Lead naphthalenate (24% Pb)

vii) calcium naphthalenate (4% Ca)

pigment volume concentration of white resin enamel is 27%

Uses :

i) Enamels are used in refrigerations, dairy and food processing equipments.

ii) It is used in hospital furniture, motor cars, sanitary wares etc

Unit - II

CERAMICS, GLASS AND CEMENT

Ceramics

Definition:- Ceramics are inorganic, non-metallic materials. It is possessed at high temperature. They include silicates, metallic oxides and their combination.

classification of ceramics:-

Ceramics are classified into three types, according to their common characteristics features. These are clay products, refractories and glasses.

(1) **clay Products:-** clay is hydrated aluminium silicates. The chemical formula is $Al_2Si_2O_7 \cdot 2H_2O$ clay products are divided into three types.

(i) **The Structural clay Products:-** It contains iron oxides. They are used for bricks, tiles and similar Products.

(ii) **The White Wares:-** It is paler substances such as Porcelain and china.

(iii) **chemical stone Wares:-** It has been specially treated to be hard, resilient and non-porous.

(2) **Refractories:-** Refractories are inorganic materials that can withstand high temperature without softening or undergoing any deformation in shape. **Examples:-** Silica,

alumina, fire-clay refractories, zirconia bricks etc.

Uses:- 1. Refractories are used for the construction of lining of the furnaces, kilns, crucibles etc.

(2). They are employed for the manufacture of cement, glass, ceramics, paper, metals etc.

(3) Glass:-

Glass is amorphous, hard, brittle, transparent, super-cooled liquid of infinite viscosity. It is obtained by fusing a mixture of a number of metallic silicates. It possesses no sharp melting point, definite formula or crystalline structure. It may be represented as $xR_2O.yMO.6SiO_2$ where x and y are number of moles, R is an alkali metal and M is a divalent metal. The composition of ordinary glass is $Na_2O.CaO.6SiO_2$.

Properties of ceramics:-

(1) Permeable or Porous wares:- Permeable ceramics Materials absorb water. It shows a rough fracture and sticks to the tongue when tested in this fashion. Example:- Heavy clay ware, refractory ware, terracotta and earthen.

(2) Impermeable or non-Porous wares:-

Impermeable ceramics materials absorb very little or none water. Example:- Stone ware, vitreous china and porcelain.

Manufacture of ceramics :-

Basic raw materials of ceramics :- The raw materials for making ceramics can be divided into three basic groups.

(i) Plastic materials - clay

(ii) Non plastic or leading and Mixtures - silica (Quartz, sand) cursed chamotte

(iii) fluxes or Mineralizes - Feldspar $(K,Na)_2O.Al_2O_3.6SiO_2$, $CaCO_3$, $MgCO_3$.

(1) Preparation of slip :- clay, feldspar, sand, etc, are Mixed with water and stirred in a rerolring blunger. A cream like paste is formed. It is known as slip. The slip is filtered through vibrating screen and removes the coarse materials.

(2) Filtering & Aging :- The slip is passed through filter paper. Water is removed and moist cake is obtained. The moist cake contains 10-30 % of water. The moist cake is stored in damp cellars for a few weeks. This is called aging of the slip. This process increases the elasticity of the clay.

(3) Shaping of the articles :- The shaping of the articles is done by Potters wheel. When cast is required, Na_2CO_3 or K_2CO_3 or Water glass is added to the clay.

(4) Drying the articles :- The articles are dried in air or warm air circulated chambers.

(5) firing :- During the process of firing the

Following changes occur:

(i) At 150 - 600°c, water is completely removed
(ii) At 800 - 900c, lime stone is decomposed
(iii) At 350 - 900c, ferrous salts and organic matters are oxidized.
(iv) At 1200 - 1300°c, Metallic oxides combine with silica to form metallic silicates. After the firing, the article is porous like biscuit. It is called biscuit.

(b) Glazing of biscuit:- Dipping, pouring, spraying, dusting, volatilization, etc., are the methods of applying the glazes on the articles. The biscuit is again fired in a furnace at a temperature 700 - 900°c. During firing, the article appears as smooth and shinning. SiO_2, Al_2O_3, lead oxide, cobalt oxide etc., are the examples of the glazes. The glazes at least one alkaline earth metal.

(7) colouring of the articles:- The colouring agent is mixed in glaze components. Example: Cobalt oxide - blue, copper oxide, chromium - green or red, iron oxide - yellow, organge or rod, gold chloride - pink MnO_2 - violet, TiO_2 - Fiant yellow, etc.

Applications of colors to Pottery:-

colour to the pottery are applied by the following methods..

(1) Painting (a) Hand - painting and
(b) Using banding
(2) spraying (3) Stenciling.

(4) Stamping (5) printing lithography (6) Silk Screen painting (7) Ground laying (8) Sgraffito decoration (9) Gilding (10) Relief decoration.

(1) painting :- (a) Hand painting :- This is old method of colouring of pottery. The colour is mixed with oil and turpentine. This is applied to the ware by the use of brush.

(b) Using banding :- Banding Machines contain three or more adjustable brushes. Each brush is connected with separate colour container. In this manner three or more bands of different colour can be made at the same time.

(2) Spraying :- Large coloured areas are produced by using spraying. The combining method of spraying and stencils are used for producing the white designs on coloured background.

(3) Stenciling :- Positive or negative Paper Pattern is produced on the surface of the articles. It is dipped into a coloured glaze or sprayed over with colour. The paper is removed subsequently.

(4) Stamping :- The rubber stamps are charged with colours from a pad covered with a layer of sticky pigment. The pattern is transferred to the ware by pressing the rubber stamp against surface of the ware.

(5) Printing :- A sticky mixture of the colouring material and linseed oil is spread over copper plates with the help of spatula. The plate is covered with a sheet of thin paper. It is placed

on a steam heating printing table. As a result the design is transferred to the paper. The paper pattern is rubbed on the pottery by rollers. The article is dipped in water and the paper is detached.

(b) Lithograph Printing:- Lithograph printing is art of drawing and printing from stone. It is used to incorporate the design on large coloured areas and several different colours.

(7) Silk screen Printing:- Silk screen consists in rubbing or squeezing colour through a pattern. This method is useful for printing patterns on both round and flat surfaces.

(8) Ground laying:- In this process the area is first covered with linseed oil and terpentine. The powder ceramic colour is dusted on the sticky surface and excess dust is blown off.

(9) Sgraffito decoration:- The fired article is covered with a thin layer of slip of a different colour. The covering layer is dried and scrapped off. The articles is then fired and glazed.

(10) Gilding:- The precious metallic powder such as gold, platinum, silver etc., are applied on ware as an overglaze decoration.

(11) Relief Carving:- The ornament is scratched from the surface. The scratched relieves are applied on the ceramic ware.

Glass:- Definition:- Glass is amorphous, hard, brittle, transparent, super-cooled liquid of infinite viscosity. It is obtained by fusing a mixture of a number of metallic silicates. It possesses no sharp melting point, definite formula or crystalline structure. It may be represented as $xR_2O.yMO.6SiO_2$ where x and y are number of moles, R is an alkali metal and M is a divalent metal. The composition of ordinary glass is $Na_2O.CaO.6SiO_2$.

Physical Properties of glass:-

(i) They are transparent or amphous solids.
(ii) Glass is completely vitrified Product.
(iii) They are hard and rigid.
(iv) They have no definite melting point.
(v) They have high viscosity, greater than 10^{13} Poise
(vi) They are insulator of heat & electricity
(vii) Can incorporate colouring material preserving transparency.

Chemical Properties:-

1. Glass is not affected by air & Oxiding agent.
2. Ordinary glass is resistant to acids except hydrofluoric acid.

$$Na_2O.SiO_2 + 6HF \rightarrow 2NaF + SiF_4 + 3H_2O$$
$$CaO.SiO_2 + 6HF \rightarrow CaF_2 + SiF_4 + 3H_2O.$$

3. ordinary glass is affected by alkalies.
4. ordinary glass is alkaline in reaction. The water slowly reacts on glass, to form NaOH. This reaction is enhanced in the Presence of acids.

5. If acids kept in glass bottles for long time, silicic acid is deposited on the glass of bottles. The glass is known as neutral glass like pyrex glass which contains small amount of alkali silicate.

6. Glass is fused with excess of fusion mixture. It decomposes to alkali silicates and carbonates of other metals. The resulting mass is cooled and treated with dil HCl to form silicic acid and chlorides of metals.

Manufacture of glass:-

Raw materials:- (1) Sodium is soda, Na_2CO_3 - soft glass

(2) Potassium is potash, K_2CO_3 - Hard glass.

(3) Calcium is limestone, chalk and lime.

(4) Lead is litharage and red lead - flint glass

(5) Silica is quartz, white sand and ignited flint

(6) Zinc is Zinc oxide - Heat & shock-proof glass

(7) Borate is borax & boric acid - Heat & shock-proof glass.

(8) Cullets or pieces of broken glass to increase the fusibility.

(9) colours:- (a) Yellow - ferric salt.

(b) Green - Ferrous & Chromium salts

(c) Blue - cobalt salts

(d) Purple - manganese salts

(e) Red - Nickel or Cu_2O

(f) Lemon yellow - CdS

(g) fluorescent greenish yellow - uranium oxide

(h) opaque milky white - cryolite or Calcium phosphate.

Manufacturing steps:- (1) Fusion of raw materials:-

Fine powder of Na_2CO_3, $CaCO_3$ and sand are mixed together in proper proportions, is called batch. This is mixed with pieces of scrap glass, which is known as cullets. These mixture are fused either in the pots of the pot furnace or in the tank of the tank furnace. The furnace is heated by producer gas, on the regenerative principle of heat. The following reaction takes place:

$$Na_2CO_3 + CaCO_3 + 6SiO_2 \rightarrow Na_2O \cdot CaO \cdot 6SiO_2 + 2CO_2 \uparrow$$

In beginning, considerable frothing is produced on account of the formation of CO_2. On continued heating, the whole of the CO_2 escapes out. A clear, viscuous, fused mass is obtained. To get coloured glass, colouring material is added. The mass is heated till it becomes homogenous.

(2) Shaping:- The fused mass is allowed to cool and then blown into moulds. The desired shape of the article is formed. If the sheet glass is required, it is between the rollers.

(3) Annealing:- The shaped glass articles are cooled slowly. This process is known as annealing. During this process, the molecules of glass arrange themselves without strain. If the articles are cooled quickly, they become brittle on account of high strain.

4) Finishing:- After annealing, the articles require some finishing touch such as cutting, grinding, polishing, etc. The finished products are sent to the market.

Types of glass:- (1) Soda glass or soft glass or ordinary glass: This is also called as window glass. It is a Mixture of potassium and sodium silicates. The chemical formula is $Na_2O.CaO.6SiO_2$

Preparation:-

$$Na_2CO_3 + CaCO_3 + 6SiO_2 \rightarrow Na_2O.CaO.6SiO_2 + 2CO_2$$

Properties:- (i) It softens at lower temperature and can be shaped into different shapes. Hence, it is called soft glass.

(ii) It is very slowly attacked by chemical reagent and water.

Uses:- It is used in making glass tubes, window panes, bottles, dishes, etc.

(2) Potash glass or hard glass:- This is also called as Bohemian glass. It is a Mixture of potassium and calcium silicates. The chemical formula is $K_2O.CaO.6SiO_2$.

Preparation:-

$$K_2CO_3 + CaCO_3 + 6SiO_2 \rightarrow Na_2O.CaO.6SiO_2 + 2CO_2\uparrow$$

Properties:- It is resistant to the action of water and acids.

Uses:- It is used in making combustion tubes and chemical apparatus which can withstand high temperature.

(3) Potash-lead glass or flint glass:- It is a Mixture of potassium and lead silicates. The chemical formula is $K_2O.PbO.6SiO_2$.

Preparation:- $K_2CO_3 + Red\ lead + 6SiO_2 \rightarrow K_2O.PbO.6SiO_2 + 2CO_2\uparrow$

Properties:- (i) It is lustrous and transparent product (ii) It has high refractive index. Hence, it is soft and scratches easily.

Uses:- It is used in making prisms, lenses, optical instruments, electric bulbs, etc.

(4) Jena glass:- (i) Jena glass is a mixture of barium and zinc boro-alumino silicates.

(ii) It contains $BaO.ZnO.Al_2O_3$ and B_2O_3.

(iii) It has low coefficient of expansion.

(iv) It is resistant to heat, shock, acid & alkali

(5) Pyrex glass:- (i) Pyrex glass is a mixture of boro and alumino silicates of Zn and Ba.

(ii) The composition is 80·1· of SiO_2, 4·1· of Na_2O, 0·5·1· of CaO, 0·5·1· of K_2O, 12·1· of B_2O_3 & 3·1· of Al_2O_3.

(iii) It can withstand sudden changes of temperature.

(iv) It is used in making laboratory glass wares such as flasks, beakers, etc.

(6) Crooke's glass:- (i) Crooke's glass contains oxides of Pb, Ba, Zn, Cd or Mg.

(ii) Cerium oxide is also added. This oxide cuts ultraviolet rays.

(iii) Thus, this glass used in making special type of lenses.

(7) Quartz glass or silica glass:- (i) Quartz glass is prepared by melting of silica in the electric furnace. (ii) It has low co-efficient of expansion.

(iii) It does not break.

(v) It can withstand a temperature of over 1000°C.

(v) It is resistant to chemical reagents.

(vi) It is used in making tubes, Crucibles, basins etc.

(vii) Vitreosil is an opalascent form of quartz glass.

(B) Crown glass :- A partial replacement of silica by P_2O_5 gives crown glass.

(9) Ground glass :- It is prepared by grinding ordinary glass by emery and turpentine oil or by sand blasting.

(10) Safety glass :- (i) Safety glass is prepared by a layer of transparent plastic between two layers of glass by means of suitable adhesives. Transparent plastic is a sheet of vinyl acetate resin. The three layers are joined together tightly by the action of heat and pressure.

(ii) It is does not breake under heavy impact.

(iii) This glass does not shatter because they are held by plastic.

The following table gives the different types of glass, their properties & uses :-

Sl. No	Type	Special additives	Property	Uses
1.	Soda glass	Aluminium oxide	Fuses easily at relatively low temperature	Window pane bottles, tumblers.
2.	Boro-silicate glass	Boron	Withstand high temperature fluctuation	Laboratory equipments

	Lead glass	Lead oxide, Potassium carbonate	Highly transparent; high refractive index; absorbs radiations	Lenses, prisms, window panels of nuclear installations.
4.	Coloured glass	Metal oxide	Choice of metallic oxide is decided by the colour to be imparted	window panels, decorative materials.
5.	Safety glass	Synthetic Plastic is sandwiched between two thin glass sheets	Withstands high stress, Sharpe edges are not formed when it break (it is splinter-proof).	Windshields of automobiles bullet-proof glass.
6.	Fibre glass	Molten glass is drawn into thin fibres & sheets prepared	Light, strong, and Fire Proof	Fire Proof curtain dresses, manufacture of parts of automobiles.

CEMENT

Definition:- A material possessing adhesive & cohesive properties, and capable of bonding other materials like stones, sand, bricks, building etc.; is called as cement. The cements have the property of setting and hardening under water some chemical reaction with it are, therefore called hydraullic Cement.

Manufacture:- Raw materials:-

1. Calcareous Materials like lime, chalk etc.,
2. Argillaceous materials like alumina, silica, Clay etc.

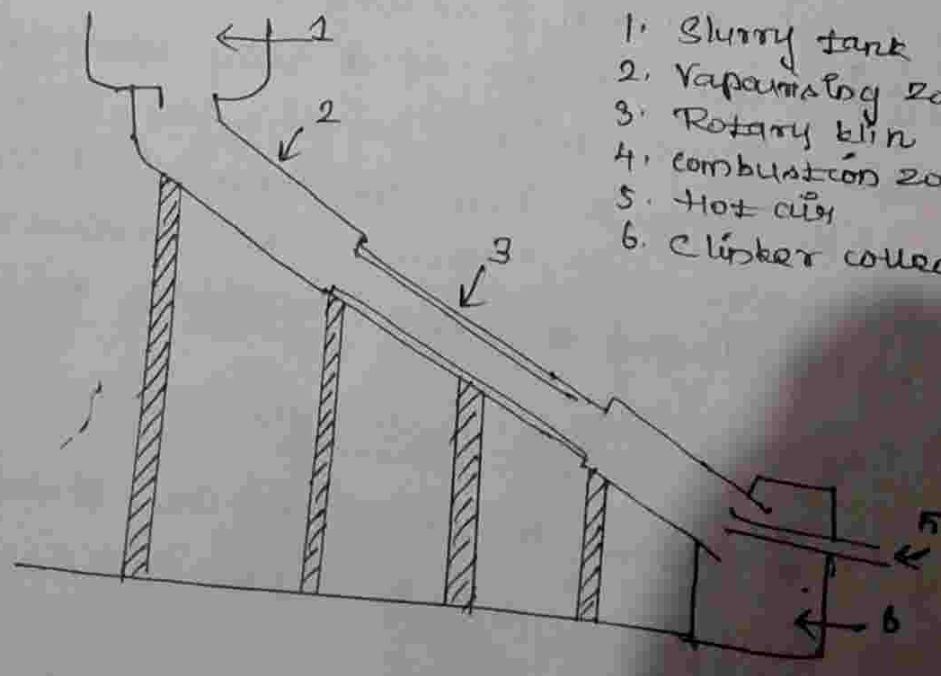
(3). Powdered coal. (4) Gypsum ($CaSO_4 \cdot 2H_2O$)

Manufacturing steps:- (1) Mixing of raw materials

(a) Dry Process:- Lime stone as well as clay are separately crushed into 2.5 cm size and converted into fine powder by ball mills. These powdered materials are mixed together and stored in storage bins (silos).

(b) Wet Process:- Lime stone are crushed and stored in big storage tank. Clay mixed with water and washed several times. Both materials are allowed to flow in a channel for grinding where they are converted to paste called Slurry. Slurry has 40% of water.

(2) Burning:- Raw mixture is burnt by rotary kiln. Rotary kiln is a steel tube; it has 3m diameter and 120m length. Its inside lined with refractory bricks and rotation speed of kiln is 1 rpm (rotation per minute). Hot flame is produced by injecting coal and air, about 1450°C. Raw mixture is injected into upper part of the kiln. Due to the slope of kiln, the mixture fed in moves towards the hottest end about 15 m per hour.



1. Slurry tank
2. Vaporising zone
3. Rotary kiln
4. combustion zone
5. Hot air
6. Clinker collector.

upper part:- water is evaporated at 400°c

Central part: Slurry is decomposed to form CaO and CO_2 at 1000°c.

Lower part: CaO reacted with silica, alumina and iron oxide at 1400°c.

The reaction as follows;

$2CaO + SiO_2 \rightarrow 2CaO \cdot SiO_2$ (Dicalcium silicate - C_2S)

$3CaO + SiO_2 \rightarrow 3CaO \cdot SiO_2$ (Tricalcium silicate C_3S).

$3CaO + Al_2O_3 \rightarrow 3CaO \cdot Al_2O_3$ (Tricalcium aluminate - C_3A).

$4CaO + Al_2O_3 + Fe_2O_3 \rightarrow 4CaO \cdot Al_2O_3 \cdot Fe_2O_3$ (Tetra Calciumalumino ferrite - C_4AF)

Aluminate and silicate of calcium fused together to form small hard (1 cm diameter), greyish stone called clinkers. These hot clinkers fall into another small rotary kiln and are cooled.

(3) Grinding:-

cooled clinkers are ground to a fine powder in a ball mills. During this time 3% gypsum is added. So cement does not set quickly if it comes in contact with water. Gypsum act as retarding agent for early setting of cement.

$$3CaO \cdot Al_2O_3 + 3(CaSO_4 \cdot 2H_2O) + 2H_2O \rightarrow 3CaO \cdot Al_2O_3 \cdot 3CaSO_4 \cdot 2H_2O + 6H_2O$$

(4) Packing:- The ground cement is stored in silos and packed automatically about 50 kg. The composition of the portland cement is calculated form.

$$\frac{CaO - 0.7SO_3}{2.8SiO_2 + 1.2Al_2O_3 + 0.65Fe_2O_3}$$

5) Setting and curing

Cement sets into a hard mass when Mixed with water. Therefore it makes an excellent binding material in construction work The Mixture of Sand and cement along with water undergoes many complex changes. The first Stage of Setting takes place within 24 hours after adding water to the cement.

The Second Stage of Setting requires about two weeks. The Subsequent Setting of cement is achieved by adding water The method of hardening cement by treating it with water is known as curing. During curing cement absorbs water. Calcium Silicate and aluminates of cement are converted into a colloidal gel. This process is exothermic; hence it requires continuous water treatment.

6) cement concrete

The mixture of cement gravel and Sand in the ratio of 1:2:4 or 1:3:6 is known as concre An iron Skeleton inside concrete gives mechani Strength to the Structure.

composition of portland cement

i) Lime, CaO = 50 - 60%.
ii) Silica, SiO_2 = 20 - 25%.
iii) Alumina, Al_2O_3 = 5 - 10%.
iv) Magnesia, MgO = 2 - 3%.
v) Ferric oxide, Fe_2O_3 = 1 - 2%.
vi) Sulphur trioxide, SO_3 = 1 - 2%.
vii) Sodium oxide, Na_2O = 1%.
viii) Potassium oxide, K_2O = 1%.

Types of portland cement

portland cement are divied into five types. It contains varying amount of clinker compounds, dicalcium silicate (C_2S), tricalcium silicate (C_3S), tricalcium aluminate (C_3S), tetracalcium aluminoferrite (C_4AF) and MgO.

1) Regular portland cements.

They are usual products for general concrete construction and harden to full strength in about 28-30 days. They contain 40-60% C_3S, 10-30% C_2S and 7-13% C_3A.
Example: White cement, oil well cement, etc.

2) Modified portland cements.
These are sulphate resistant cement. The heat evolved from these cement should not exceed 70 and 80 cal/gm after 7 and 28 days respectively.

These cements are characterized by higher ratio of C_2S and C_3S.

3) High early strength portland cements:

These cements contain higher percentage of C_3S and C_3A. The higher proportion of C_3S causes quicker hardening than regular portland cement. Thus this cement attains strength is only three days.

4) Low heat portland cements. Thus, this cement attains strength is only three days.

4) Low heat portland cements.

These cements contain lower percentage of C_3A. The heat evolved should not exceed 60 and 70 cal/gm after 7 and 28 days respectively. These cements are designed for massive structure work.

5) Sulphate resisting portland cement

These are good for sea water contact. It resists the sulphates better than the other types. These cements contain lower percentage of C_3A and higher percentage of C_4AF. It

is used for structural purposes.

uses of cements

i) cements are used in the construction of roads, buildings, dams, bridges, etc. for construction purpose, it is used in the form of a paste with sand and water.

ii) concrete is a mixture of cement, sand, gravel and water. The concrete sets to a hard mass. Hence, it is used in foundations, floors, roads, walls of buildings, dams, bridges and building of roofs.

iii) concrete is filled in and around skeleton of iron rods and allowed to set. The resulting structure is very hard and rigid. This is known as reinforced concrete. Reinforced concrete is used in the construction of bridges and roofs.

Raw Materials in India

1) Lime Stone

Lime Stone deposits are common in every State in India, except, perhaps, Kerala.

Madhya pradesh: High grade lime stone - Jabalpur, cement and flux grade lime stone - Dewa and cement grade lime stone - Akaltara, Mahali, Kawardah, Beladih and Chattisgarh.

Tamilnadu: cement grade lime stone - Ramanatha puram Tirunelveli, Tiruchirapalli, Salem, coimbatore and madurai districts.

In Andra pradesh: cement grade lime stone - Nalgonda district.

In Gujarat: Cement grade limestone - Kherad and Garapipla

In Haryana: cement grade lime stone

In Himachal Pradesh:- Cement grade lime stone - Bilaspur district.

In utter Pradesh:- High grade lime stone - Dehradun and Mussoorie area

In Bihar: Cement grade lime stone - Bundu, Basaria and kurkeita - Religara area of Hazaribagh district.

(2) clay:- In India best quality of china clay occurs at kundara in kerala and singhbhum in Bihar. china clay is also occurs at karnataka, Tamil Nadu, west bengal, Rajasthan, Himachala Pradesh, Andra Pradesh and Haryana.

Good quality of fire clay is found in Bihar, orissa, madya pradesh, Gujarat, Maharashtra, Andhra pradesh, karnataka and Rajasthan.

Growth of cement industry in India :-

(1) Responsible for 7.8 % of global cement production, India is the second largest cement market in the world, and also an exported to 30 countries.

(2) The cement industry in india is divided into five geographical segments. These are North, South, East, west and central regions.

(3) North and south regions are the leading suppliers of cement.

(4) The East, West and central regions face deficit of cement. Hence, these regions purchase the cement from the North and South.

(5) According to the cement Manufacturer's Association (CMA), there are 139 large cement plants and 365 mini and white cement plants in the country.

(6) According to the cement manufactures Association (CMA), cement sales for may 2012 were registered at 16.26 million tonnes (MT), which signifies a 14 % growth over the same period in 2011.

(7) Although India is one of the largest cement Markets in the world, its per capita consumption is only around 170 kg, Much lower than the global average consumption of about 430 kg.

(8) According to the latest report from the working group on the industry for the 12th

Five-year plan (2012-17), India would require overall cement capacity of around 480 million tonnes.

(9) This would mean the industry will have to add another 150 million tonnes of capacity during the period.

(10) Leading players in the sector (by market share) are Shree chem, Uttartech Ambuja, Binani, ACC, India cem, Dalmia cem, Madras cem, Lafarge, and ucl India.

Unit - II.

Soap, Detergents and Refractories.

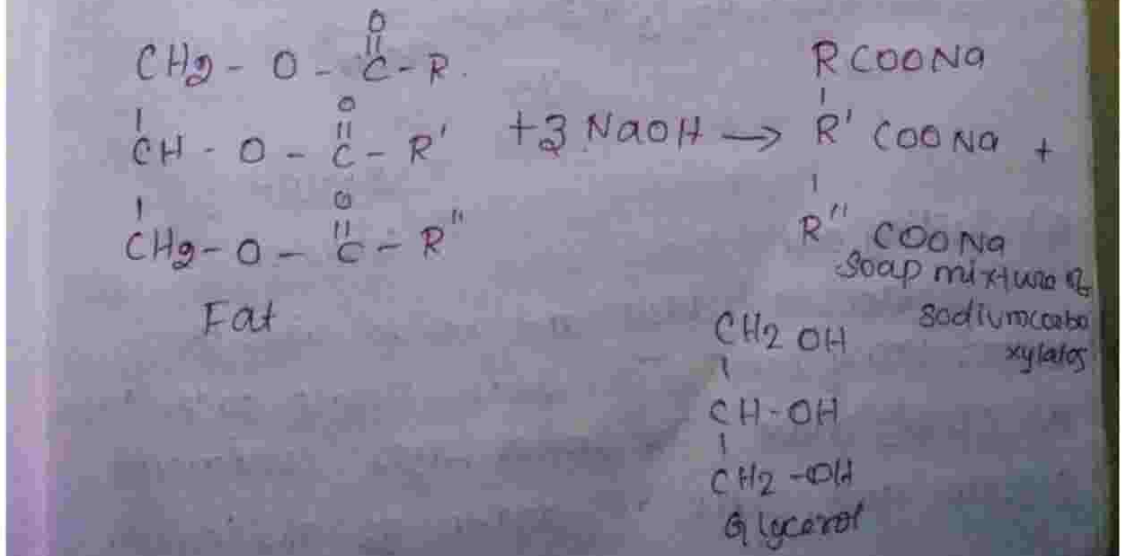
Soap:

Definition:

The Sodium or potassium Salt of higher Fatty acids. Such as Oleic, Stearic, Lauric, plamitic acid are called Soap. Sodium salt of higher unsaturated Fatty acid like plamitic acid. Steric acid are called hard Soap. potassium Salt of higher Saturated Fatty acid like Oleic acid are soft Soap.

General consideration of making of Soap.

The basic principle of making of all kind of soap is the combination of higher Fatty acid with Sodium or potassium Hydroxide or Carbonate



Manufacture of Soap.

They are generally three method used for Soap manufacture.

i) Hot process or Kettle process.
ii) Cold process
iii) Hydrolyser process or Modern Process

Hot process or Kettle process

The kettle process is now used in small Factories or for special production on a limited Scale. This process is carried in a Steel tank or kettle.

Manufacturing Step:-

i) Boiling

The Fat and NaOH solution are charged into the kettle and boiled with Steam. The boiling is continued till saponification is complete about 80%.

$$C_3H_5(COOC_{17}H_{35})_3 + 3NaOH \xrightarrow[\text{Steam}]{\Delta} 3\,C_{17}H_{35}COONa + C_3H_5(OH)_3$$

Fat — Lye — Sod. Stearate Soap — Glycerol.

ii) Salting out

Nacl is added and boiled upto the seperation of soap. The soap Floats on the surface as curdy mass. The lower layer containing glycerol and salt is drawn off. The leaving

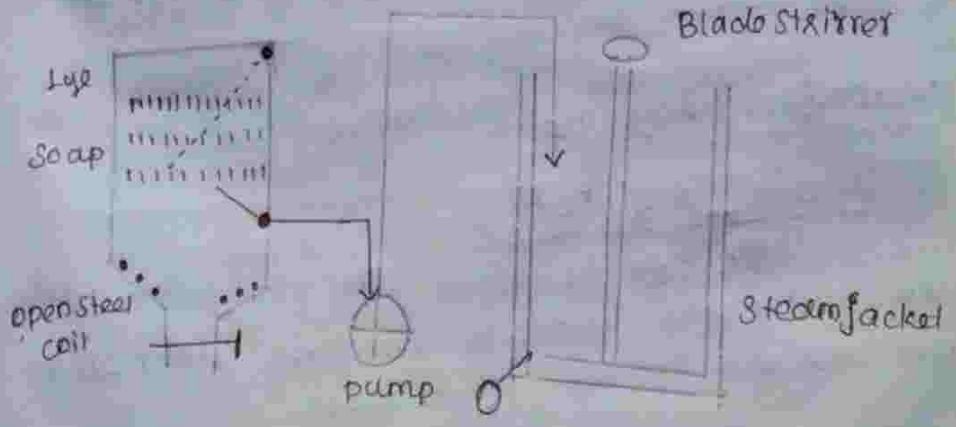
Soap contains 30% Fat.

g) Addition of Fresh Lye.

The Soap contains Fat are removed by esterification process. It is boiled with a Fresh supply of NaOH Solution. More soap is formed. The Soap layer left in kettle. It is boiled with H_2O and wash away excess of lye.

4) Finishing:-

The neat Soap is pumped into the Crutcher. Here the Soap is mixed with colour, perfumes, Germicides etc. till it becomes a homogeneous mass. The crutched Soap is poured into Frames and on Solidification cut into cake.



b) Cold process.

The oil or the molten Fat is taken in an iron pan fitted with a Stirrer. It is treated with Caustic soda solution (lye)

The Charge is stirred until the Soap begins to set

Soap is solidified Frames and cut into cakes.

All the glycerin get free. Most soap contains starch or some other filling material which is thoroughly mixed with the soap prior to the addition of caustic soda.

The proportion of the various ingredients are : alkali (1 part) water (1 part) and starch (1 part).

This process does not yield pure stuff. The hot process is superior to this.

Hydrolyser process or Modern process.

This is the Modern continuous process for soap manufacture. It is economical than the Kettle process and gives better quality of soap.

Manufacturing Step:-

i) Hydrolysis of Fat.

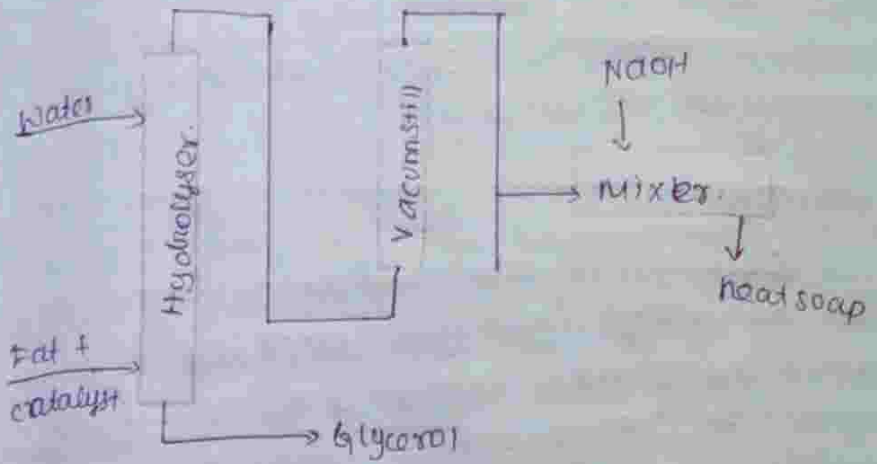
The fat is mixed with zinc oxide catalyst and water are heated to 230-250c under 40-50 atm pressure in the hydrolyser.

2) Distillation of Fatty acids.

The fatty acid is mixed with water. This is discharged at the top into a steam flash tank. The water is vapourised. The fatty acid are distilled under vaccum still.

8) Neutralization of the Fatty acids.

The vapours of Fatty acid are passed through condenser. The condensed Fatty acid are neutralized in the mixture containing alkali. The product is neat soap



Toilet Soap:-

Toilet Soap are manufactured from the best quality Fat or oil and great care is taken to add the right amount of lye. There is no free alkali in the Finished products. Toilet Soap is injurious to the skin.

Toilet Soap contain:-

Finest White Tallow	50 to 70%.
Coconut oil	05 to 30%.
Lard	upto 20%.
Palm Kernel oil	upto 20%.
Castor oil	upto 5%.
Resin	Trace amount

For Saponification, NaOH is used. This makes hard and stable Soap. KOH produces a

Soft soap.

Transparent soap:-

Transparent soap are prepared by dissolving soft soap in methylated spirit and then removing the insoluble part by filtration. The solid transparent soap is obtained on evaporating of alcohol.

Detergents:-

Detergents are sodium salt of sulphonic acid or alkyl hydrogen sulphates. It is reduced the surface tension of the water. This is known as surface active agent. Since, they are used for washing and cleaning purposes. Detergents contain one end of hydrophilic and other end of hydrophobic molecules.

Classification of surface active agent

Detergents can be classified int three claus:
i) Anionic detergent
ii) Cationic detergent
iii) Non-ionic detergent.

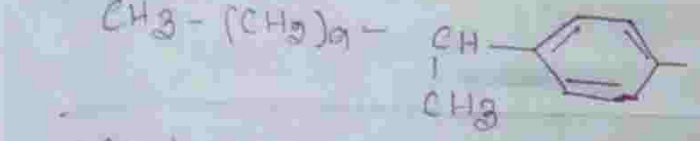
Anionic detergents.

Anionic detergent are sulphates of long chain primary alcohol (C_{10} to C_{18}) alcohol or sulphonate salt of hydro carbons.

Example: Sodium lauryl sulphate.

$CH_3-(CH_2)_{10}-CH_2-OSO_3^-Na^+$

sodium dodecyl benzene sulphonate.



The hydrophilic end is $-SO_3^-Na^+$ or OSO_3Na^+ and hydrophobic end is long chain alkyl / aryl part. They are effective cleaning agent for fabrics like cotton, wool, silk etc.

2) Cationic detergent

Cationic detergent are amine acetates and alkyl trimethyl ammonium chlorides. These are called as invert soap / detergent because their water soluble end carries a positive (cation) charge rather than negative charge. These are good cleaning agent. They possess germicidal properties.

Example: n-hexadecyl trimethyl ammonium chloride

$(CH_3)_3-\overset{+}{N}(Cl^-)-(CH_2)_{14}-CH_3$

ethanolamines like Sapamine.

$C_{17}H_{33}CONHCH_2CH_2N(CH_3)_3SO_4$.

NON-ionic detergent:

In non-ionic detergents, the polar covalent structure provides the required water solubility. These are used in dishwashing liquid.

Different between soap and detergent

Soap	Detergent
Soap cannot be used in hard water because it forms insoluble precipitate	Detergent can be used in hard water.
It cannot be used in acidic water.	There is no such problem.
It is biodegradable	It is non-biodegradable.
The ionic part of a soap is $COO^- Na^+$	The ionic part of a detergent is $SO_3^- Na^+$ or $OSO_3^- Na^+$
Soap take more time to dissolve in water	Detergent dissolve faster in water
Example: Sodium Stearate.	Sodium Lauryl Sulphate.

Shampoo:-

Shampoo is a liquid detergent. The liquid solution is massaged into wet hair. It creates lather and breaks up deposits of oil and dirt. The lather is rinsed from the hair after a few minutes, leaving the hair cleaning. Hence it is used as cleaning agent to hair.

Raw materials:-

Water - Basic element

Ammonium Lauryl sulfate and ammonium Laureth sulfate - Surfactant.

Cocamide or cocamidepropyl - Foamingagent

Sodium citrate or citric acid - Maintain the PH level.

Dimethicone - conditioner. It creates smoothness and shine of the hair.

polyquaternium - It makes manageable hair.

panthenol, Fatty alcohol and nutoil - common additives for moisturize.

Midazolidinyl urea, Iodopropynyl, isothiazolinone and sodium benzoate - It retard the growth of bacteria.

Refractories:-

Introduction:-

Definition:-

Refractories are inorganic materials that can withstand high temperatures without softening or undergoing any deformation in shape.

Function:- The Function of a refractory is to confine heat (construction of Inner lining of a furnace), to maintain high temperature and to resist the abrasive and corrosive action of molten mateis.

Characteristic or requisites of a good refractory.

It should not be fused at the operating

temperature.

Its physical, chemical and mechanical properties should not undergo any changes at high temperature.

It should not be crack and spiral the operating temperature.

It shoud be able to withstand overload at the operating temperature.

It should be chemically inert towards the corrosive action of molten metals, slags and gases.

It should expand and contract uniformly with temperature rise respectively.

Classification of refractories:

Refractories are classified into three types.
i) acetic ii) basic and iii) Neutral refractories

i) Acetic refractories:-

These are made up of acetic materials like alumina and silica. They are not attacked by acidic materials, but are easily attacked by basic materials.

EX:) Si, Al, Fire clay refractories.

ii) Basic refractories.

They are made up of basic material like calcium oxide and magnesium oxide. They are not attaked by basic materials, but

are easily attacked by acidic substance.

ii) Magnesite (magnesia) and dolomite refractories

3) Neutral refractories:-

They are made up of neutral materials like graphite, zirconia, and silicon carbide. They are inert towards both acidic and basic substance.

Example: Graphite, Zirconia.

properties of refractories:-

1) Refractoriness:-

Definition:- Refractoriness is the ability of a refractory material to withstand high temperature without softening or deformation under working conditions.

Measurement of refractoriness:-

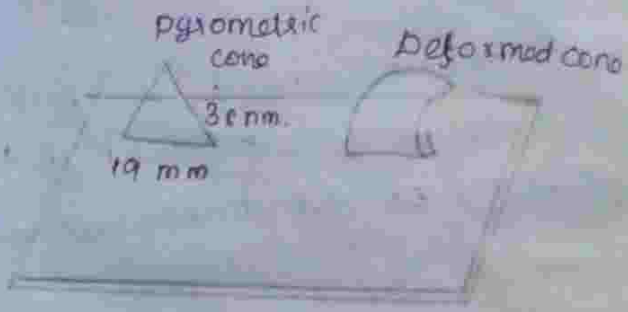
Refractoriness is usually measure by the softening or fusion temperature of the material. A refractory materials should have softening temperature high then the operating furnace temperature. The softening temperature of refractory is determined by the standard pyrometric cone equivalent (PCE) test or Seger cones test.

Pyrometric cone equivalent (PCE) test :-

Pyrometric cone equivalent is the number which represent the softening temperature of a refractory specimen of standard dimension any composition

Measurement :-

In this test, pyrometric cones or Seger cones of standard dimension (38 mm high with triangular base of (19 mm side) are prepared from various refractory materials. These are known as standard cones. The test cone is prepared from a refractory as the same dimension of standard cone.



When a test cone is heated on a base along with standard cone under standard condition (10 °C / minute) at one stage, the apex of the cone bends and touches the base. The temperature of the cone. The PCE value of the test refractory is taken as the number of standard cone whose softness along with the test cone. A good refractory should have high refractoriness.

2) Thermal Spalling or Spalling resistance.

Definition: Thermal spalling, is the property of breaking, cracking or peeling of a refractory material under high temperature. A good refractory should be resistant to thermal Spalling.

The reason for the thermal spelling:

uneven thermal expansion or contraction due to temperature differences (rapid heating or cooling) is the main cause for thermal Spalling. The Spalling tendency is directly proportional to the coefficient of expansion.

Thermal Spalling can be decreased by

i) low coefficient of expansion
ii) good thermal conductivity refractory.
iii) avoiding sudden temperature changes.

3) Strength or Refractoriness under load (RUL)

Refractories used in metallurgical operation and industries have to withstand varying load. Refractories like alumina do not bear loads, but refractories like silica bricks bear maximum load under operating temperature, so refractories should have high mechanical strength under operating temperature.

Definition:-

Strength or refractoriness under load of a refractory is its ability to withstand high temperature under the influence of maximum load without breaking.

The load bearing capacity of a refractory can be measured by RUL test.

RUL Test :- RUL is performed on a test specimen of standard size (cylinder diameter 50 mm and height 50 mm). The specimen is heated in a furnace at a rate of 10°C/minute under a load of 1.75 kg/cm². RUL is expressed in terms of the temperature at which 10% deformation occurres in the specimen. A 'good' refractory should have a high RUL value.

4) Porosity :-

Definition :- Porosity of a material is defined as ration of its pores volume to that of its bulk volumes. Thus, porosity is given as

$$P = \frac{W - D}{W - A} \times 100$$

W = Wght of Std Specimen in

D = Wg of dry Specimen in air

A = Wg of Std Specim Submerged in wat

A Saturation of Specimen may be carried out by boiling in water for two hours.

Dis advantages :-

Due to porosity, slags, gases, etc are likely to enter more easily to greater depth and also react with a refractory.

It reduced the strength.

It reduces resistance to corrosion.

So a good refractory in general should have lower porosity.

Advantage:

The lower porosity increase thermal conductivity due to the absence of air voids and increases resistance to thermal spalling.

The high porosity refractories possess lower thermal conductivity due to the presence of more air voids, which act as insulator and hence it can be used for lining in furnace, oven etc.

6) Dimensional stability:

Definition: It is the resistance of a refractory to any volume changes when exposed to high temperature over a prolonged time.

These dimensional changed may be i) reversible ii) irreversible.

i) Reversible dimensional changes.

The refractory material will result in uniform expansion and contraction refractory material should have reversible dimensional changes.

ii) Irreversible dimensional changes.

Irreversible changes may lead to contraction or expansion of refractory on heating: magnesite bricks (specific gravity is 3.05) is gradually converted into more dense Shrinkage crystalline form of periclase (specific gravity 3.5)

But in certain refractories, prolonged heating may lead to expansion eg, on heating there is an increase in the volume of silica brick due to transformation of quartz form (specific gravity is 2.65) into cristobalite (specific gravity is 2.32)

Manufacture of Refractories:-

1) Crushing:- The big lumps raw materials are crushed to small size about 25 mm.

ii) Grinding:- The crushed material are removed from raw materials. This is done by sorting, magnetic, seperation and chemical methods grading machine to 200 mesh size.

3) Screening:- The unwanted materials are removed from raw materials. This is done by sorting, magnetic seperation and chemical methods.

4) Storage:- After screening and mineral dressing the pure materials are stored in strong bins.

5) Mixing:- It is done in order to distribute the plastic materials equally throughout the mass. This makes moulding easier.

6) Moulding:- Moulding may be done either manually or mechanically by the application of pressure. Hand moulding process

produce the low density and low strength refractories. Mechanical moulding the de-airing the high density and high strength refractories. Mechanical moulding the de-airing process is essential de-airing is done i) by applying vaccum ii) by allowing air to inside the void space, iii) by double pressing.

7) Drying:- Drying is carried out slowly in tunnel driers. The bricks are placed in a long tunnel. The hot steam passes through the tunnel. Drying is used to remove the moisture from refractories.

8) Firing:- The refractories are fired to stabilize and strengthen their structure. Firing is done in tunnel kilns or rotary kilns. The firing temperature of different bricks are; high fired super duty brick - 1580°c Kaolin brick - 1700°c basic brick - 1870°c.

Manufacture of Fire-clay refractories:-

Fire clay refractories contain 50-80% of silica and < 50% of alumina. The Chemical Formula is $Al_2O_3 SiO_2 H_2O$.

Raw materials:-

Fire-clay and calcined Fire-clay.

Manufacturing Steps:-

1) Crushing: The big lumps raw materials are crushed to small size about 25 mm.

2) Grinding: The crushed materials are ground in grinding machine to 200 mesh size.

3) Screening: The unwanted materials are removed from materials. This is done by setting magnetic seperation and chemical methods.

4) Storage:-
After screening and mineral dressing, the pure materials are stored in storage bins.

5) Mixing: It is done in order to distribute the plastic materials equally throughout the mass. This makes moulding easier.

6) Moulding:- Moulding may be done either manually or mechanically by the application of pressure. Hand moulding produced low density and low strength refractories. Mechanical moulding produced high density and high strength refractories. After the mechanical moulding, the de-airing process is essential. De-airing is done i) by applying vacuum ii) by allowing air to inside the void space
iii) by double pressing.

7) Drying:- Drying is carried out slowly in tunnel dryers. The bricks are placed on the long tunnel. The hot steam passes through the tunnel. Drying is used to remove the moisture from refractories

8) Firing:- The refractories are fired to stabilize and strengthen their structures. Firing is done in tunnel kilns or rotary kilns. The firing temperature of fire clay bricks is 1300°C. After the firing the bricks are cooled slowly.

Uses:-

1) They are used in steel industries.

2) They are used for lining of blast furnaces, open hearths furnaces and lime kilns.

3) They are used for construction of stoves, ovens, crucible furnaces, flues, charging doors etc.

Unit IV

Fertilizers:

Definition:

Fertilizers are substances which are added to the soil in order to make up the deficiency of essential elements like nitrogen phosphorous and potassium required for the growth of plant.

Manufacture of ammonium sulphate:

Amonium Sulphate is obtained from ammonical liquor which is obtained by produ in the manufacture of coke. This liquor contain free ammonia and two types ammonium salts

i) volatile ammonium salts like ammonium chloride, ammonium sulphate etc volatile salts decomposes by boiling. fixed sal decomposes by lime water. These salts decompo to evolve ammonia.

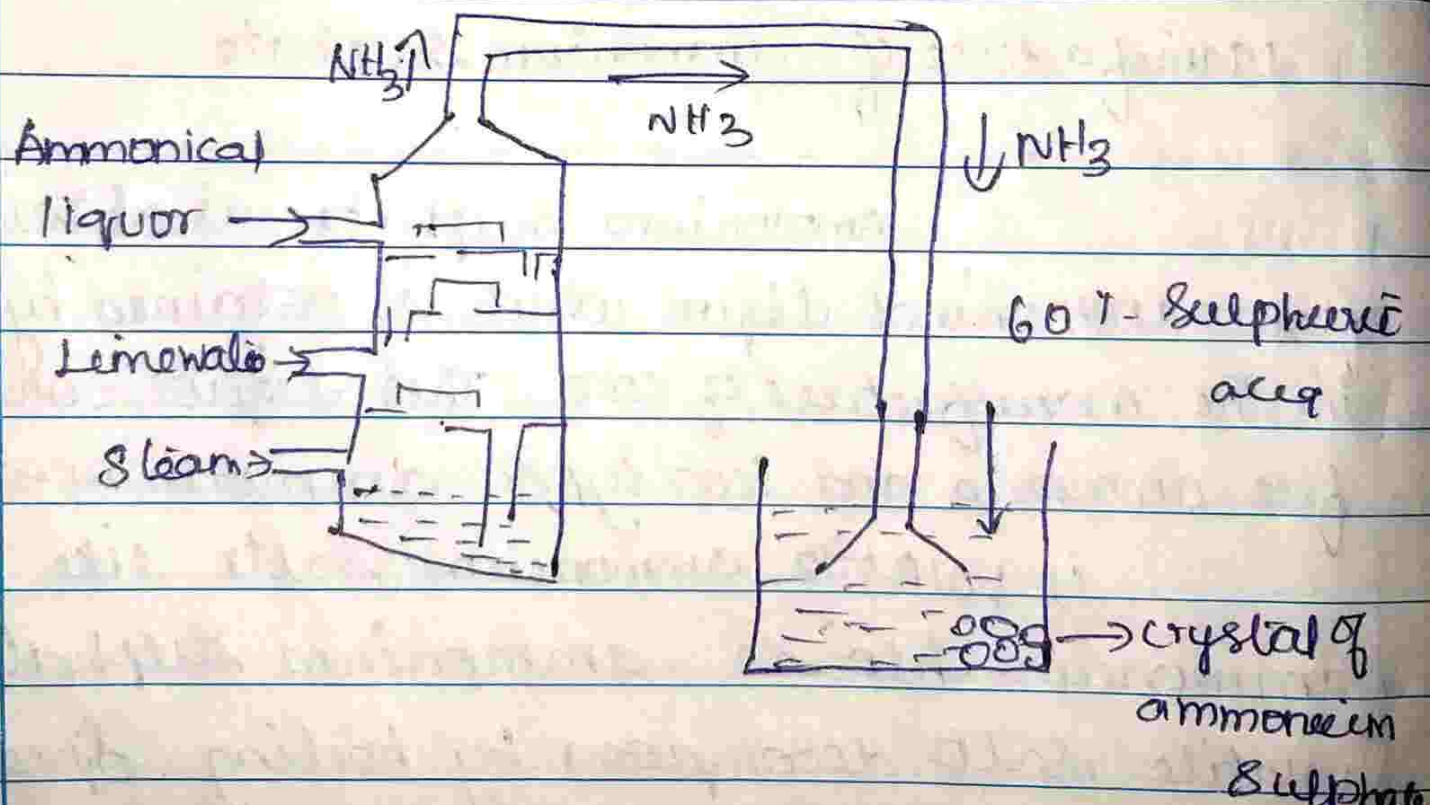
Voltaile salt $\begin{cases} (NH_4)_2CO_3 \longrightarrow 2NH_3 + CO_2 + H_2 \\ (NH_4)_2S \longrightarrow 2NH_3 + H_2S \end{cases}$

fixed solid $\{(NH_4)_2SO_4 + Ca(OH)_2 \rightarrow 2NH_3 + CaSO_4 + 2H_2O$

$(NH_4)_2Cl + Ca(OH)_2 \rightarrow 2NH_3 + CaCl_2 + 2H_2O$

This ammonia is passed through 60% Sulphuric acid and crystals of ammonium Sulphate separate on cooling.

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



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Sindri process of ammonium sulphate:

The process empolyed at Sindri fertiizers factory. it consists of various steps

1) Air and Steam are passed over red hot coke. A mixture of CO, N_2 and H_2 is formed

$$C + Air \longrightarrow CO + N_2$$
$$C + H_2O \longrightarrow CO + H_2$$

2) The Mixture of CO, N_2, H_2 is passed over a hot catalyst bed consisting of Fe_3O_4 and Cr_2O_3 Here CO get oxidized to CO_2.

Now the gaseous mixture consists of CO_2, N_2 and H_2 This is compressed to about 20 atm pressure in the presence of water, Hence CO_2 dissolve in water under these conditions.

3) The resulting mixture of N_2 and H_2 is adjusted in the ratio 1:3 and converted into ammonia by haber process

$$N_2 + 3H_2 \underset{150\text{-}200\ atm}{\overset{450\text{-}500^\circ C}{\rightleftharpoons}} 2NH_3 + Heat$$

4) The resulting ammonia is mixed with CO_2 solution. An adequate ammount of calcium sulphate is also added

$$CaCO_3 \longrightarrow CaO + CO_2$$

$$2NH_3 + H_2O + CO_2 + CaSO_4 \longrightarrow (NH_4)_2SO_2 + CaCO_3 \downarrow$$

Calcium carbonate precipitate out. it is removed by filteration This is called precipitated chalk. it is important by product. The solution is concentrated and crystallized.

Manufacture of Calcium ammonium nitrate:

CAN is manufactured at Nangal Punjab. it is also known as nitro lime stone manufacture of CAN consists of

Various Steps

1) Ammonia is synthesized by habea process by direct combination of nitrogen and hydrogen under specified condition

$$N_2 + 3H_2 \underset{150-200\ atm}{\overset{450-500^\circ C}{\rightleftharpoons}} 2NH_3 + heat$$

2) Ammonia is converted into nitric acid by Ostwald's process using platineum or platinum rhodium catalyst

$$4NH_3 + 5O_2 \underset{Pt\ guase}{\overset{820-920^\circ C}{\rightleftharpoons}} 4NO + 6H_2O$$

By

$$2NO + O_2 \longrightarrow 2NO_2$$

$$3NO_2 + H_2O \longrightarrow 2HNO_3 + NO$$

3) Solution of nitric acid is concentrated and heated to about 75°c it is allowed to neutralizer

Ammonia gas poheated to about 70° is introduced from the bottom of the neutrali

This operation results in neutralization of nitric acid by ammonia and ammonium nitrate is formed

$$NH_3 + HNO_3 \longrightarrow NH_4NO_3$$

4) The ammonium nitrate solution is concentrated and treated with powder lime stone. The slurry is obtained. it is converted into small pellets. They sold under the name calcium ammonium nitrate

$$CaCO_3 + 2HNO_3 \longrightarrow Ca(NO_3)_2 + H_2O + CO_2$$

5) CAN is very hydroscopic Hence the pellets of CAN are stirred with concentrated solution of soapstone (Sodium silicate) This treatment protects the CAN from moisture The pellets are dried and packed it contain 19.5 % of nitrogen

$$Ca(NO_3)_2 + NH_4NO_3 \longrightarrow Ca(NO_3)_2 + NH_4NO_3$$

Manufacture of urea:

Large scale:

Urea is Prepared on a

Large scale by reacting liquid ammonia with gaseous carbondioxide at 135°C and about 220 atm pressure to yeid ammonia Carbonate some of ammonia carbonate decomposes simultaneously to give urea.

$$2NH_3 + CO_2 \longrightarrow NH_2COONH_4$$

ammonium Carbonate

$$NH_2COONH_4 \longrightarrow NH_2CONH_2$$

urea.

The undecomposed ammonium Carbonate is processed separately under reduced pressure to give urea.

Modern process:

In the modern manufacturing plant. the production of urea has been made highly economical. crude naphtha is subjected to partial combustion burners. it gives a mixture of hydrogen and carbonmonoxide

The mixture reacts with steam in the presence of catalyst like mixture of Fe, Cr and Co. Here CO is oxidised to CO_2

$$CO + H_2O + H_2 \xrightarrow[\text{steam}]{\text{catalyst}} CO_2 + 2H_2$$

Carbondioxide is separated by washing with water under pressure or by treatment with $KHCO_3$ solution.

The above hydrogen is converted into ammonia by haber process. The regenerated carbondioxide from aqueous or alkali carbonate solution is compressed and reacted with ammonia to give urea

$$N_2 + 3H_2 \underset{150\text{-}200\text{atm}}{\overset{450\text{-}500^\circ C}{\rightleftharpoons}} 2NH_3 + \text{heat}$$

$$2NH_3 + CO_2 \longrightarrow \underset{\text{ammoniumcarbonate}}{NH_2COONH_4}$$

$$NH_2COONH_4 \longrightarrow \underset{\text{urea}}{NH_2CONH_2}$$

calcium super phosphate or super phosphate:

Calcium super phosphate is a mixture

The chemical formula is [$Ca(H_2PO_4) + CaSO_4 \cdot 2H_2O$]

Manufacture of calcium phosphate or Super phosphate

It is manufactured by treating calcium phosphate with calculated Quantity of sulphuric acid

$$Ca_3(PO_4)_2 + 2H_2SO_4 + 4H_2O \longrightarrow$$

$$Ca(H_2PO_4)_2 + 2(CaSO_4 \cdot 2H_2O)$$

Superphosphate + Heat

Plant and procedure:

The powdered phosphate rock is placed in a cast iron mixture. A calculated quantity of Sulphuric acid is added to it The whole mass is stirred mechanically about 2 to 5 min. The mixture is left for about 24 hrs. The temperature rises to 100-110°c because of exothermic reaction. The phosphate

contain $CaCO_3$ and CaF_2 as impurities. They react with sulphuric acid to evolve CO_2 and HF

$$CaCO_3 + H_2SO_4 \longrightarrow CaSO_4 + CO_2 + H_2O$$

$$CaF_2 + H_2SO_4 \longrightarrow CaSO_4 + 2HF$$

Free HF reacts with silica in the phosphate rock to produce SiF_4 which form hydro fluosilicacid in the presence of water.

$$4HF + SiO_2 \longrightarrow SiF_4 + 2H_2O$$

$$3SiF_4 + 2H_2O \longrightarrow SiO_2 + 2H_2SiF_6$$

The gases like CO_2, HF and H_2SiF_6 are led in to suitable absorption tower. As result the hard mass is obtained. it is solidified to a porous dry solid due to the formation of gypsm. The mass is allowed to stand few days in den and it becomes dry. The dried mass is kept in the open for 4-6

weeks. During this period the excess of sulphuric is completely consumed and the mass is completely dried. The dry mass is crushed to fine powder and is sold in the name of super phosphate of lime.

Mixed fertilizers:

A fertilizers which contain more than one of the major plant nutrients, is called a mixed fertilizers.

Mixed fertilizers contain nitrogeneous, phosphatic potash fertilizers, ammonium sulphate, calcium ammonium nitrate is used as a source of nitrogen. Calcium Super phosphate is used as a source of phosphorous potassium chloride or sulphate is used as a source of potassium. These are referred to as NPK fertilizers.

Fertilizer industry in INDIA:

India is the largest producer of nitrogenous fertilizers in the world only behind china and USA. At present there are 30 large size units in the country producing urea, 21 unit produce DAP and 5 units produce complex nitrogenous fertilizers.

Besides, there are about 80 small and medium scale units in operation producing single super phosphate. The total installed capacity of fertilizer production which was 119.60 LMT of nitrogen and 53.60 LMT of phosphate as on 31.03.2004 has marginally increased to 120.61 LMT of nitrogen and 56.59 LMT of phosphate as on 31.3.2011. the nation level, the total consumption of all nutrient based fertilizers in 2010-11 is estimated at 590 lakh tones.

Out of the 16 plant nutrients nitrogen, phosphorous and potash (NPK) are

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Out of the 16 plant nutrients nitrogen, phosphorous and potash (NPK) are

Major three nutrients that contribute more on the productivity. The Governments aimed at achieving the maximum self sufficiency in the production of nitrogenous fertilizers in india more than 60 fertilizers industry present in private as well as in public Sectors.

Factories in pubilic sector:

The important factories are,

1. Fertilizer corporation of India: This corporation contains nine units. These units are situated at Sindri (bihar), nangal (punjab) Namrup (up), Trombay (maharashtra) Korba (mp) barauni (Bihar), Talchar (orissa) and Durgapur (west bengal).

2) Fertilizer and chemical Travancore Ltd. Alwaye

3) Madras fertilizer, Chennai

2) Factories in private Sector:

The important units are.

1. DCM Chemical Works Delhi and Kota.
2. Indian explosive Ltd kanpur
3) Zuari Agrochemicals Ltd Goa
4) coromandal fertiiizer Ltd Visakhapatnam.
5) ELD parry's Ltd, Chennai
6) phosphate company Ltd calcutta

Sugar Industry:

Manufacture of Sugar from molasses:

1) Extraction of Juice:

There are three roller mills connected eact with metal plates it is used to crush the cane and forms canemat The can mate is passed into a long tank containing number of compartments. The Sucrose is extracted from the partially exhausted cane mat. it is passed on the conveyer by washing with cold or hot wates and forms jeiice. The jeiice is

diluted by a counter current method. water is sprayed on to mat in all compartment the ~~rich~~ richest juice is formed. The juice is pumped to the clarification unit. This method is called as diffusion process.

2) Purification of sugar:

Raw juice contain 15-20% of sucrose and much impurity. The impurities are organic acids, mineral phosphates, proteins and colloidal colouring matter the raw juice is slightly acidic in nature. Hence the juice is purified by the following operations.

1) Defecation:

The raw juice is transfered into tanks. it is heated by steam and treated with 2-3% lime. This process is called defecation. This operation removes the organic acids and phosphates are insoluble calcium salts

The protein and the colloidal colouring Matter are thrown out as a soution of thick scum. The precipitated Calcium and the scum are removed by filtration.

ii) Carbonation:

The juice after defecation is treated with carbondioxide. This operation is known as carbonation. This process is remove the excess of lime and decomposes Calcium Sucrosate to give sugar and Calcium carbonate.

$$C_{12}H_{21}O_{11}CaOH + CO_2 \longrightarrow C_{12}H_{22}O_{11} + CaCO_3\downarrow$$

Calcium Sucrosate

iii) Sulphitation:

The juice after carbonation is treated with SO_2 This operation is known as sulphitation This process complete the neutralization of lime and decomposition of calcium sucrosate. The colour of juice

is also bleached. The Clarified juice is obtained by filteration.

3) Concentration and crystallization of the juice:

The clarified juice is concentrated by boiling under reduced pressure in multiple effect of evaporators. The concentrated juice is passed to the vacuum pans. The water content reduces from 6-7%. The contents of pan are known as massecuite. The massecuite and discharged in a tank. Crystals grow in size and form a thick mo

4) Separation and drying of crystals:

The massecuite is charged into centrifugal Machines. The sugar crystals are separated from the Mother liquor. The crystal are sprinkled with little water to wash the impurities sticking on the surface. The crystal are dried by hot air. The sugar is 96% pure. for

further purification. it may be dissolved in hot water and recrystallized.

The Mother liquor obtained after the removal of crystals is called as molasses. it contain large amount of sugar. it is concentrated to get fresh crop of crystals. molasses contains also glucose and fructose.

Manufacture of sugar from Beet Root

The various stages in the manufacture of sugar from beet roots are

1) Extraction of sugar solution by diffusion
2) purification
3) concentration and crystallization
4) Separation and drying of crystals

Extraction of sugar Solution:

The washed beet roots are cut to be V-Shaped slices. This is called

as coselites. The crude sugar solution is extracted from coselots. it is passed into a series of large tanks called diffusers. Hot water is pumped through these tanks. The extraction is conducted on counter current principle Sugar is removed from beet root by two fold process.

1) Leaching: it means washing out sugar with water.

2) Dialysis: The sugar solution is passed through the cell wall membrane and leaves the larger colloidal material.

Fermentation:

Big molecules of organic compound are slowly decomposed into simples ones under catalytic influenced of non living complex substance or yeast called terments The phenomen is called as fermentation since a number of ferments present in yeast they are also called enzymes yeast is a single celled living plant.

Manufacture of Spirit from molasses:

Molasses is the mother liquor left after the crystallization of cane sugar from the concentrated juice. it is dark coloured thick syrup mass. molasses contain about 30% sucrose which cannot be separated by crystallization it is converted spirit by the following steps

i) Dilution:

Molasses is first diluted with water to bring down the concentration of sugar to about 8 to 10 percent

ii) Addition of ammonium salts:

Molasses usually contains enough nitrogenous matter to act as food for yeast during fermentation if the nitrogen content of the molasses is poor, it may be fortified by the addition of ammonium sulphate or ammonium phosphate

iii) Addition of Sulphuric acid.

The solution is then made acidic with small amount of sulphuric acid. Acidity is favourable to the growth of yeast but unfavourable to most other bacteria. care should be taken to avoid excess of acid as the yeast may be killed

iv) Addition of yeast:

The solution from step (ii) is collected in large 'fermentation tanks and yeast is added to it. The mixture is kept at about 303K for a few days. During this period the enzymes invertase and zymase present in yeast. bring about the conversion of sucrose into ethanol

$$C_{12}H_{22}O_{11} + H_2O \longrightarrow C_6H_{12}O_6 + C_6H_{12}O_6$$

$$C_6H_{12}O_6 \longrightarrow 2C_2H_5OH + 2CO_2$$

The fermented liquid is technically called wash.

v) Distillation of wash:

The fermented liquid

containing 15 to 18 percent alcohol and the rest of the water is now subjected to fractional distillation. The main fraction drawn is an aqueous soultion of ethanol which contain 95.5% of ethanol and 4.5% of water. This is called rectified spirit.

Manufacture of wine from grapes:

Raw material: Grapes.

Manufacturing Steps:

1) Extraction of juice:

The grapes are crushed by wooden rollers called crushers The crasher macerates them. but does not crush the seeds. Some of the stems are removed. The juice extracted from the grapes is called must. The grape juice containing glucose. fructose and

to

tartaric acid. The skin of grapes contains tannin various, essential oils and there may be colouring matter

2) Fermentation:

The must is passed into a large tank and sulphurous acid is added to check the wild yeast. An active culture of selective and cultivated yeast is added. The active fermentation is allowed proceed at the temperature about 85°F. The CO_2 gas is liberated as a result of conversion of glucose in to alcohol. The CO_2 gas carries the stems and seed to top. This allows extraction of the colour and the tannin from the skin and seeds.

3) Clarification:

After the active fermentation the juice is pumped into a loosely large tank This is prevented the conversion of alcohol to acetic acid. The juice is stored for several month. The yeast ferments the remindes of the sugar and wine is formed.

During this period, yeast settles dow tartaric acid, various salts and colouring matters separates out. The wine is allow to cellar treatment and stand for about 2 month, Hence the suspended matters ar removed

An insoluble precipitates with tanni is formed. extra tannin is added and filtered through asbestos. The resulting clarified wine is blended with other wines, Sugar, acid and tannin in order to maintain commercial standard.

Chilling:

Argot or potassium hydrogen tartrate is removed from the wine by chi method. As a result a more finished wi is obtained

Ageing:

Good sweet wine is obtained by ageing method in about 4 month.

pasteurization, refrigeration; sunlight, UV light ozone, agitation and aeration are various ageing methods.

6) Freezing:

The wine may be kept at about freezing for 3-4 weeks and oxygen is passed through it. The wine is then racked, clarified and filtered.

Wines are classified as natural wine - alcohol 7-14%. fortified wine - alcohol 14-30%. sweet or dry wine and still or sparkling wine

Manufacture of ethanol from molasses (By distillation)

Molasses is the mother liquor left after the crystallization of cane sugar from the concentrated juice. It is dark coloured thick syrup mass. Molasses contain about 60% cane sugar, mostly sucrose glucose and fructose it forms an industrial ethyl alcohol molasses is converted into alcohol.

i) Dilution:

Molasses is first diluted with water to bring down the concentration of sugar to about 8 to 10 percent.

ii) Addition of sulphuric acid:

The solution is then made acidic with a small amount of sulphuric acid. acidity is favourable to the growth of yeast but unfavourable to most other bacteria. care should be taken to avoid excess of acid as the yeast may be killed.

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$$C_6H_{12}O_6 \longrightarrow 2C_2H_5OH + 2CO_2 \uparrow$$

The fermented liquid is techineally called wash. it contain 15 to 18 percent alcohol.

V) Distillation of wash:

The wash is distilled in a specially designed continous still called coffe still. it consists of two tall fractionating column These are analyser and rectifier. These are provided with perforated horizontal plates ha valves opening upwards. The coffey still work on the counter current principle. The steam and alcohol travel in opposite direction thro the still.

The wash is pumped to the coffe still and then it is passed into heat exchange A current steam is passed from the lower end of the analyzer. Steam moves up the analyser and takes the vapours of alcohol fo the down coming wash.

The mixture of alcohol and vapour leaves the analyser at the top end. It enters into the rectifier. Here the steam is condensed because of higher boiling point (100°C) than that of ethanol (78.3°C) The uncondensed vapours escape near the top it is condensed with the help of a condenser. The 90% pure alcohol is obtained it is subjected to fractional distillation

The fractions are given to below

i) The first fractions contain low boiling liquids like acetaldehyde

ii) The second fraction contain 95% ethanol called rectified spirit or industrial alcohol. This mixture is heated under reflux over Quick lime for about 5 to 6 hours and then allowed to stand for 12 hours. On distillation of this mixture pure alcohol (100%) is obtained is called absolute alcohol.

iii) The last high boiling fraction (125-145°C) contain fusel oil. it consists mainly of amyl alcohol.

Manufacture of vinegar by Quick vinegar process:

Quick vinegar process is limited to production of vinegar for food industry vinegar is 4-6 % acetic acid. it is obtained from fermented liquor containing 12-15 % ethanol. The aqueous solution of ethanol in contact with air and under influence of bacterium acetic produces acetic acid.

$$2CH_3CH_2OH + O_2 \longrightarrow 2CH_3CHO + 2H_2O$$

$$2CH_3CHO + O_2 \longrightarrow 2CH_3COOH$$

Manufacturing steps:

1) In the Quick vinegar process large wooden vats filled with wood shavings impregnated with old vinegar (bacterium aceti)

are used in series.

2) The vats are fitted with a perforated cover. ethanol is introduced at the top of the first vat and allowed to trickle down the shaving

3) Air is drawn in through the holes in the lower walls of the vessel and passes up in the opposite direction to the trickling liquid

4) The heat generated in the oxidation of ethanol to acetic acid maintains the temperature at 35°C which is favourable to the growth and activity of bacteria.

5) The liquor leaving the bottom of each vat is introduced at top of the next vat

6) The maximum concentration of acetic acid obtained by the method is 10%. The process requires 8-10 days for completion.

3) Balrampur chini mills Ltd. westbengal
4) bannri amman Spining mills Ltd westbengal
5) Dalmia bharat sugar & Industries Ltd

Match Industries:

Manufacture of matches:

Raw materials:

i) White pine or aspen woods
ii) Ammonium phosphate
iii) paraffin wax
iv) potassium chlorate
v) animal glue
vi) antimony trisulfide
vii) Sulphur
viii) powdered glass
ix) inert fillers
x Red phosphorus, White
xi adhesive such as gum arabic or urea formaldehyde.

Manufacture of Match stick:

1) cutting the match sticks:

Logs of white pine or aspen are cut into short length about 0.5m by the debarking machine. The stripped log is placed in a peeler it cut into a sheet about 0.1 inch thick called veener. The veener glassed into chopper. it cuts into small sticks.

2) Treating of match sticks:

The cut match sticks are soaked with a dilute solution of ammonium phosphate for several hour retardant. the dried stick are stored in large tank

3) forming of match heads:

The stored sticks are transferred into holes on a long, continuous preforated steel belt. The perforated belt

wax and dried. paraffin provides a fuel to the match stick.

This fuel transfers the flame from the burning chemicals to the match stick. further the match sticks are dipped in solution of match head base chemicals. The base solution contains a mixture of potassium chlorate and small amount of phosphorus sesquisulphide. it also contains sulphur, rosin and a small amount of paraffin wax. A water soluble dye may be added to give the base a colour such as red or blue

Further the match sticks are dipped in tip solution. These increase the friction and control burning rate. Zirconeode may be added are coated the matches are dried slowly

pyrotechnics:

Pyrotechnics refers to making fire by chemical reaction. it produce light heat noise or gases it done by combustion of a fuel and an oxidiser. in pyrotechnics the combustion process is instantaneous.

uses:

1) crackers and sparkers are used for commercial purposes

2) coloured bombs are used for military signals.

UNIT - V

ADHESIVES, ENAMELS AND EXPLOSIVES

Adhesives:- An adhesive can be defined as any substance capable of holding materials together by surface attachment.

classification of adhesives:- The broad classes of adhesives and their brief description are given below.

Animal glue:- Preparation:-

(1) Animal glue is prepared from the bones of dead animals, wastes of animals, wastes of slaughter-houses and scrapes from leather industry.

(2) The waste is first purified by lime. It is degreased by adding benzene.

(3) It is treated with HCl to remove Calcium Phosphate.

(4) The product is hydrolysed by hot water to get liquor glue.

(5) The liquor glue is filtered and then bleached with SO_2.

(6) It is mixed with borax, formaldehyde (preservative) and concentrated.

(7) The concentrated liquor is allowed to cool.

(8) cakes of glue are precipitated.

(9) The cakes are dried and cut into flakes or powdered.

(10) for using, cakes or flakes or powder is boiled with water to get a jelly-like mass, which is then applied.

Uses:- (1) Animal glues are used in manufacturing furniture.

(2) It is used in radio- cabinets and card. boxes etc.

Protein adhesives:-

Preparation:- Protein adhesives are prepared from soyabeans, corn, casein albumin, peanut etc.,

(1) Soyabean glue:- Dry soya beans are crushed to extract oils. The left over material is then mixed with milk of lime [$Ca(OH)_2$] and caustic soda (NaOH) to form jelly like adhesive paste.

(2) Casein glue:- Skimmed milk is curdled with dilute acid. The solid casein is precipitated. The casein is separated, dried and mixed with lime and preservative. The casein is powdered. It mixed with water to form jelly like adhesive paste.

Uses:- (1) Casein adhesives are used in wood work industry.

(2) Casein adhesives are used in the manufacture of drinking cups, straws and icecream containers.

(3) Soyabean adhesives are used in combination in veneer field.

Starch adhesives:-

Preparation

Required Materials:- (i) Starch - 100 Parts
(ii) water - 200 parts
(iii) caustic lye - 25 Parts

(iv) Borax - 0.14 parts
(v) HCl - 5 parts.

Starch is stirred with hot water and caustic lye is added slowly. After one and a half hour borax as well as acid is added slowly. Now the paste is placed in slightly alkaline urea to lower the viscosity of the paste. The pH of the liquor is adjusted by adding monosodium phosphate.

Uses:-
(1) It is used for manufacturing of envelops and stamps.

(2) It used for manufacturing of note books, binding books and other paper goods.

(3) It is used for sealing of wrappers, wood bonding wall paper etc.

ENAMELS:- INTRODUCTION:

Enamel is hard and glassy coating applied on wares for decorative and protective purposes. The enamels used to coat the metal surface are known as porcelain enamel. Porcelain enamel is a ceramic mixture containing a large proportion of fluxes. All porcelain enamels are opaque. They are either white or coloured. It is fused on the metal surface at moderate red heat. Opaque and white or coloured metal surface is formed. The enamelled metal is easy to clean and resist corrosion.

Raw Materials:-

Raw materials used in enamels may be six types. These are

(1) Refractories :- Refractories contribute to acidic part of the melt. It gives body to glass. clay, feldspar & quartz are used for this purpose.

(2) Fluxes :- Fluxes are basic in character. They react with acidic refractories to form the glass. They decrease the fusion temperature of the enamels. Example :- borax, soda ash cryolite and fluorspar.

(3) opacifiers :- opacifiers are compounds which are added to the glass to give white appearance. Insoluble opacifiers - TiO_2, SnO_2 and ZnO; Devitrification opacifiers - cryolite and feldspar.

(4) colours :- Metal oxides, elements, Frits and salts are used as colouring materials.

(5) floating agent :- The clay has a dual role. It act as a floating agent to suspend the enamel in water or as the body forming agent.

(6) Electrolytes :- Borax, Soda ash, magnesium sulphate, Magnesium carbonate are used as electrolytes, It peptizes the clay and properly suspended in the enamel.

Application :-

The enamel is applied on the metal surface in two coats by dry or wet process. Before the liquid enamel is applied to the metal, the surface is cleaned throughly.

In the Wet Process, the surface with single coating is again slip coated, dried and refined.

In dry process, a ground mixture of frit, clay, opacifiers and colours poured uniformly on the hot first coating. The article is refined finally after applying the mixture of ingredients.

After drying, the slip coated articles are fired. Hence the enamel melts on the ware in to a smooth continuous and glossy layer. The requirements for a successful firing of good enamel are:

1. Proper support of the ware
2. Uniform cooling and heating of the ware.
3. Proper firing temperature - 760 to 850°C
4. Proper time of firing - 1 to 15 min
5. An atmosphere free from dust.

Uses:- Enamel wares are applied in the field of refrigerators, dairy equipments, food processing equipments, hospital furniture, motor cars, stationary wares etc.,

Explosives:-

Definition:- An explosive is defined as a material which under the influence of thermal or Mechanical shock decomposes rapidly and spontaneous with the evolution of a great amount of heat and large volume of gases

Classification of explosives:-

Explosives are classified into three types. These are primary explosives, low explosives & high explosives.

Primary or initiating explosives:-

(1) These are inorganic salts.

(2) They are highly sensitive.

(3) It explodes on receiving a small shock of fire.

(4) They should be handled with the utmost care.

(5) It is used to initiate the explosion of the main explosives.

(6) It is less sensitive compared to the main explosives.

(7) Example: lead azide, Mercury fulminate, diazodinitrophenol, nitromannite.

(b) Low explosives or Propellents:-

(1) They burn and do not explode.

(2) The action of low explosive is less shattering.

(3) They evolve large volume of gas on combustion in a definite and controlled manner.

(4) These are used in the cartridge cases of rifles, pistols etc.

(5) Example: colloidal cellulose nitrate.

(c) Secondary or High explosives:-

(1) These are organic materials.

(2) These are quite insensitive to flame and Mechanical shock.

(3) They explode violently.

(4) The action of high explosive is rapid shattering.

(5) Example:- TNT, picric acid, diphtramine.

Characteristics of an explosive:-

(1) Its rate of decomposition should be fast. It should produce a large volume of gaseous products exothermically.

(2) It should be cheap and stable under normal condition. Stability of an explosive is determined by its decomposition point by DTA.

(3) It should have lower energy of dissociation. Usually, explosive molecules contain N-N, N-O, N-Cl and O-Cl bonds. The difference in electro-negativities in this case is zero or very small.

(4) It should have a positive oxygen balance. The oxygen balance indicates the oxygen present in the molecule. This oxygen is utilized to oxidize the C and H to CO and H_2O respectively. Percentage of oxygen in $C_xH_yO_z$ molecules is given below.

$$C_xH_yO_z \rightarrow xCO + y/2\ H_2O + [z-(x+y/2)]/2\ O_2$$

$$\% \text{ of Oxygen balance} = \frac{[2 - (x + 4/2)] \times 16 \times 100}{\text{Mol. wt. of } C_xH_4O_2}$$

Nitrocellulose or cellulose nitrate:-

Preparation:-

Cellulose nitrate is prepared from cotton linters which are purified by boiling in kiers with a dilute solution of caustic soda. Now the cotton linters are free from dust, natural oil and non-cellulose matter. It is bleached with $CaOCl_2$. The bleached linters are dried and weighed. The bleached and dried cotton linters are heated with the mixed of 21% HNO_3, 63% H_2SO_4, 0.5% N_2O_4 and 5.5% of water at 30°C for about 2-2.5 hours in a mechanical dipper nitrator. The excess of nitrating mixture is centrifuged from nitrated cotton. The nitrated cotton is washed and boiled with H_2O. This gives a more stable nitrocellulose.

$$C_6H_7O_2(OH)_3 + 3HONO_2 + H_2SO_4 \longrightarrow C_6H_7O_2(ONO)_3 + 3H_2O + H_2SO_4$$

Nitrocellulose

The nitrocellulose contains about 12.6% nitrogen is called pyrocotton, cotton nitrated to contain 13.2% or more nitrogen is known as gun cotton.

Properties:-

(1) When set on Fire, dry gun-

cotton explodes rapidly.

(2) When wet, it is set-off by a small amount of another explosive. Mercury fulminate is commonly employed.

(3) Dry gun-cotton is ignited by shock.

(4) Military smokeless powders are prepared from a blend of Pyrocotton and gun cotton. It contains about 13.15.1. nitrogen.

Uses:-

(1) Dry gun-cotton in Fibre form is used in torpedoes and submarine mines.

(2) It is used as propellent in rifles or artillery shells.

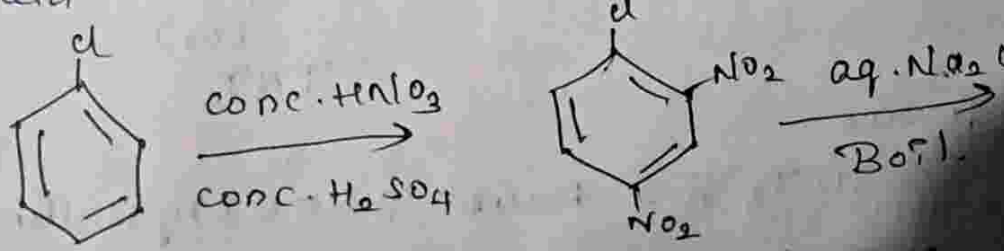
(3) It is used for forming granules of particular shape and size.

(4) Nitrocellulose is used for the Preparation of military smokeless powder.

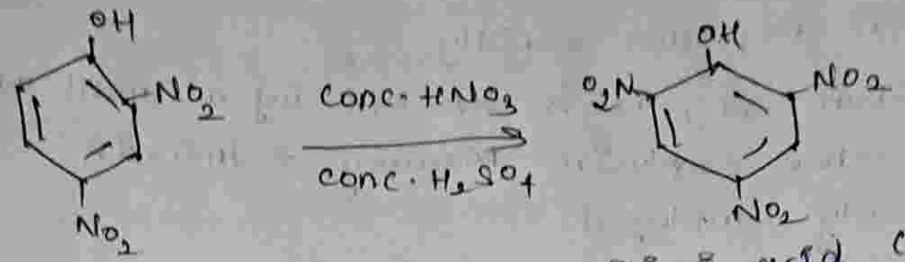
Picric acid:-

Preparation:-

Chlorobenzene is treated with a Mixture of conc. HNO_3 and conc. H_2SO_4. 2,4-dinitrochlorobenzene is formed. It is boiled with aqueous sodium carbonate solution 2,4-dinitrophenol is formed. It is treated with conc. HNO_3 and conc. H_2SO_4 to give picric acid.



Chlorobenzene 2,4-dinitrobenzene



2-4-dinitrophenol

Picric acid (or) 2,4,6-trinitro-phenol.

Properties:-

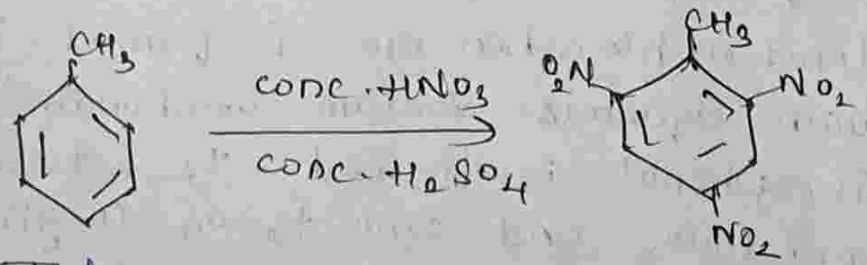
(1) Picric acid is a high explosive.

(2) It explodes violently.

Trinitrotoluene (TNT) or 2,4,6-trinitro-toluene

Preparation:-

TNT is prepared by the nitration of toluene using a nitrating mixture of conc. HNO_3 and conc. H_2SO_4 in 1:1 ratio in tank reactor. These contents are stirred continuously. Liquid TNT is formed. It is washed with ammonical solution of sodium sulphide. It is passed into cold water. TNT crystallizes out. crystals of TNT are filtered and purified by melting. The melt is dried and poured in containers.



Toluene

2,4,6-dinitrotoluene (or) TNT.

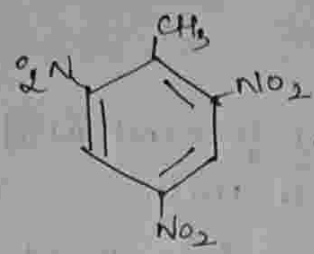
Properties:-

(1) It is a faint yellow crystalline solid

(2) It is a high explosive

(3) TNT is superior to picric acid because of its low melting point (81°C)

(4) TNT has enough Oxygen for internal combustion. Hence, it explodes violently on detonation and liberates large volume of gases.



2,4,6-trinitrotoluene
(or) TNT

Detonation

$14\,CO + 3N_2 + 5H_2$

Large volume of gases

(5) It is safe explosives, requiring strong detonation to set it off.

Uses:-

(1) It is used in shell firing and under water explosions.

(2) It is used for filling bomb shells, hand grenades and torpedoes alone or with other explosives.

(3) TNT is mixed with ammonium nitrate, it forms the blasting material amatol which is used for demolishing old buildings and rocks.

(4) It is used for demolishing loading in containers because of its low boiling point.

(5) It is important in military because

(i). It is safe explosive in manufacture, transportation and storage.

(ii) It is non-hydroscopic.

(iii) It is a violent disruptive explosive.
(iv) It does not react with metals to form unstable compounds.

Gun Powder or black Powder :-

An intimate mixture of KNO_3, Charcoal and sulphur is known as gun Powder or black Powder.

Manufacture :-

(1) Raw materials are finely ground and mixed together under a wheel mill.

(2) It is passed through a fine mesh sieve of copper wire.

(3) The mixture is converted to moist state in a mill under heavy edge runners.

(4) The cake is obtained. It is broken up into small pieces which are subjected into a pressure of about 400 psi.

(5) A hard mass is obtained. It is granules by rollers. The resulting grains are polished in wooden drums and added small amount of graphite.

(6) The obtained gun Powder is dried at 40°C.

Properties :-

(1) It is very cheap

(2) It is high lifting Power and produces large blocks on quarrying.

(3) Destructive Power of gun powder is low compared to dynamite.

(4) Efficiency of gun powder is comparatively lower than dynamite.

Uses:- It is used in quarrying stones.

Cordite:-

Cordite is prepared by mixing a paste of 65·1. nitrocellulose, 30·1. nitroglycerin and 5·1. vaseline with acetone. The mixture is forced by hydraulic pressure and formed a thread or cord like material. Hence the name is cordite. Acetone is evaporated from cordite to form the horny cordite.

Properties:-

(1) cordite is very sensitive to shock.

(2) It is easy to handle.

Uses:- It is excellent propellent for large caliber naval guns.

Dynamite:-

original dynamite is a mixture of 75·1. nitroglycerin and 25·1. kieselghar. modern dynamics use wood flours ammonium nitrate or Sodium nitrate as the absorbing agents of nitroglycerin. An oxidizer is added sometimes Dynamite is easy to handle.

Properties:- (1) It is a high explosive.

(2) It is costlier than gun powder.

(3) It has high shattering power and produces small blocks on quarrying.

(4) Destructive Power of dynamite is high compared to gun powder.

(5) Efficiency of dynamite is comparatively larger than gun powder.

Uses:- It is used for rock blasting and gold mining.