Inorganic materials of Industrial importance

- Silicate industries
- Fertilizers
- Surface coatings
- Batteries
- Alloys
- Catalysis
- Chemical explosive.

Fertilizers

What is Fertilizers:

A fertilizer is any material of natural or synthetic origin that is applied to soils or to plant tissues to supply one or more plant nutrients essential to the growth of plants.

Mechanism of action:

Fertilizers enhance the growth of plants. This goal is met in two ways, the traditional one being additives that provide nutrients. The second mode by which some fertilizers act is to enhance the effectiveness of the soil by modifying its water retention and aeration.

Fertilizers typically provide, in varying proportions:

- Three main macro nutrients:
  Nitrogen (N), Phosphorous (P), Potassium (K)

- Three Secondary macronutrients: Calcium (Ca), magnesium (Mg), Sulfur (S)
- micronutrients: Copper (Cu), Iron (Fe), manganese (Mn), molybdenum (Mo), Zinc (Zn) Boron (B).

Classification:

Fertilizers are classified in several ways. They are classified according to whether they provide a single nutrient (e.g. N, P, K), in which case they are classified as "straight fertilizers". Multinutrient fertilizers provide two or more nutrients. Fertilizers are also sometimes classified as inorganic versus organic. Inorganic fertilizers exclude carbon-containing materials except Urea.

Single nutrient fertilizers:

The main nitrogen-based straight fertilizer is ammonia or its solution. Ammonium nitrate (NH_4NO_3) is also widely used. Urea is another popular source of nitrogen, having the advantage that it is solid and non explosive unlike NH_4NO_3

The main straight phosphate fertilizers are the superphosphate.

Multinutrient fertilizers

Binary (NP, NK, PK) fertilizers

The main NP fertilizers are mono ammonium phosphate (MAP)

NPK fertilizers are three component fertilizers.

Urea manufacturing process: * Give a detailed process involved in the manufacture of urea with a proper flow diagram and using chemical reaction wherever necessary.

Liquid ammonia is allowed to react with liquid carbon dioxide in a reactor at high temperature and pressure. The conditions employed are 130°–150°C and a pressure of 35 atm.

Ammonia & Carbon dioxide (NH_3 & CO_2) —(180°C–210°C, 150 atm)→ Ammonium carbamate NH_2COONH_4

↓ Number of decomposition under gradually decreasing pressures

Urea crystals ←(Concentrating from evaporating)— Urea solution $CO(NH_2)_2 + H_2O$

First step reaction:

$$NH_3(g) + CO_2(g) \rightleftharpoons NH_2COONH_4(s)$$

Second step reaction:

$$NH_2COONH_4(s) \rightleftharpoons CO(NH_2)_2\,aq + H_2O(l)$$

* Manufactured Urea contains unreacted ammonia and CO_2 and ammonium carbamate. Ammonium carbamate is removed by reducing the pressure. Under heating ammonia and CO_2 is separated. The

advantage of this process is NH_3 and CO_2 can be recycled back to the process. Urea is obtained as a solution, but that solution is concentrated to give 99.6% molten urea, and granulated for use for fertilizer.

* What is triple super phosphate?

Triple superphosphate is highly concentrated phosphorus fertilizer with contents of 46% diphosphorous penta oxide (P_2O_5). It is appropriate for feeding all the types of soils which have pH within the limits of weakly acidic to alkaline medium. It assists the acceleration of the growth and the development of the root system, increases the resistance of the plants to freezing, helps for the full absorption of the soil moisture, and in this manner it reduces the probability of damages to the plants in times of drought.

* Define the basic requirement of a chemical to be used as a fertilizer.

Fertilizers are chemical substances that are used to enrich soils with specific nutrients to help plants grow.

Generally fertilizer industry is engaged in the production of primary plant nutrients (2) suitable for applications in the soils.

So those chemical are generally used as a fertilizer which provide basic nutrients for plant growth.

1. It should not be a poison for plant
2. It should not be very costly
3. It should maintain the pH of the soil in the vicinity of 7 to 8
4. The substance must be soluble in water
5. The element

Write Short note on NPK value:

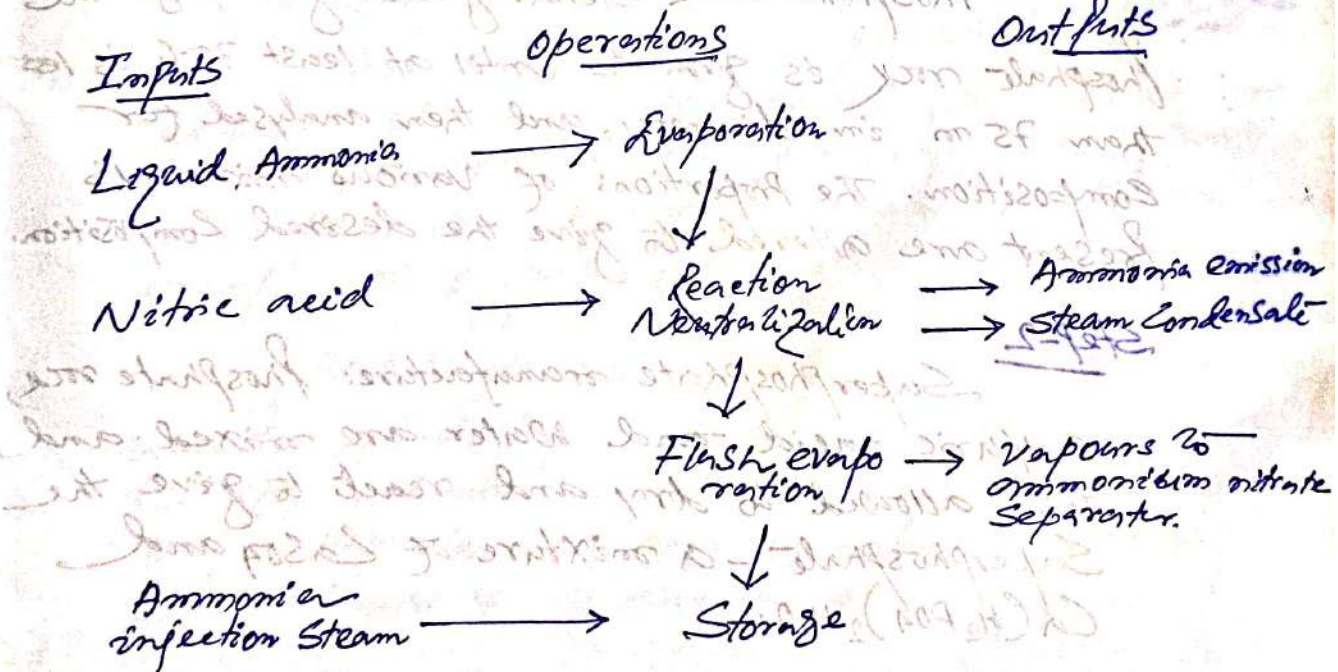
Many countries have standardized the labeling of fertilizers to indicate their contents of major nutrients. The most common labeling convention, the NPK or N-PK label, shows the amounts of the chemical elements nitrogen, phosphorus and potassium.

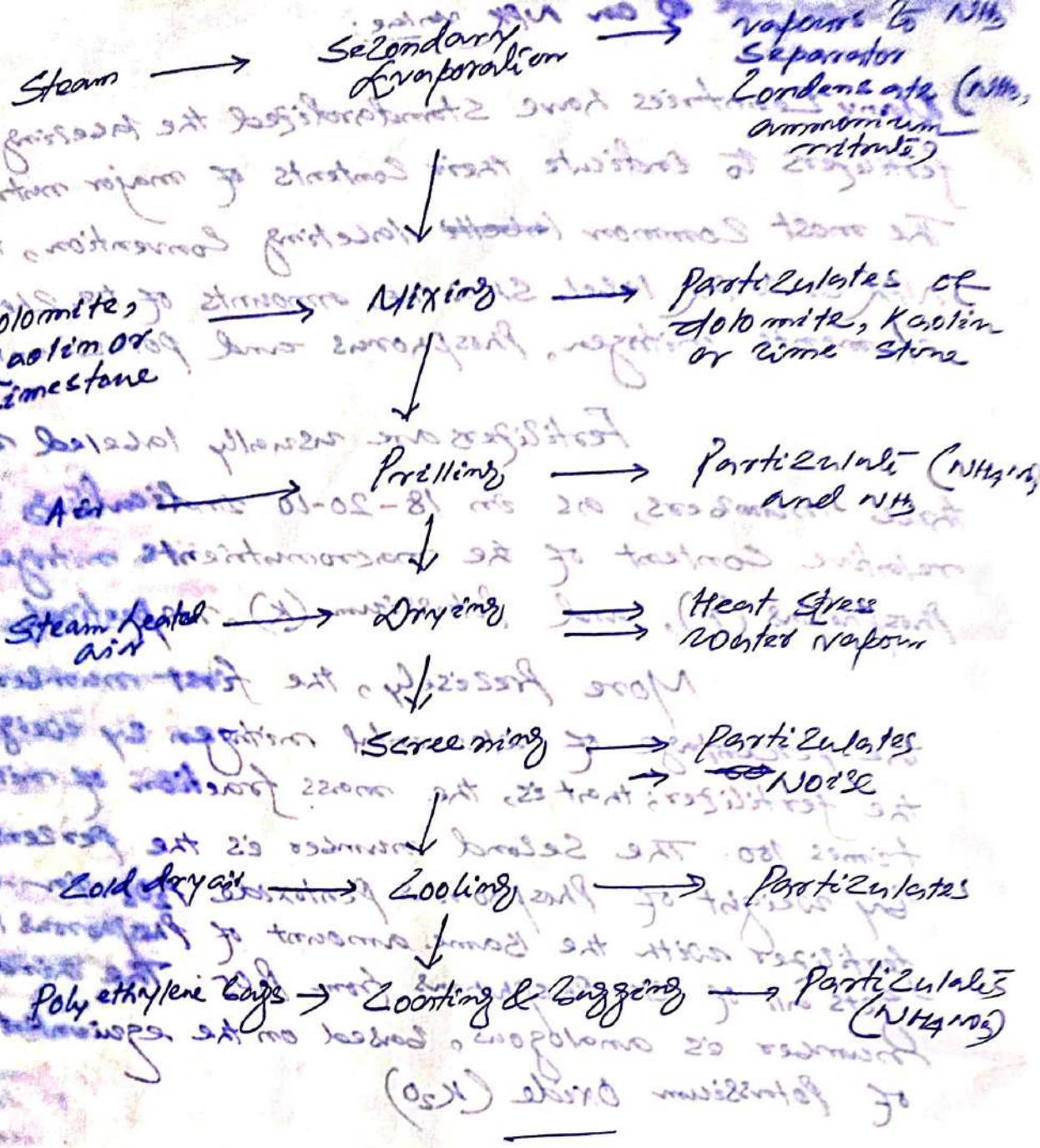
Fertilizers are usually labeled with three numbers, as in 18-20-10 indicating the relative content of the macronutrients nitrogen (N), phosphorous (P), and potassium (K), respectively.

More precisely, the first number is the percentage of elemental nitrogen by weight in the fertilizer; that is, the mass fraction of nitrogen times 100. The second number is the percentage by weight of phosphorous pentoxide, P_2O_5, in a fertilizer with the same amount of phosphorous that gets all of its phosphorous from P_2O_5. The third number is analogous, based on the equivalent content of potassium oxide (K_2O).

* Manufacture of ammonium nitrate:

Process Flow diagram for Ammonium Nitrate Manufacturing:





Manufacture of Superphosphate:

Step-1

Phosphate rock blending and grinding: The phosphate rock is ground until at least 75% is less than 75 m in diameter, and then analysed for composition. The proportions of various minerals present are altered to give the desired composition.

Step-2

Superphosphate manufacture: Phosphate rock, Sulfuric acid and water are mixed and then allowed to dry and react to give the Superphosphate — a mixture of $CaSO_4$ and $Ca(H_2PO_4)_2 \cdot H_2O$.

Step-3

Granulation:

The cake of superphosphate is then ground to give particles no more than 6 mm in diameter.

$$Ca_5(PO_4)_3F + 5H_2SO_4 \rightarrow 5CaSO_4 + 3H_3PO_4 + HF$$

$$Ca_5(PO_4)_3F + 7H_3PO_4 + 5H_2O \longrightarrow 5Ca(H_2PO_4)_2H_2O + HF$$

Overall equation is

$$2Ca_5(PO_4)_3F + 7H_2SO_4 + 3H_2O \longrightarrow 7CaSO_4 + 3Ca(H_2PO_4)_2H_2O + 2HF.$$

* What are differences between organic and chemical fertilizers? Which one of them is better to use?

Chemical fertilizers are manufactured or are refined from natural materials such as rock, animal or petroleum products. Nutrients are concentrated in industrial process to make them more available to plants. $(NH_4)_2SO_4$, ammonium phosphate and potassium sulfate are example of processed or chemical fertilizer.

On the other hand organic fertilizers are composed of natural materials such as mined minerals, animal or plant materials with little or no processing. Manure cottonseed meal are examples of organic fertilizer.

Nutrients in chemical fertilizer are usually immediately available to plants. Organic fertilizer nutrients are not all as quickly available, they release some of their nutrients more slowly over the course of weeks or months

Advantage of Organic fertilizer:

- Since they are ultimately slow release fertilizer it's very difficult to over fertilizer (and harm) the plants
- Organic fertilizers are renewable, biodegradable and ecofriendly

Disadvantage of organic fertilizer:-

- Nutrient ratio are often unknown, and the overall percentage is lower than chemical fertilizers.

* Advantages and disadvantages of Chemical fertilizer:

- Since nutrients are available to the plants immediately, improvement occurs in days.
- They are highly analyzed to produce the exact ratio of nutrients desired.
- Because the nutrients are easily available, there is a danger of over fertilization. This not only kill plants but upset the entire ecosystem.

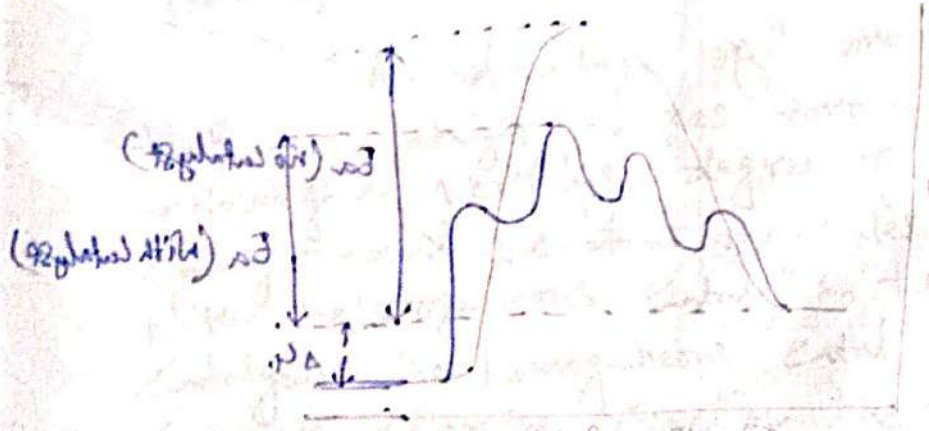
This both organic and chemical fertilizer has advantages and disadvantages. But in terms of human health and ecofriendly environment, Organic fertilizer is more safer to use than Chemical fertilizer.

* Define Bio-fertilizer?

A Bio-fertilizer is a substance which contains living micro organism which, when applied to seeds, plant surface or soil, colonize the rhizosphere or the interior of the plant and promotes growth by increasing the supply availability of primary nutrients to the host plant. e.g. Rhizobium, Azotobacter, Azospirillum and blue green algae (BGA)

* What is NPK fertilizer(1)

NPK fertilizer are three component fertilizers providing nitrogen, phosphorus and potassium to seeds plant surface or soil.



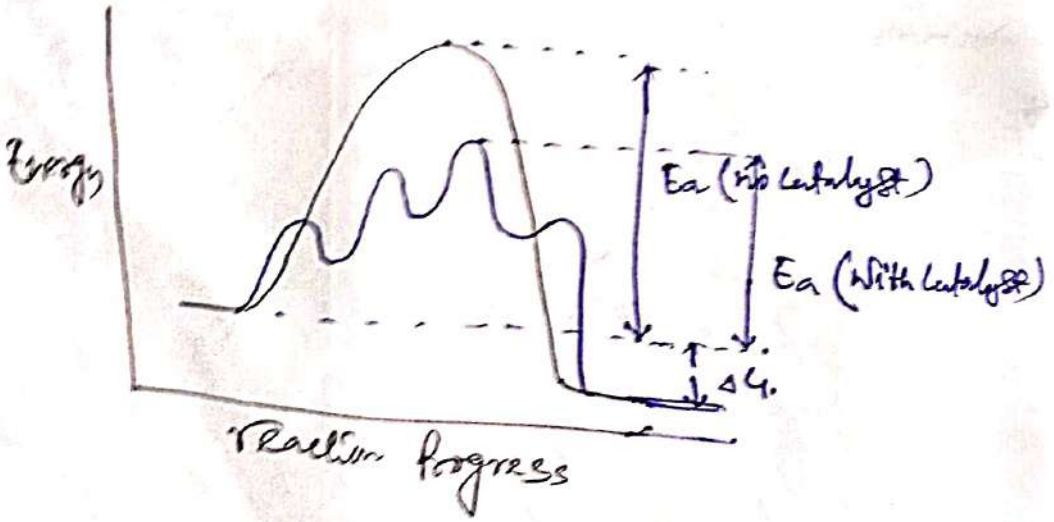
Catalysis

What is Catalysis:

Catalysis is the process of increasing the rate of a chemical reaction by adding a substance known as a catalyst, which is not consumed in the catalyzed reaction and can continue to act repeatedly. Because of this, only very small amounts of catalyst are required to alter the reaction rate in principle.

Mechanism of action:

In general, chemical reactions occur faster in the presence of a catalyst because the catalyst provides an alternative reaction pathway with a lower activation energy than the non-catalyzed mechanism. In catalyzed mechanisms, the catalyst usually reacts to form a temporary intermediate, which then regenerates the original catalyst in a cyclic process. A substance which provides a mechanism with a higher activation energy does not decrease the rate because the reaction can still occur by the non-catalyzed route. An added substance which does reduce the reaction rate is not considered a catalyst but a reaction inhibitor.

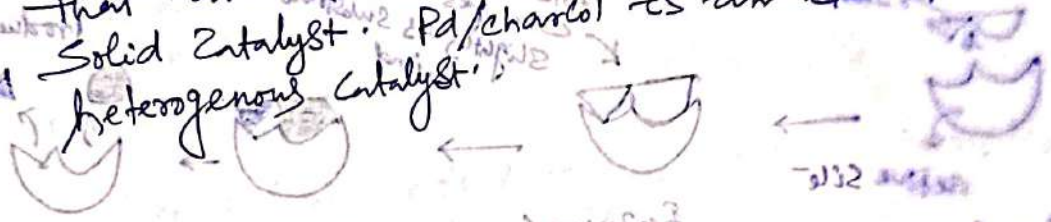


Classification:

Catalyst may be classified as either homogeneous or heterogeneous.

A homogeneous catalyst is one whose molecules are dispersed in the same phase (usually gaseous or liquid) as the reactant's molecules. Wilkinson catalyst, enzyme example of homogeneous catalyst

A heterogeneous catalyst is one whose molecules are not in the same phase as the reactant's, which are typically gases or liquids that are adsorbed onto the surface of the solid catalyst. Pd/charcol is an example of heterogeneous catalyst.



* Homogeneous Catalysis:

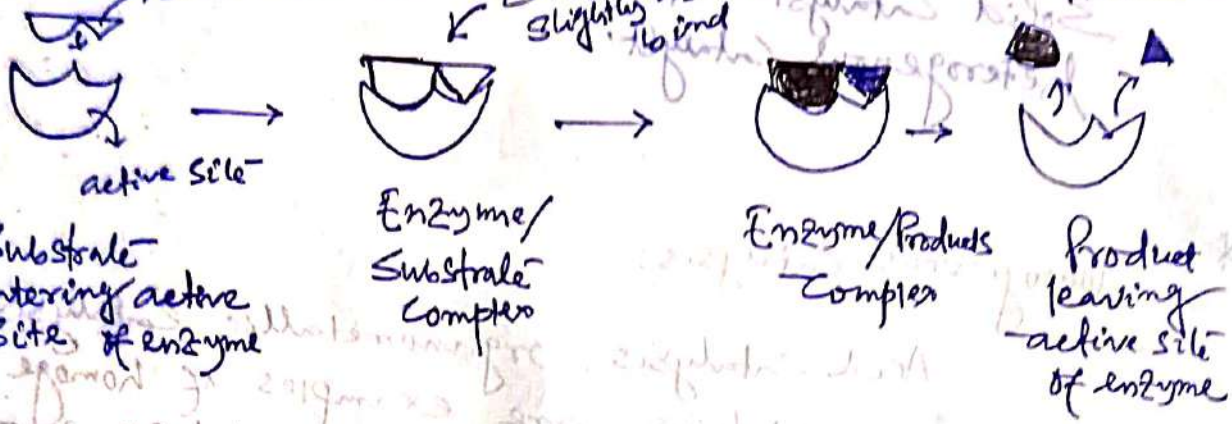
Acid catalysis, organometallic catalysis and enzymatic catalysis are examples of homogeneous catalysis. Most often, homogeneous catalysis involves the introduction of an aqueous phase catalyst into an aqueous solution of reactants. In such cases, acid and bases are often very effective catalysts, as they can speed up reaction by affecting bond polarization.

An advantage of homogeneous catalysis is that the catalyst mixes into the reaction mixture, allowing a very high degree of interaction between catalyst and reactant molecules. However, unlike with heterogeneous catalysis, the homogeneous catalysis, the homogeneous catalyst is often irrecoverable after the reaction has run to completion

Homogeneous catalysts are used in variety of industrial applications, as they allow for an increase in reaction rate ~~without~~ without an increase in temperature.

Catalytic Path for enzyme Catalysis:

Enzymes are proteins that help to lower the activation energy for various biochemical reactions. They do this by binding the reactant(s), known as the substrate(s), to an active site within the enzyme. At the active site, the substrate(s) can form an activated complex with lower energy. Once the reaction completes, the product(s) leaves the active site, so the enzyme is free to catalyze more reactions.



Mechanism of homogeneous catalysis reaction.

The mechanism of catalytic action in homogeneous catalysis consists in the formation of an intermediate compound between one or more reactants and the catalyst. These intermediates are sometimes separated or detected analytically. Processes with the participation of catalysts are accelerated in almost all cases because of lowering in activation energy due to the formation of an intermediate in comparison with the activation energy of formation of an non-catalytic homogeneous active complex. The intermediate compound is loosely held and is unstable. This compound then takes part in subsequent reactions which result in the final products and the regenerated catalyst.

Let us consider that a non-catalytic bimolecular reaction proceeds as follows.

$$A + B \rightarrow [AB]^* \longrightarrow C + D$$

In the presence of catalyst, the reaction will proceed in the three steps.

a. The formation of an intermediate A-Cat as a result of the reversible reaction between the catalyst and one of the reactants.

$$A + \text{Catalyst} \underset{K_2}{\overset{K_1}{\rightleftharpoons}} A\text{-Cat}$$

b. The formation of an active complex as a result of the reaction between the intermediate A-Cat and the second component B.

$$A\text{-Cat} + B \xrightarrow{K_1} [AB]^* Cat$$

c. The formation of the products and regeneration of the catalyst.

$$[AB]^* Cat \xrightarrow{K_2} C + D + Cat$$

In the presence of a catalyst the reaction follows a different path, as a result of which activation energy of the process decreases.

Mechanism of heterogeneous catalyst reaction:

Heterogeneous catalysis is used in the industry on a larger scale than homogeneous catalysis. Majority of known industrial heterogeneous catalytic processes are based on reactions between gaseous substances in presence of a solid catalyst, although other combinations are also known.

There are several different theories which explain the catalytic process. Each of them, supplementing and developing the other ones, explains the accelerating effect of solid catalysts. An important role in catalysis is played by active centres, i.e. in homogeneous sections of a surface having an increased activity. All the theories of catalysis indicate the formation of an intermediate absorption-type compound on the surface of solid catalyst. The nature of this compound may be different — an active complex or an active ensemble, which is a definite kind of geometric formation, a multiplet or a chemical compound with the participation of free electrons of the catalyst. The properties of such an intermediate determine the direction and, if the process is in the kinetically controlled region, the rate of the chemical transformation, the level of catalyst activity, and other catalytic characteristics.

Zeolites as Catalyst:

Zeolites are hydrated aluminosilicate minerals made from interlinked tetrahedra of alumina (AlO_4) and silica (SiO_4). In simpler words, they're solids with a relatively open, three dimensional crystal structure built from the elements aluminium, oxygen and silicon with alkali or alkaline earths metals, plus water molecule trapped in the gaps between them. Zeolites form with many different crystalline structure, which have large open pores in a very regular arrangement and roughly the same size as small molecules.

Properties of Zeolite:

Zeolites are very stable solid that resist the kinds of environmental conditions that challenge many other materials. High temperatures don't bother them because they have relative high melting points, and they don't burn. They also resist high pressures, don't dissolve in water or other inorganic solvents, and don't oxidize in the air.

Zeolite Catalyst:

An important use for zeolites is as catalyst in the petrochemical industry, where they're used in catalytic crackers to break large hydrocarbon molecules into gasoline, diesel, kerosene, waxes and all kinds of other by products of petroleum. The many pores in zeolites open structure are like millions of tiny test tubes where atoms and molecules become trapped and chemical reactions readily take place.

The catalysis process consists of

① Diffusion of the starting materials to the catalyst surface ② Their absorption on the

Catalyst ③ formation of intermediate complex at the Catalyst surface ④ formation of Cracking products ⑤ Desorption of Cracking products from the Catalyst surface and their diffusion first inside the Catalyst pores and then into the free space. The Chemical processes which take place over a Catalyst are chain reactions. They are accompanied by homogeneous, thermal decomposition of the hydrocarbon.

Phase transfer Catalyst:

See in 2nd sem notes (substitution rea)

Silica industries

* ~~What is Pozzolan cement~~

Cement

What is cement?

Cement is the general term given to the Powdered materials which initially have Plastic flow when mixed with water or other liquid, but has the property of setting to a hard solid structure in several hours with varying degree of strength and bonding properties.

What is Portland cement?

Portland cement is one of the most important building materials at the present time. Joseph Aspdin found that a strongly heated mixture of limestone and clay, when mixed with a small amount of water, set in few hours to a hard stone like substance. Portland cement is chemically defined as the finely ground mixture of calcium aluminates and silicates of varying compositions, which hydrated when mixed with water to form a rigid solid structure with good compressive strength.

What is pozzolan cement?

To save on portland cement, a universal but expensive cement, mixed cement is made, which can only be used with certain limits. Pozzolan cements are finely ground mixtures of Portland cement clinker with hydraulic admixtures added in amounts from 20 to 50%. The hydraulic ~~dirt~~ ingredients may be porous volcanic rock, sedimentary minerals containing mainly the amorphous silica or silica containing industrial waste materials. This cement is made by grinding 2-4 parts of pozzolan, with I part of

hydrated lime in presence of some burnt clay. It is mixed with Portland cement as a cheap extender.

* What are the important functions of various ingredients present in cement?

Ans: Different ingredients of cement and their proportions are as follows:

1. Lime (CaO)
2. Silica (SiO_2)
3. Alumina (Al_2O_3)
4. Iron (Fe_2O_3)
5. Magnesia (MgO)
6. Calcium Sulfate ($CaSO_4$)
7. Sulfur (SO_3)
8. Alkalis

Function:

Lime (CaO): Adequate quantity of lime in cement is helpful to form the silicates and aluminates of calcium. If lime is added in excess quantity the cement becomes unsound as well as expansion and disintegration of cement will occour. The cement contains 60-67% of lime init.

Silica (SiO_2): Sufficient quantity of silica helps for the formation of di-calcium and tri-calcium silicates which imparts strength to the cement. The cement contains 17 to 25% of silica in it

Alumina (Al_2O_3):

Alumina imparts quick setting property to the cement. In general, high temperature is required to produce required quality of cement. But alumina when added with cement ingredients it behaves as a flux and reduces the clinkering temperature which finally weakens the cement. So, to maintain the high temperature alumina should not be used in excess quantity. The range of alumina in cement should be 3 to 8%.

Iron oxide:

The main function of iron oxide is to impart colour to the cement. Iron oxide quantity in cement is ranges from 0.5 to 6%.

Magnesia (MgO): Magnesia in cement in small quantities imparts hardness and color to the cement. Cement contains magnesia in the range of 0.1 to 3%.

Calcium Sulfate ($CaSO_4$): The function of calcium sulfate in cement is to increase the initial setting time of cement.

Sulfur (SO_3): Its function is to make the cement sound.

Alkali: Alkalis like soda and potash are present in the cement which ranges from 0.1 to 1%. During manufacturing process of cement most of the alkalis are carried away by the flue gases at the time of heating. Hence cement contains very small quantity of alkali of it.

Why is gypsum added to Cement?

Gypsum plays a very important role in controlling the rate of hardening of the cement. During the cement manufacturing process, upon the cooling of clinker, a small amount of Gypsum is introduced during the final grinding process. Gypsum is added to control the "setting of cement".

Define the term setting of cement?

When cement is mixed with water and allowed to stand, it sets to a hard, rigid mass by a series of complex reactions. Hydration reaction begins, resulting in the formation of gel and crystalline products. The process of solidification consists of setting and hardening. Setting is regarded as stiffening of the original paste mass because of initial gel formation and hardening is regarded as development of strength because of crystallization. This is also known by the fact that while the first setting occurs within 24h the subsequent hardening requires 15-20 days.

* Discuss the physiochemical changes that occurs during the setting of cement. (4)

Ans: The process of setting or hardening of cement is now believed to be partly a chemical change and partly physical. The chemical changes involve hydrolysis of various constituents with accompanying heat changes, and physical change is gel formation followed by separations of crystalline products.

~~By the hyd~~

In general, initial setting of cement is mainly due to the hydration of tricalcium aluminate (C_3A), because its reaction is complete within 7 days.

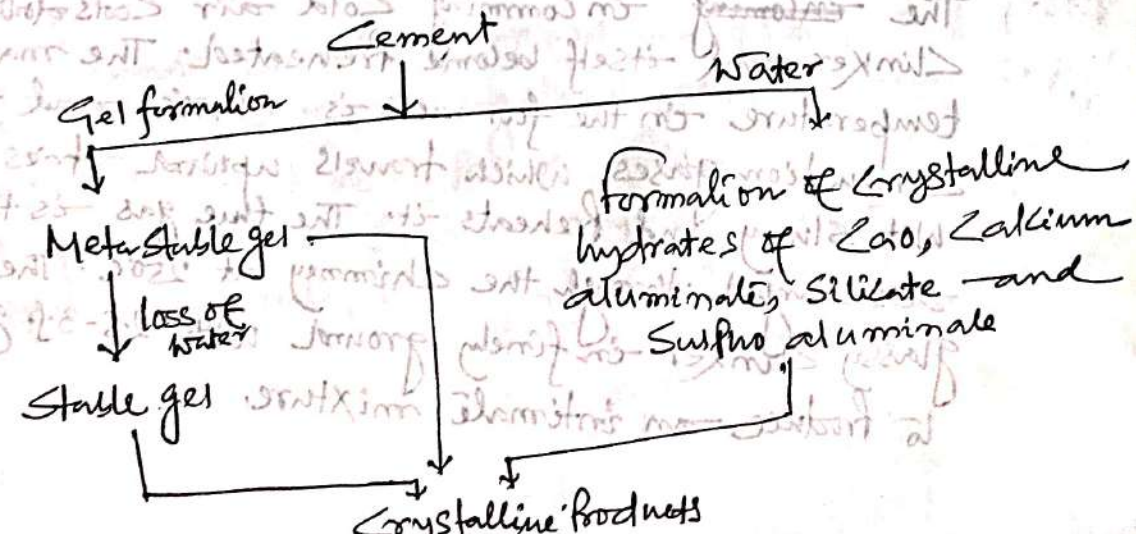
$$3CaO \cdot Al_2O_3 + 6H_2O \rightarrow 3CaO \cdot Al_2O_3 \cdot 6H_2O + 880 KJ/Kg$$

Dicalcium Silicate also undergoes hydrolysis and forms tobermonite gel which has high surface area and very high adhesive property. Hence $2CaO \cdot SiO_2$ (C_2S) also contribute to initial setting.

$$2[2CaO \cdot SiO_2] + 4H_2O \rightarrow 2CaO \cdot 2SiO_2 \cdot 6H_2O + Ca(OH)_2 + 250 KJ/Kg$$

final setting and hardening of cement is mainly due to the formation of tobermonite gel and crystallization of $Ca(OH)_2$ and hydrated tricalcium aluminate, $3CaO \cdot Al_2O_3 \cdot 6H_2O$.

In an alternative pathway, water reacts with cement grains at the surface to form a gel which acts as a bonding material between the grains. The gel loses water slowly to the inner layers thereby getting hardened slowly and offers some mechanism for the setting or hardening process. The setting of cement in term of crystalline hydrate and gel formation can be represented as:



* Discuss the manufacture of Portland Cement with a suitable flow diagram and mention the chemical reactions involved (5)

Ans

The chief raw materials for the manufacture of Cement are limestone and clay which roughly all the four principle ingredients, viz, CaO, Al_2O_3, Fe_2O_3 and SiO_2.

There are two methods of manufacturing Portland Cement. The wet process and the dry process. The differences are in the treatment of raw material only. In dry process no water is added to the material in grinding and thus no slurry is made, otherwise very much same equipment is used in both.

In the wet process, the materials are ground in wet condition in ball mill to produce a slurry containing ~ 40% water. The slurry is filtered and put directly to the upper end of an inclined rotary kiln. The inclination of the kiln is about 1° to the horizontal. The outer steel cylinder of the kiln is lined inside with refractory bricks. As it rotates in the inclined position, the charge gradually travels down towards discharge end. Heat is generated by burning fuel which enters at the lower end of the ~~Klin~~ kiln. The ~~coming~~ incoming cold air cools down the clinker and itself become preheated. The maximum temperature in the furnace is ~ 1450°C and the hot combustion gases which travels upward dries up the wet slurry and preheats it. The flue gas is then discharged through the chimney at 250°C. The hard glassy clinker is finely ground with 2.5-3% gypsum to produce an intimate mixture.

The various chemical reactions involved are as follows –

$CaCO_3$ (limestone) $\rightarrow CaO + CO_2$

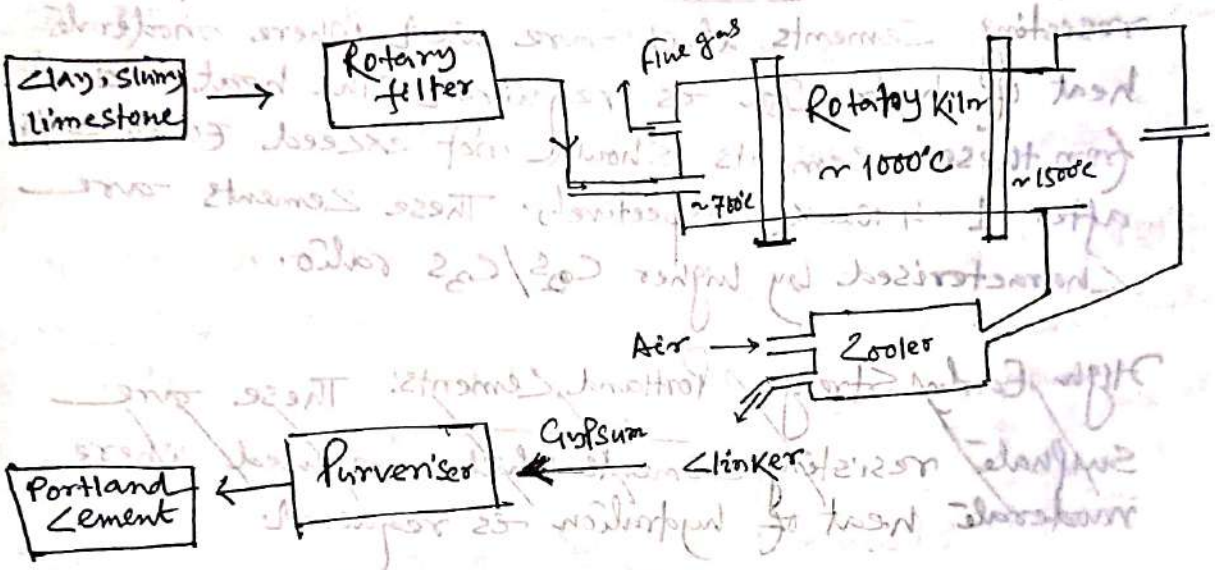
$2CaO + SiO_2 \rightarrow 2CaO \cdot SiO_2$

$3CaO + SiO_2 \rightarrow 3CaO \cdot SiO_2$

$3CaO + Al_2O_3 \rightarrow 3CaO \cdot Al_2O_3$

$4CaO + Fe_2O_3 + Al_2O_3 \rightarrow 4CaO \cdot Al_2O_3 Fe_2O_3$

} at 1450°C at the end of the Kiln.



* Write the composition of Portland Cement. (2)

Ans: Portland Cement is a mixture of the following ingredients:

i. $2CaO \cdot SiO_2$ (C_2S) ii. $3CaO \cdot SiO_2$ (C_3S)

iii. $3CaO \cdot Al_2O_3$ (C_3A) iv. $4CaO \cdot Al_2O_3 \cdot Fe_2O_3$ (C_4AF)

v. MgO vi. CaO

* Discuss about the different types of Portland cement.

Ans: Portland Cement is of various types, depending upon the rate of setting, heat evolution and strength characteristics five types of Portland Cement are recognised, which contain varying amounts of the clinker compounds C_2S, C_3S, C_4AF and MgO.

Regular Portland Cement: 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% CA_2S and 5-13% C_3A. White cement, quick setting cements etc belong to this class.

Modified Portland Cement: These are sulphate-resisting cements which are used where moderate heat of hydration is required. The heat evolved from these cements should not exceed 70-80 cal/g after 1-4 week respectively. These cements are characterised by higher C_2S/C_3S ratio.

High Early Strength Portland Cements: These are sulphate resisting cements which are used where moderate heat of hydration is required.

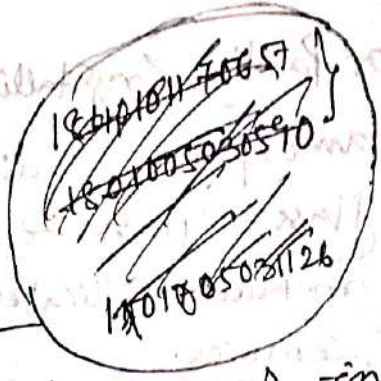
High early strength Portland cements These cements contain higher percentage of C_3S and C_3A with finer grinding to increase hydration rate. The high proportion of C_3S causes a quicker hardening than regular Portland cement and thus attains a strength of type 1 in only 3 days.

Low heat Portland Cement:

These cement contain a lower percentage of C_3S and C_3A and thus decrease the heat evolution. These cements are designed for massive structure work.

Sulphate resisting Portland cement: These are good for sea water contact, resist sulphates better than other four types, lower in C_3A and higher in C_4AF.

Glass



* What is photochromatic glass?

Such glasses have a large number of microscopic particles of silver halides trapped in the three dimensional silicate network in fixed concentration. On exposure of light, temporary colour centres consisting of silver particles only are produced and these add up quickly producing total darkness. The intensity of darkness depends upon the concentration of Ag. Because reversible darkening is controlled by the radiations in the UV region, quite abundant in day light, the photoblackening does not occour markedly in the lamp light in the night.

* Write the composition of soda and pyrex glass.

Ans Soda-lime glass, most common form of glass produced. It is composed of about 70 %. silica (SiO_2), 15 %. soda (Sodium oxide), and 9 %. lime (CaO), with much smaller amounts of various other compounds

pyrex glass composed of 4.0 %. boron, 54.0 %. oxygen, 2.8 %. Sodium, 1.1 %. aluminium, 37.5 %. silicon and 0.3 %. potassium.

* Distinguish between glass and ~~[illegible]~~ ceramic.

Glass can be called as a type of ceramic. Glass is known to be a non-crystalline material. It is an amorphous solid, which means that it has no long-range order of positioning of its molecule.

Ceramic can be termed as an inorganic material. Unlike glass, ceramics may have crystalline

or partly crystalline structures. Ceramics may also be amorphous. Silicon dioxide is the main component of glass. Glass is a mixture of two or more kinds of metallic silicates. Clay is the main component in ceramics.

Both glass and ceramics are brittle and break at the instance of a small force. Glass is also transparent, which means light passes through it. Ceramics may be opaque, which means it does not allow light to pass through it.

Ceramics are hard, brittle, oxidation resistant, wear-resistant, thermal and electrical insulating, refractory, nonmagnetic, chemically stable and prone to thermal shock.

Glass is hard, amorphous, inert, biologically inactive, fragile and transparent.

In the manufacture of both glass and ceramics there is slight difference. A glass kiln will have heating elements on the top whereas a ceramic kiln will have heating elements on the sides.

* Discuss briefly about fiber glass.

Such type of glass is used in textiles and reinforcing and can be spun into yarn, gathered into a mat, and made into insulation and great variety of other products may be made with it. fiber glass is nothing but molten glass processed mechanically to a flexible thread of filament. A hot platinum nozzle filled with molten glass forces out the fluid in the form of a thin continuous thread which when caught by a rapidly moving disc gets converted into fiber through elongation and twist given by the disc. fiber glass are not brittle, bad conductor of heat, and fire proof.

What is meant by annealing of glass?

Ans:

Annealing of glass is a process of slowly cooling hot glass objects after they have been formed, to relieve residual internal stresses introduced during manufacture. Especially for smaller, simple objects, annealing may be incidental to the process of manufacture, but in larger or more complex products it commonly demands a special process of annealing in a temperature-controlled kiln known as lehr. Annealing of glass is critical to its durability. Glass that has not been properly annealed retains thermal stresses caused by quenching, which indefinitely decrease the strength and reliability of the product.

To anneal glass, it is necessary to heat it to its annealing temperature, at which its viscosity drops to 10^{13} Poise. For most kinds of glass, this annealing temperature is in the range of 454-482° and is the so called Strass-relief point or annealing point of the glass. At such a viscosity, the glass is still too hard for significant external deformation without breaking, but it is soft enough to relax internal strains by microscopic flow in response to the intense stresses they introduced internally.

* Differentiate between glass and porcelain.

Ans: Glass is an amorphous solid, that is, it has no crystalline structure and is made by a different process than porcelain. Glass is a combination of various compounds mixed together and heated until melted and stirred to condition the glass and remove air bubbles. Many glasses are made three basic ingredients; sand, limestone and soda ash.

Porcelain is very specific type of ceramic. Porcelain ware has a white translucent body. It is dense, vitrified and impermeable to water. It has very defined chemical structure where all of the elements come together in a unique way to impart the chemical and physical properties.

* What is borosilicate glass?

This glass is an example of optical glass and contains about 13-28 wt.% of B_2O_3 and 80-87 wt.% silica. It has low expansion coefficients, superior resistance to shock, high electrical resistance and high chemical stability. The composition of typical borosilicate glass is: SiO_2 = 80.5 wt.%, B_2O_3 = 13 wt.%, Al_2O_3 = 2 wt.%, K_2O = 3 wt.% and Na_2O = 0.5 wt.%. These glasses are used in the manufacture of baking dishes, laboratory glass ware, pipe lines, insulators and washers.

What is glass?

Physically glass may be defined as hard, rigid, undercooled, brittle, non-crystalline substance having no definite melting point and sufficiently high viscosity to prevent crystallization. Chemically glass may be defined as a fused mixture of silicates, alkali and alkaline earth compounds and other glass constituents, such as CaO, MgO, SnO_2, B_2O_3, PbO.

Physical properties:

1. They are visually transparent, amorphous solid.
2. Glass is completely vitrified product.
3. They are hard and rigid and have no definite melting point.
4. They have sufficiently high viscosity.
5. They are insulator of heat and electricity.

Chemical properties:

1. Glass is not attacked by air and oxidising agent.
2. Ordinary glass is readily attacked by alkalies, but very resistent to acids, except HF. Glass is a silicates and HF reacts with it to form SiF_4 gas and fluorides of metals.

$$Na_2O.SiO_2 + 6HF \longrightarrow 2NaF + SiF_4 + 3H_2O$$

Characterstics of glass:

i. hardness ii. transparency iii. Refractive capacity iv. dispersive capacity v. low coefficient of cubical expansion vi. High electrical insulation vii. Low thermal conductivity.

* Write down the composition of soda glass and flint glass.

Ans: Soda glass composition is already given previously.

Flint glass: It is clear transparent potash lead glass used in making electric bulbs and optical instrument. Flint glass contain 45-65% lead oxide they are high density, high dispersion, high refractive-index glasses.

* What is white cement?

The colour of ordinary cement is grey-ish-black due to the presence of iron oxide present as one of the constituents. If iron oxide can be avoided by suitable selection of raw materials, it is even possible to get white cement. Hence if low iron feldspar, limestone and gypsum are fused together at 900°C and then leached with water, the fusion of the leached product at 1400°C gives white cement. This is mainly used for decorative constructions.

* What is biofertilizer? Give examples?

* What is Glass wool?

Glass wool is obtained by the action of steam jets on dripping streams of molten glass down from small holes. The glass wool formed in this manner is carried away by a conveyor belt on which is is hurled. Glass wool is a fibrous wool like material composed of intermingled fine threads or filaments of glass and number of important properties. For example,

i. It is non-combustible.

ii. It is fire

iii. It has low electrical conductivity
iv. It is heat proof.
v. It does not absorb moisture or water
vi. It is chemically resistance to a number of chemicals.
vii. It has a low density
viii. It has low thermal conductivity
ix. It has a high tensile strength.

* Define the term Glazing.

Ans: Glazing is important in White Wares and table Wares. A Glaze is a thin coating of glass that is melted onto the surface of the more of less porous ceramic material. In other words, Glaze is applied on the surface to cover the pores which are present in all classes of ceramic, except hard porcelain. A Glaze is a fine powder, consisting of a mixture of glass forming materials, such as feldspar, silica and china clay and fluxes, such as soda, potash, fluorspar and borax in different proportions. Different combinations of these materials and different temperature at which they are fired give a wide range of texture and quality. The Glaze may be put on the ware by dipping, spraying, pouring or brushing.

The Purpose of Glazing is:

i. To produce decorative effect.
ii. To improve the appearance of the article
iii. To improve the durability of ceramic article.
iv. To provide a smooth and glossy surface to the glaze materials.
v. To make the surface impervious to liquids.

* What are the division of raw materials for manufacturing porcelain?

Ans: Porcelain and china are made from white burning raw materials. The ~~~~ important raw materials are.

i. Kaolin or china clay.
ii. White burning ball clays.
iii. Quartz or flint.
iv. Feldspar.

Paints and Pigments

* What is Pigments?

Pigments are various organic and inorganic insoluble substances, which are widely used in surface coatings. They are also employed in ink, plastic, rubber, ceramic etc

* What is Paints?

Paints are stable mechanical mixtures of one or more pigments. The main function of the pigments is to impart the desired colour and to protect the film from penetrating radiation, such as UV rays.

* Define the term Paint failure.

The failure of Paints may be due to various causes, and in each case there is a special term used to explain the failure. Progressive Chalking or powdering of the paint film is called Chalking and is caused by the destructive Oxidation of the oil after drying of the paint on the surface. If Chalking is very rapid, the term erosion is used. Poor attachment of the paint on the surface to be coated is called peeling. If the center portion remains attached to the surface and the portion around the centre peels off, a term alligatoring is employed. Fine surface Cracking is called as checking and is due to the absence of plasticizers in the paint.

* Write the essential constituents of a paint and state function of each constituent.

Ans: Constituents of Paints are:

i. Pigments ii. Extenders of Fillers iii. Film forming materials iv. Driers v. Thinners vi. anti Skinning agent vii plasticizers ix. Resins x. Binders

Pigments:- They protect the film by reflecting the destructive Ultra violet lights to strengthen the film.

Extenders of fillers:- The extenders or fillers are added to the paint inorder to decrease the cost of the paint and to supplement the pigment in increasing the covering and weathering power of the film.

Film forming materials:- They act as carriers for the pigments and as formers of the protective film.

Driers:- It is use in order to accelerate the drying of the film through oxidation and polymerisation.

Thinners:- Thinner is also added to the paint, in order to dissolve film forming materials and to thin concentrated paints for better handling.

Anti skinning agent- Certain anti skinning agents are added to the paint in order to prevent gelling and skinning of the finished product before application of the paint by brushing.

Plasticizers:- Plasticizers are added to the paint by proper choice of the oils. Plasticizers provide elasticity to the film and thus prevent cracking of the paints.

Resins:- Resins are not essentially required for oil base paints. Water base paints contain no oils and depends on vinyl acetate, acrylic, Styrene polymer resin as the film forming materials.

Binders:- Binders act to fix the paint on the coated surface and provide tough, tenacious and glossy film on the surface being painted.

* Discuss the basic chemical reactions involved in the manufacture of glass.

Ans:

Glass is a solid solution having no definite composition. However, ordinary glass may approximately be written as:

$$Na_2O \cdot CaO \cdot 6SiO_2$$

When quartz or silica is heated with soda ash (Na_2CO_3) the silica, being an acidic oxide, displace the carbonic acid from the carbonate and a compound known as sodium silicate is formed.

$$Na_2CO_3 + SiO_2 \rightarrow Na_2SiO_3 + CO_2$$

The limestone ($CaCO_3$) also reacts with silica to give a glassy mass on cooling known as calcium silicate. The latter is, however, insoluble in water, but soluble in acids.

$$CaCO_3 + SiO_2 \rightarrow CaSiO_3 + CO_2$$

But if silica is simultaneously fused with Na_2CO_3 and $CaCO_3$ (soda ash + lime stone), sodium calcium silicate is obtained, which sets to a glassy mass on cooling and it is insoluble in water and acid both.

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

Sometimes, a mixture of salt cake, sodium sulphate and charcoal is fused with sand and lime stone to get glassy mass.

$$2Na_2SO_4 + 2SiO_2 + 2C \rightarrow 2Na_2SiO_3 + 2CO + 2SO_2$$

$$Na_2SiO_3 + CaCO_3 + 5SiO_2 \rightarrow Na_2O \cdot CaO \cdot 6SiO_2$$

* What are toners?

Insoluble organic dyes are known as toners and can be used as pigments. They are quite durable and have high colouring power.