Q. 1 Solve any five of the following

(a) Explain the advantages of galvanizing over tinning

In galvanizing Zn protects the iron sacrificially, since it is more electropositive than iron. Thus even if coating of Zn is punctured or broken Zn continues to protect the underling iron by galvanic cell action. Whereas Tin protects the underling iron till coating is perfect. Any break in coating causes rapid corrosion of iron.

(b) 0.5 gm coal on combustion in bomb calorimeter and the content on treatment with BaCl2 produce 0.06 gm BaSO4. Calculate % of sulpher in coal sample

$$\% \text{ Sulphur} = \frac{\text{Wt. of } BaSO_4 \times 32}{233 \times \text{Weight of Coal sample}} \times 100$$

$$\% \text{ Sulphur} = \frac{0.06 \times 32}{233 \times 0.5} \times 100$$

$$\% \text{ Sulphur} = 1.648\ \%$$

(c) Give manufacturing process of Silicon carbide ceramic powder

This is the most important non oxide ceramic which is widely used for abrasives or wear resistant material. Silicon Carbide exists as hexagonal & cubic structure. The SiC which is the stable form is first manufactured in 1891 by following reaction

$$SiO_2 + 3C \longrightarrow SiC + 2CO$$

The starting material is pure sand, petroleum coke, some saw dust to decrease packing density and 1-3 % of NaCl for purification. This is heated with graphite electrodes at 2000 to 2300^0C for 30 hours. β SiC is obtained by gas phase reaction of $SiCl_4$ with hydrocarbons.

(d) Explain non hazardous chemical principle of green chemistry with suitable example

Wherever practicable, synthetic methods should be designed to use & generate substances that possess little or no toxicity to human & the environment.

If hazardous products are formed their effects on the worker must be minimized by use of protective clothing, respirators etc. This will add to the cost of production. Sometimes it is found that controls may fail which ultimately increases risk.

Example – Synthesis of Indigo from Aniline (Traditional) & L-Tryptophan (Green route)

(e) What is cracking? Distinguish between thermal & catalytic cracking

Cracking is defined as the decomposition of bigger hydrocarbon molecules of high boiling point into simple, low boiling hydrocarbons of lower molecular weight.

Example- $C_{10}H_{22} \longrightarrow C_5H_{12} + C_5H_{10}$

(Decane) B.P. 174^0C — (Pentane) B.P. 36^0C — (Pentene) B.P. 30^0C

Thermal Cracking	Catalytic Cracking
It is carried out at high temp. & Pressure	It is carried out in presence of suitable catalyst
Yield of the petrol is low	Yield of the petrol is High
Quality of petrol is not better	Quality of petrol is much better
External Fuel is required for heating	No External fuel is required
High pressure is required	Much lower pressure (1-5 kg/cm^2) is needed
No control over the process	Process can be controlled to obtain desired product

(f) What are composite? What are their advantageous characteristics?

A composite material may be defined as a material system consisting of a mixture of two or more macro constituents, which are mutually insoluble, forming distinct phases. Such a combination usually possesses different properties than any of its individual constituent.

Characteristic properties-

1. Composites are more economical than metal & ceramics
2. Weight if composite articles are approximately 25% to 50% of the weight of conventional metallic design. Thus there is significant weight saving required for minimising fuel consumption of vehicle.
3. Composites excellent mechanical properties such as high strength, stiffness, excellent impact & damage resistance, friction & wear resistance
4. It maintains the strength at high temperatures.
5. Composites also show excellent chemical properties like corrosion resistance especially in marine environment
6. Good insulator of heat as well as low thermal expansion.
7. Easily fabric able.
8. Lower electrical conductivity

(g) Explain any two characteristics of catalyst with suitable examples

1 A catalyst remains unchanged chemically at the end of reaction. The change in its physical state, colour may occur.

2 A small amount of catalyst is sufficient to bring about a considerable change in the speed of reaction. However in some catalytic reactions the rate of reaction is proportional to the concentration of catalyst.

3 A catalyst is very specific in its action just like a key can open a particular lock. Thus different products are obtained in presence of different catalysts even though the reactants are same.

4 The catalyst does not affect the position of equilibrium in a reversible reaction. However a catalyst affects the rate of forward and backward reactions and helps in attending the equilibrium more quickly

5 A catalyst cannot initiate or start the reaction but can only increase or decrease its rate.

6 Change of temperature alters the rate of a catalytic reaction. A catalyst is most active at a particular temperature called optimum temperature.

7 The addition of a small amount of foreign substance sometimes increases the activity of catalyst. Such substances are called promoters. Example – Mo acts as a promoter for iron used as catalyst in the manufacture of NH_3 by Haber's process.

If the presence of a foreign substance inhibits the catalytic activity than it is called anti catalyst or catalytic poison. Example – in the manufacture of H_2SO_4 by contact process, a trace of arsenic oxide (As_2O_3) poisons the platinum used as a catalyst

Q.2 (a) What is petroleum? Describe the refining of petroleum with reference to bubble tower diagram

The word petroleum is derived from two Latin words, Petra - rock and oleum - oil. It is also known as crude oil, mineral oil.

It is dark greenish-brown, viscous oil found deep in earth's crust which is a result of decomposition of marine plant and animal bodies of pre historic forests.

It is mainly composed of various hydrocarbons such as paraffin, cyclo-paraffin, olefins and aromatics along with small amounts of organic compounds containing oxygen, nitrogen, & S

The process by which the crude oil is freed from impurities and separated into various useful fractions having different boiling points is known as refining of petroleum.

The process of refining involves following steps

1. Separation of water

2. Removal of harmful sulphur compounds -

3. Fractional distillation

3. Fractional distillation:- The crude oil is heated to about 400^0C in an iron retort, where all liquid constituents except residue (asphalt or coke) are evaporated. The hot vapours are then passed up a fractionating column. A fractionating column consists of a tall cylindrical tower containing number of horizontal stainless steel trays at short distances. Each tray is provided with small chimney, covered with a loose cap. As the vapours go up, they become gradually cooler and fractional condensation takes place at different heights of column. Higher boiling fraction condenses first while the lower boiling fractions turn by turn. Thus the crude oil gets fractionated into different fractions in the order of their boiling ranges, which are collected at different heights in the columns.

Diagram-

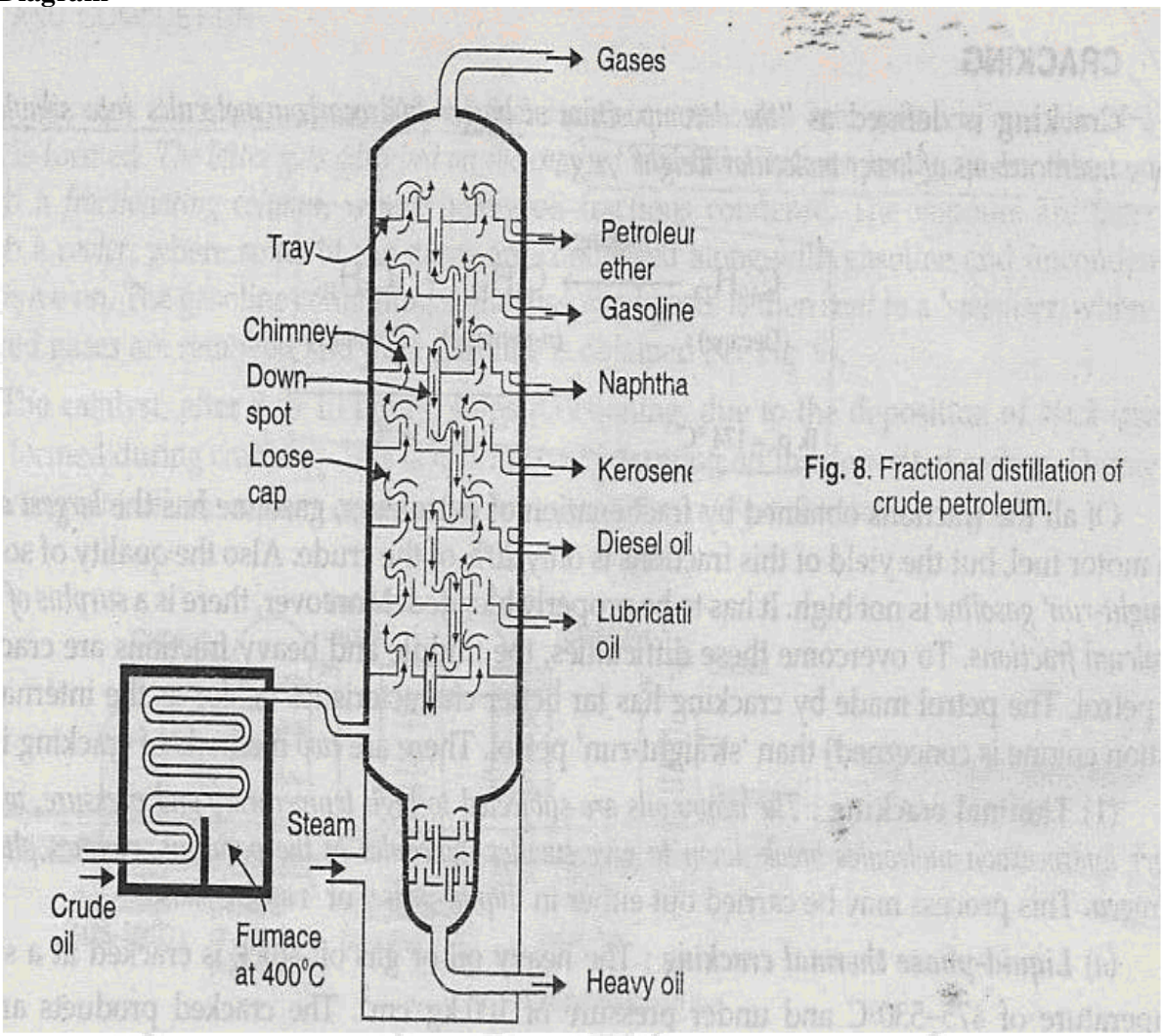


Fig. 8. Fractional distillation of crude petroleum.

Diagram from Engineering Chemistry by Jain & Jain

Q. 2 (b) Define Corrosion & explain the corrosion due to differential aeration with neat sketch.

Corrosion may be defined as the gradual eating away or disintegration or deterioration of a metal / alloy by chemical or electrochemical reactions with its environment starting at its surface.

Differential aeration corrosion:- When a part of a metal is exposed to different air (oxygen) concentration from the other part of a metal, a oxygen concentration cell is set up and anodic and cathodic areas are generated on the surface of the metal. Area, which is highly exposed to or accessible to oxygen (air), acts as cathode and the area which is less exposed to or accessible to oxygen (air) acts as anode. The concentration cell is represented as under –

$$M \left| \begin{matrix} H_2O, O_2 \\ P_1 \end{matrix} \right| \left| \left| \begin{matrix} H_2O, O_2 \\ P_2 \end{matrix} \right| M \qquad P_1 < P_2$$

Corrosion Reactions:

Anode reaction (Oxidation):- At anode i.e. area less exposed to oxygen (air) undergoes oxidation and pass in to solution in the forms of +ve ions

$$\underset{\textbf{(Metal)}}{M} \longrightarrow \underset{\textbf{(Metal Ion)}}{M^{n+}} + ne^-$$

Cathode reaction (Reduction):- The electrons released on the anode are conducted to the cathode i.e. area highly exposed to oxygen (air) for cathodic reactions.

$$H_2O + \frac{1}{2}O_2 + 2e^- \longrightarrow 2OH^-$$

Example: When a drop of water containing some salt is placed on iron surface, it is found that surface of iron under water undergoes corrosion. This is because the metal surface under the water is less exposed to air compared to the surface at the periphery of the drop. Thus oxygen concentration cell is set up where the surface under the water behaves like anode and the surface at the periphery acts as cathode.

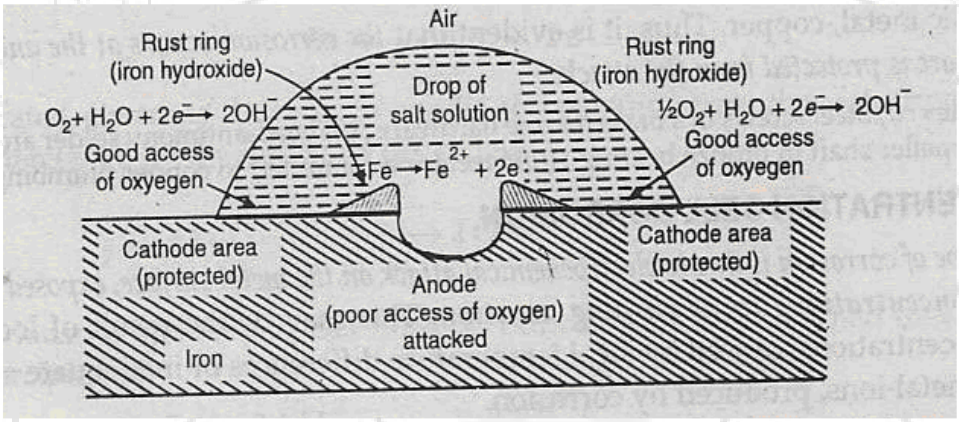


Diagram from Engineering Chemistry by Jain & Jain

Q. 2 (c) Define and explain activation energy.

Activation Energy According to the collision theory, a chemical reaction takes place only by collisions between the reacting molecules. However all the collisions are not effective and only a small fraction of the collisions bring about a reaction. A collision will be productive only when colliding molecules collide with sufficient kinetic energy and with proper orientation.

A chemical reaction takes place by breaking bonds between the atoms of the reactant molecules and forming new bonds between the atoms to produce the molecules of the product.

The energy required for this purpose comes from the kinetic energy associated with the reacting molecules before collision. It has been found that to carry out a chemical reaction between colliding molecules; they should acquire some minimum energy, known as the 'Activation Energy'. Only those molecules that collide with K.E. greater than Activation Energy are able to overcome the energy barrier for the particular reaction. The activated molecules form an activated complex called transition state which then decomposes to give the product.

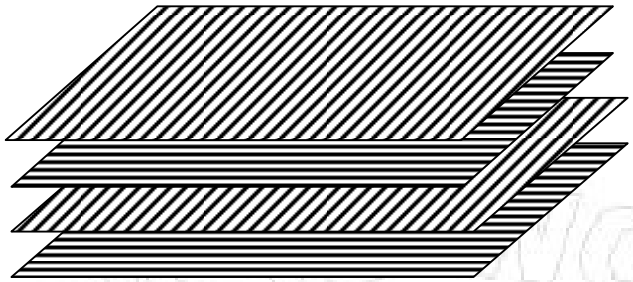
One of the methods to increase the K.E. of the molecules is to increase the temperature.

Alternatively, the reaction can be carried out in presence of suitable catalyst, which lowers the activation energy. Thus it is possible to increase the number of effective collisions in a reaction in presence of a catalyst than what would have occurred at the same temperature in the absence of catalyst. The above principle is illustrated as below

Q. 3 (a) Explain laminar composites and sandwich panel with suitable example.

i) Laminar Composite:- It consists of two dimensional sheets or panels having good strength. Successive oriented layers are stacked and then cemented together in such a way that the orientation of the high strength varies with each successive layer.

Example – Plywood.

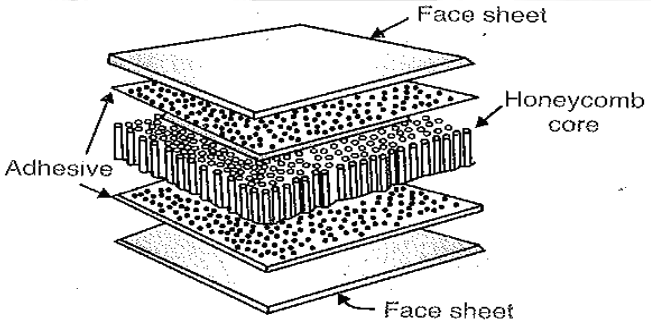


Adjacent wood sheets in plywood are aligned with the grain direction at right angles to each other. Laminar composite may also be constructed using fabric materials such as cotton, paper, woven glass fibres embedded in suitable plastic matrix.

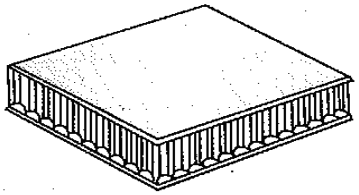
Applications – Interior designing, False ceiling, Furniture

ii) Sandwich Panels:- It consists of two strong outer sheets called 'Faces' separated by a layer of less-dense material called 'core', which is of lower strength and lower stiffness. Typical face material includes fiber-reinforced plastic, plywood, steel and aluminum alloys. Typical core material includes synthetic rubbers, foamed rubber, and inorganic cements.

The faces bear most of the loading as well bending stresses. The core separates the faces and resists any deformations. It also provides certain degree of shear rigidity along the planes which are perpendicular to the faces. A popular type of core material comprises of honeycomb structure made up of thin foils have been formed into interlocking hexagonal cells, with their axes oriented in a perpendicular to the face planes.



(a) Honeycomb core sandwich panel : Construction



(b) Sandwich panel : Fabricated

Q. No. 3 (b) Write short note on paint ingredients and their functions

1. **Pigment** – Pigment is a solid substance, which is an essential constituent, and comprise 60 to 80% of the weight of the paint. Functions of pigments are
   i. To provide strength to the paint film.
   ii. To give aesthetical appeal to the film.
   iii. To give desired colour to the paint film.
   iv. To protect the film from U.V. light
   v. Protect the film from abrasion (wear)

Examples- White lead, ZnO, TiO (White), Fe_2O_3, Pb_3O_4 (Red), Cr_2O_3 (Green), $PbCrO_4$ (Yellow)

2. Vehicle, Medium - It is film forming constituent of the paint. Functions of drying oil are –
i. It forms protective film by oxidation & Polymerisation.
ii. It holds the pigment on the metal surface.
iii. It gives toughness to the film & durability.
iv. It has water repellent character and hence provides water proofness.
Most widely used drying oils are linseed oil, soyabean oil, dehydrated castor oil.

3. Thinner - Thinner is added to paint to reduce consistency (viscosity) of the paint, so that it can be easily applied on the metal surface. Thinners are generally volatile liquids which evaporates easily after application of paint. Functions of thinner are
i. To reduce consistency of the paint.
ii. To dissolve different constituent of paint.
iii. Evaporates rapidly and helps the drying of the paint film.
iv. Increase penetration power of vehicle.
Most commonly used thinners are turpentine, sprit, benzene, kerosene etc.

4. Drier- Driers are oxygen carrier catalyst. They accelerates the drying of oil film through oxidation, condensation and polymerization. The most effective driers are linolates of Co, Mn, Pb & Zn

5. **Fillers** – Fillers are cheap inert material. Functions of fillers are
i. Reduce the cost of the paint.
ii. Increase the durability of the paint.
iii. Prevents settling of heavy pigments.
Important fillers used are – $BaSO_4$, $CaCO_3$, $CaSO_4$, talc, asbestos, silica, slate powder etc

6. Plasticizer- Plasticizers are used to give elasticity to the film to prevent cracking of the film. Examples of plasticizers are – tricresyl phosphate, triphenyl phosphate, tributyl phthalate etc.

7. Anti-skinning agent - are sometimes added to some paints to prevent gelling of paint film. e.g. poly-hydroxy phenol

Q. No. 3 (b) Give composition properties & uses of High phosphorous bronze

Composition:- Sn = 10 – 13%; P = 0.4 – 01%; Cu = rest
Properties:- i. It is hard, brittle & abrasion resistance
ii. It possesses low coefficient of friction .
Uses:- i. For making bearings & gear, taps, bushes, springs, turbine blades etc

Q. 4 (a) Explain in detail fibre reinforced composite.

In this composite the dispersed phase is in the form of fibres. This composite is mainly contains fibre filament polymer matrix & bonding agent. Fibre is a long and thin filament of any polymer, metal or ceramic having high length to diameter ratio. These composites provide very high strength and stiffness. The mechanical properties of fibre reinforced composite depends upon following factors

1. Properties of the fibre.
2. The degree to which the applied load is transmitted by matrix phase. This depends upon bond strength between fibre & matrix.
3. Fibre length – for effective strengthening and stiffening of the composite some critical fibre length (l_c) is required. If fibre length is much greater than l_c then the fibres are termed as continuous. If fibre length is considerably lesser than l_c then the fibres are termed as discontinuous or short fibres.
4. Fibre orientation & concentration- As far as orientation is concerned three cases are possible
a) Continuous and aligned b) Discontinuous & aligned c) Discontinuous & random

Characteristics of Fibre reinforced composites.
i. Higher strength, stiffness & lower density (low weight)
ii. Fibers prevent slip & crack propagation thereby increasing mechanical properties.
iii. If soft phase is present in hard matrix, shock resistance of the composite is increased.
iv. If hard fibres are present in soft matrix, the strength of composite is increased.

Examples of fibre reinforced composite

1) **Glass fibre –** They are obtained by forcing glass melt though spinneret (having no. of small openings or orifices) followed by cooling the emerging continuous filaments. (Automobile parts, storage tanks, Plastic pipes etc
2) **Carbon fibres –** Carbon fibres are obtained as continuous filament by the pyrolysis in an inert atmosphere of organic fibres such as cellulose. (wings & body of aircraft & Helicopters
3) **Metal Fibre composite** etc.

Q. 4 (b)) A coal sample was found to contain the following
C - 81%, O – 8%, S – 1%, H – 5%, N – 1%, & Ash – 4%
Calculate minimum amount of air required for complete combustion of 2 kg of coal

Amount of O_2 required for complete combustion of 1 Kg of coal $= \frac{1}{100}[32/12\ C + 8\ H + S - O]$

$$\frac{1}{100}[32/12\ (81) + 8\ (5) + 1 - 8]$$

$$= 2.49\ Kg$$

O_2 required for 2 Kg coal $= 2.49 \times 2 = 4.98$ Kg
Air required for combustion $= 4.98 \times 100/23 = 21.65$ Kg

Q. 4 (c) What is powder metallurgy? Explain cold powder extrusion moulding.
Powder metallurgy is the art or science of manufacturing useful metallic and alloy articles by compacting the metal (or alloy) powders and other powders in a die, with little or no melting followed by sintering. (The shaping by pressure is called compaction & the heat treatment process is called sintering.
Cold powder extrusion:- It involves forcing a plasticized powder by piston or screw unit into a die so that products of constant cross section are produced (rods, tubes). Plasticizers used in this process are organic binders with medium & high viscosity. This technology is used in producing rod shaped tool for hard metal drilling.
Diagram-

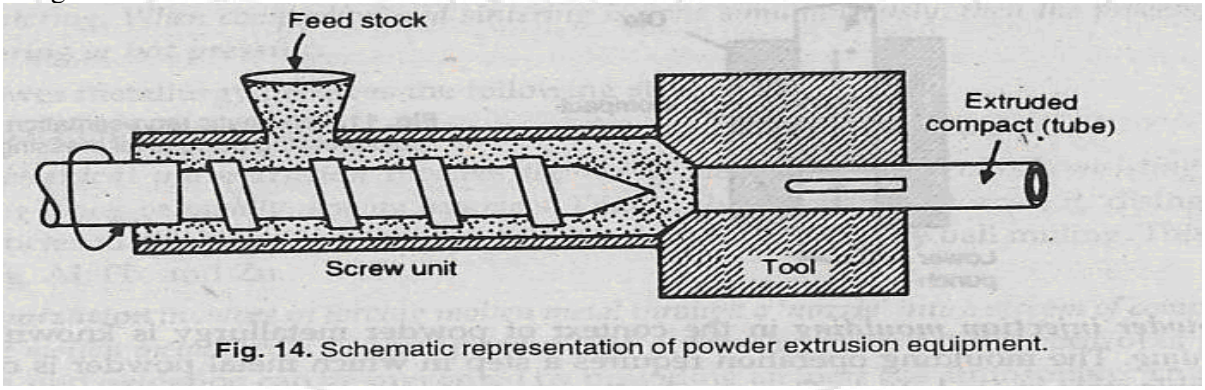
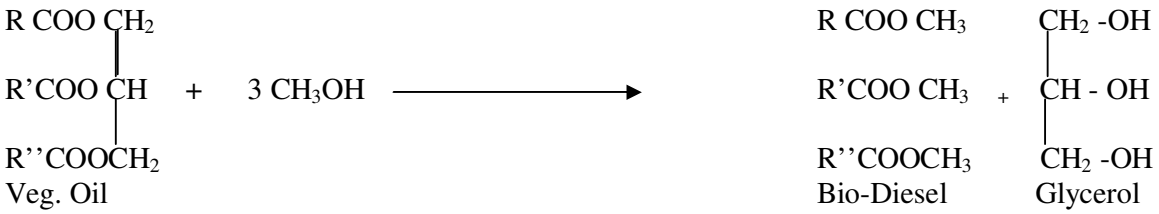


Fig. 14. Schematic representation of powder extrusion equipment.

Q. 5 (a) What is Bio-diesel? Explain the method to obtain bio-diesel from veg. oil & expedite why bio-diesel.
The fatty acid methyl esters formed by replacing glycerol of higher fatty acid by methyl group is called Bio-diesel.
Bio-diesel is defined as mono alkyl esters of long chain fatty acids derived from vegetable oils which can be used as an alternative fuel in diesel engine. Bio-diesel is simple to use biodegradable, non toxic and free from sulphur and aromatics.
Esterification is carried at atmospheric pressure at temperature 60 to 70^{O} C with excess of methanol.

Reaction –



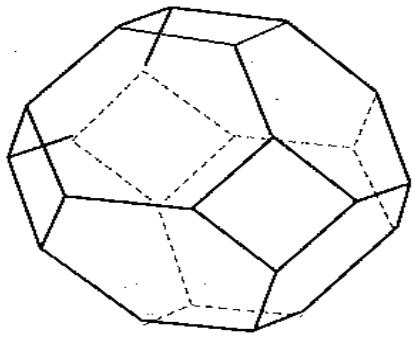
Veg. Oil Bio-Diesel Glycerol

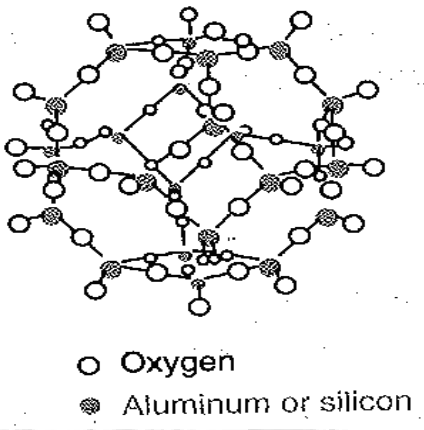
The major advantages of Bio-diesel are

1. It is prepared from renewable resources.
2. Exhaust gas emissions like CO, un-burnt hydrocarbon, particulate matter etc. are lesser
3. It is biodegradable.
4. Best engine performance and less smoke emission are achieved.

Q. 5 (b) What are zeolite catalyst? Give the types of zeolites and explain the structure of sodalite as building block zeolite.

Zeolites are crystalline hydrated alumino silicates with general formula $M[(Al_2O_3)_x.(SiO_2)_y.(H_2O)_z]$where M is alkali or alkaline earth metal ion. In Zeolite Aluminium and silicon atoms are at the center of the Tetrahedron and O atoms are at the corners of tetrahedron. There is a negative charge on Al atoms because of 3 valancy of Aluminium and 4 valency of Silicon. Thus zeolites have three dimensional network containing molecular sized cavities and pores. These cavities contain H2O molecules and mobile cations to compensate negative charge of anionic network. Because of free valancies on the surface of zeolite, it has good adsorption property. It also increases surface area. Sodalite has general formula $Na_6\ Al_6\ Si_6\ O_{24}\ 2H_2O$





Q. 5 (c) What are the important applications of composites?

1. Transportation Industry

i) Glass reinforced resins have been used for many applications requiring high mechanical strength such as automobile body, chassis part, engine components etc.

ii) Resins reinforced with Carbon or Graphite fibres are used for making aircraft wing surfaces, nose cones for missiles etc.

iii) Automobile tyres are found to be a composite material of rubber matrix & textile reinforcing fibre. Metal wires can also be used to improve stability to alternating mechanical stress.

2. Sports Industry

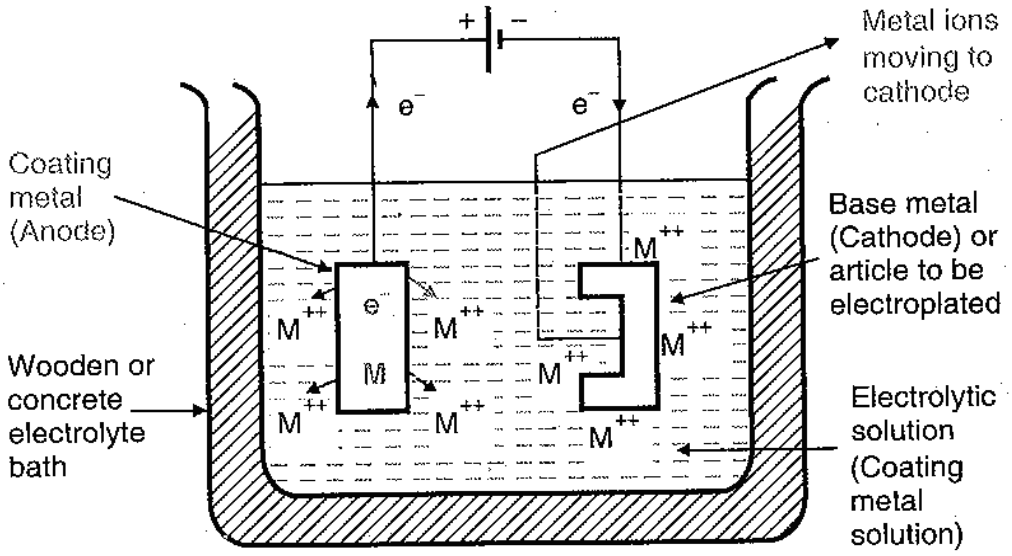
Composites are used to manufacture sport cars, fishing rods, tennis rackets, boots etc.

3. Industrial & scientific equipments

i) High speed machinery
ii) Communication antenna
iii. Electronic circuit boards (PCB/PWB) Printed circuit board/wiring board
iv) Construction industry
v) Agriculture Industry

Q. No. 6 (a) State the principle and explain electroplating process with neat sketch.

Electroplating is carried out in a plating tank containing electrolyte solution of metal salt whose plating is to be carried out. The Metal article to be coated is made cathode by connecting it to the –ve terminal of the cell. +ve terminal of the cell is connected to inert electrode like graphite immersed in the same bath solution. On passing current through electrolyte solution reduction occur on cathode and metal ions get coated on the metal surface.



Q. No. 6 (b) calculate GCV & NCV of the coal

$$HCV = \frac{1}{100}\,[8{,}080C + 34{,}500\,(H - O/8) + 2{,}240S]$$

$$HCV = \frac{1}{100}\,[8080(85) + 34500\,(7\text{-}3/8) + 2240\,(3.5)$$

$$HCV = \frac{1}{100}\,[686800 + 228562.5 + 7840$$

HCV = 9232.025 Kcal/Kg

$$LCV = HCV - \frac{9H}{100} \times 587$$

$$LCV = 9232.025 - \frac{9x7}{100} \times 587$$

LCV = 8862.215 Kcal/Kg

Q. No. 6 (c)

$$\%\ \text{Atom Economy} = \frac{\text{Molecular Weight of Main Product}}{\text{Molecular Weights of all the reactants}} \times 100$$

$$\%\ \text{Atom Economy} = \frac{98}{78 + 144} \times 100$$

$$\%\ \text{Atom Economy} = 44.14\ \%$$

Q. No. 7 (a) Give Composition, properties & uses of – (i) Woods Metal (ii) Magnalumin

Woods Metal Composition:- Bi = 50%; Pb = 25%; Sn = 12.5% and Cd = 12.5%

Properties:- i. It is readily fusible (M.P. 70^0C)

Uses:- i. For making fire-alarms & automatic sprinklers.
ii. For making safety plugs for cookers, milk pot etc.
iii. As a solder for joining two metallic parts/pieces
iv. For boiler and electric fuses.

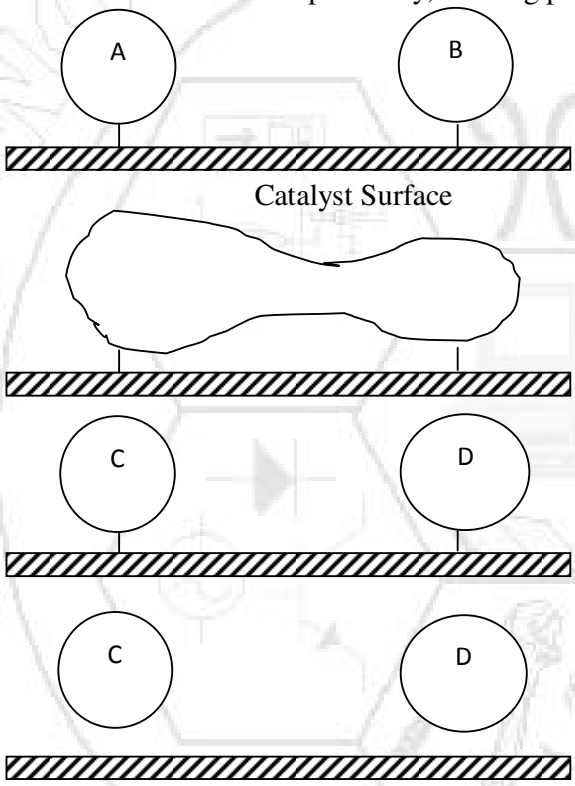
Magnalumin Composition:- Al – 70 to 90% and Mg - 30 to 10%

Properties:- i. It is strong, tough & lighter than Al.
ii. Possesses good mechanical properties

Uses:- i. Used for making cheap balances, airplanes parts, scientific instruments

Q. No. 7 (b) Explain the mechanism of adsorption theory of catalysis

This theory is used to explain reaction between gaseous reactants catalyzed by a solid catalyst. In such processes reaction is initiated by adsorption of the reactant molecules on the surface of the catalyst, which possesses residual or unsatisfied valency forces. The adsorbed molecules react due to their close proximity, forming products.



Adsorption of reactants on catalyst surface

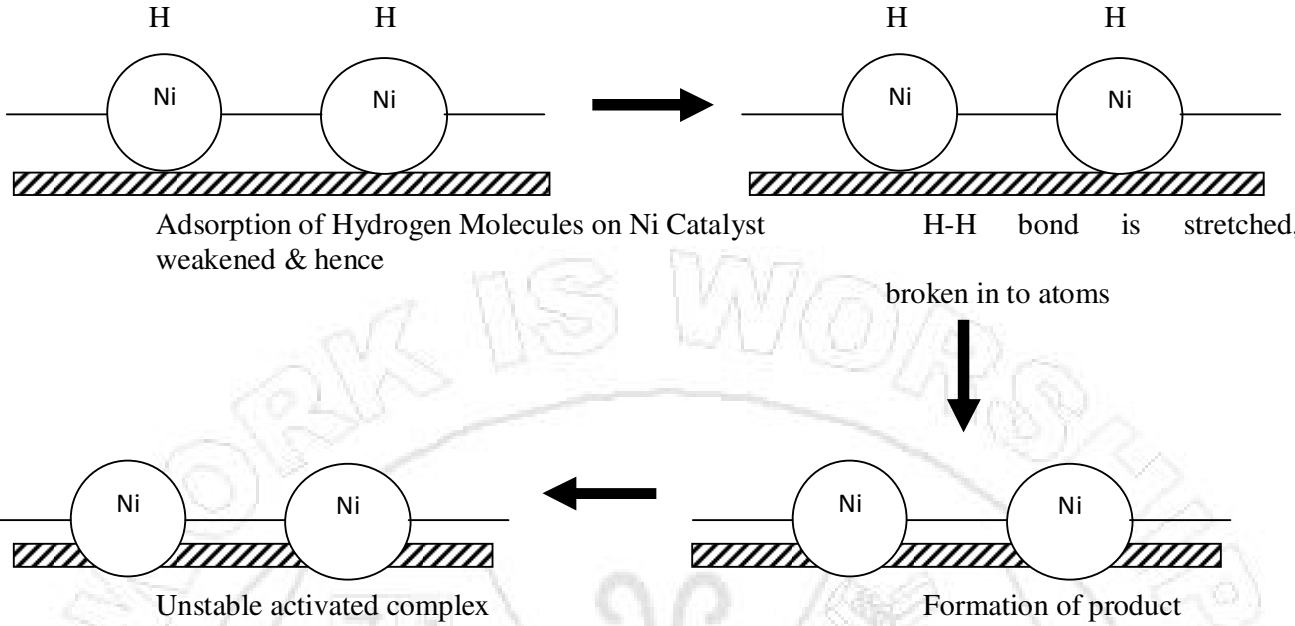
Formation of unstable activated complex

A…B

Formation of the product

De-sorption of the stable product

Example $C_2H_4 + H_2 \xrightarrow{Ni} C_2H_6$



Adsorption of Hydrogen Molecules on Ni Catalyst H-H bond is stretched, weakened & hence

Q. No. 7 (c) Explain how the following factors influence the rate of corrosion.

(i) Solubility of corrosion

If corrosion product is soluble in the environment, it dissolves in the medium as soon as it is formed. Thus underlying metal surface get exposed to medium/environment for further attack. This causes rapid and continuous corrosion of a metal.

(ii) Nature of ions present

The ions present in the surrounding medium may increase or decrease the rate of corrosion. Example – Chloride (Cl^-) ions destroy the passive film and corrode many metals. On the other hand some ions like silicates (SiO_3^{--})may form insoluble reaction product (Metal silicates) which inhibits corrosion