CMR Engineering college. Hudelabad

I B.Tech II semester End examinations (Supply) DEC-2015

Engineering chemistry (~~A12~~ CH202BS)

PART-A

1(a) what are the specifications of potable water

A: 1) colourless, odourless,
2) No turbidity
3) Total dissolved solids : <500mg/L
4) Hardness < 500 mg/L
5) pH : 6.5 - 8.5

(b) Identify break point chlorination:

A: Break point chlorination is the process of adding to water until all ammonia and other chlorine demanding substances are completely oxidized and a free residual chlorine first appears in the water.

(c) what is meant by knocking

knocking is a abnormal combustion phenomenon in an internal combustion engine in which the air-fuel mixture ignites suddenly and uncontinuously ahead of the normal flame front, produces a sharp metallic knocking sound.

⇒ occurs due to auto-ignition of the unburnt fuel.
⇒ causes pressure waves inside the cylinder
⇒ Results in loss of power, over heating & possible engine damage.

(d) Find the composition of CNG & LPG

CNG: main component - CH_4 (85-95%), C_2H_6, C_3H_8, N_2, CO_2.

LPG: main components: propane (C_3H_8) - 40-60%
Butane (C_4H_{10}) - 40-60%
Isobutane, propylene.

(E) Define Fuel cell and write its applications.

(A) A Fuel cell is an Electrochemical device that converts the chemical energy of a fuel (such as hydrogen) directly into Electrical energy through a chemical reaction with O_2, without combustion.

Applications: (1) Transportation : Fuel-cell cars, buses and trucks.
(2) power generation: Backup power for hospitals, data centers,
(3) space applications: Power supply in space craft, satellites

(F) write Nernst's equation for single electrode potential

A: The Nernst's equation gives the Electrode potential of a single electrode under non-standard condition.

$$E = E^0 - \frac{RT}{nF} \ln Q$$

E = Electrode potential ; E^0 – Standard Electrode potential
R = gas constant (8.314 J/mol-K) ; T = Temperature in kelvin
n = no. of electrons transferred, F = Faraday
Q = reaction quotient.

(G) what is meant by Galvanic corrosion of metals.

A: Galvanic Corrosion is the corrosion that occurs when two dissimilar metals are in electrical contact with each other in the presence of an Electrolyte, causing the more active (anodic) metal to corrode faster while the nobler (cathodic) metal is protected.

(H) write any two effects of corrosion of metals.

A: (1) Loss of metal and strength.
(2) Economic loss.

(I) write various engineering applications of smart materials.

A: ⇒ shape memory Alloys (SMA) : Actuators in robotics, Automatic pipe couplings.
⇒ Piezo Electric materials : sensors & actuators.
⇒ Ultrasonic transducers.

(J) Define Biodegradable polymers.

Biodegradable polymers are polymers that can be broken down naturally by micro organisms such as bacteria and fungi into simple, non-toxic substances like CO_2, H_2O & biomass.

eg: PLA, PHB, PCL etc.

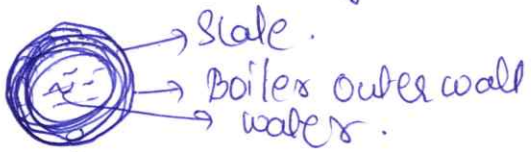
PART-B.

(20) Identify scale and sludge formation in boilers and write about the methods for prevention.

Ans: Scale formation: scale is a hard, adherent deposit formed on the inner walls of boiler tubes due to precipitation of dissolved salts, mainly calcium and magnesium salts, when water is heated.

causes: Hard water containing, $CaSO_4$, $Ca(HCO_3)_2$, Mg salts, Silicates.

Effects:
- Reduces heat transfer efficiency.
- Causes overheating and possible tube failure.

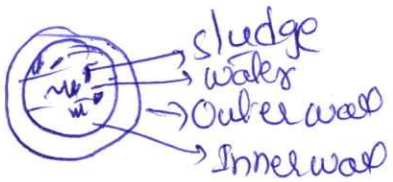


Sludge Formation:

Sludge is a soft, amorphous deposit that floats or settles at the bottom of the boiler formed from insoluble impurities and suspended solids in water.

Causes: Impure feed water containing silica, iron oxides, sand.

Effect:
- Blocks water flow
- Reduces boiler efficiency
- can lead to localized overheating



Preventive methods:

① use softened water.

② Blowdown operation

③ chemical treatment:

(i) phosphates: precipitate calcium as soft sludge

(ii) chelating agents: prevent crystal formation.

(iii) oxygen scavengers: prevent corrosion.

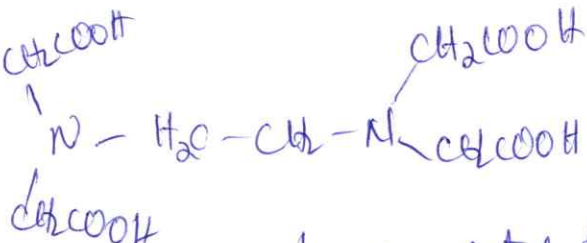
④ filtration:

⑤ De aeration:

③ Explain the principle of EDTA method? Describe the estimation of hardness of water by EDTA method.

Ans. The estimation of Hardness of water is very essential for its use in boilers for steam generation

EDTA: Ethylene Diamine Tetra acetic Acid.



On a Hard water sample, the total hardness can be determined by titrating the Ca^{+2} & Mg^{+2} present in an aliquot of the sample with EDTA solution, using NH_4Cl - NH_4OH buffer of pH – 10 and Erochrome Black-T as indicator. At the end point the color changes from the wine red to blue colour.

$$Ca^{+2} \text{ (or) } Mg^{+2} + EBT \xrightarrow{pH\,9\text{-}10} [Ca\text{-}EBT \text{ (or) } Mg\text{-}EBT]$$

unstable wine red.

$$\begin{bmatrix} Ca\text{-}EBT \\ Mg\text{-}EBT \end{bmatrix} + EDTA \longrightarrow \begin{bmatrix} Ca\text{-}EDTA \text{ or} \\ Mg\ EDTA \end{bmatrix} + EBT$$

Stable colourless complex.

Estimation of Total permanent Hardness of H_2O sample:

1) Preph of std. Hard H_2O.

Pipette out 20ml of std. Hard water into a clean conical flask add 3ml of buffer soln and add 2 or 3 drops of EBT indicator. then titrate this wine red colour sample against EDTA solution. taken in a burette. the end point is the change of colour from wine red to coloured to be ml.

Step-II: Estimation of Total Hardness of water sample:

Pipette out 20ml of Hard water sample into a clean conical flask add 3ml of buffer solution & 2 or 3 drops of EBT indicator. then titrate this wine red colour sample against EDTA soln. the end point is the change of colour from wine red to sky blue.

calculation: Vol. of std. Hard H_2O = 20ml

molarity of std. Hard H_2O = $M_1 = 0.01M$

Vol. of EDTA = $V_2 = x$ ml

molarity of EDTA = $M_2 = ?$

Acc. to volumetric law.

$$M_1V_1 = M_2V_2$$

$$M_2 = \frac{M_1V_1}{V_2} = \frac{0.01 \times 20}{x} M$$

Step-III: Estimation of permanent Hardness of water:

Take 100ml of Some Hard water sample into a 250ml beaker boil it for 15 min. During the boiling temp. Hardness gets removed. cool & filter the soln and pipette out 20ml of Hard water sample into a clean conical flask.

add 3ml of buffer soln & add 2 or 3 drops of EBT indicator. Then titrate this wine red colour sample against EDTA solution. which is.

Estimation of total Hardness:

molarity of EDTA = $M_3 = M_2$

Vol. of of EDTA = $V_3 = 4'ml$

molarity of Hard H_2O sample = $M_4 = ?$

Vol. of Hardwater sample $V_4 = 20ml$

Acc. to volumetric law.

$$M_3V_3 = M_4V_4$$

$$M_4 = \frac{M_3V_3}{V_4}$$

$$M_4 = \frac{M_2 \times 4}{V_4} \; M.$$

Hardness of water sample in terms of $CaCO_3$

$$= M_4 \times 100 \times 1000$$

Estimation of permanent Hardness:

Vol. of Hardwater sample containing permanent Hardness $V_5 = 20ml$

mol. of Hardwater sample containing Perm Hardness $= M_5 = ?$

Vol. of EDTA $= V_6 = 2ml$

molarity of EDTA $= M_6 = M_2$.

A $M_5V_5 = M_6V_6$

$$M_5 = \frac{M_2 \times V_6}{V_5}$$

$$= \frac{M_2 \times 2}{20} \; M.$$

Perm. Hd = $M_5 \times 100 \times 1000$

∴ Temp Hd = Total Hd - Perm Hd

4Q: what is refining of crude petroleum. Explain the various fractions obtained from petroleum and mention their industrial uses.

Ans: Extraction of mining of crude oil:

petroleum is found to be present below the earth surface at a depth of about 15-20m to 5000 to 15000m petroleum is extracted by digging wells.

Refining of petroleum:

The crude oil is seperated into various fractions having different boiling ranges by fractional distillation and finally converted into desired specific products. by removing impurities. The plants set up for this purpose are called oil refineries. The process of refining involves 3 steps.

(i) Seperation of water (or cottrell's process (salt H2O)

The crude oil from the oil well is an extremely stable emulsion of oil and salt H2O. The process of freeing oil from water consists in allowing the crude oil to flow between 2 highly charged electrodes. The colloidal water seperated from oil in the form of big droplets.

II) Removal of Harmful sulphur compounds.

The crude oil is treated with copper oxide Cu_2O which gives black precipitate of copper sulphide which can be removed by filtration

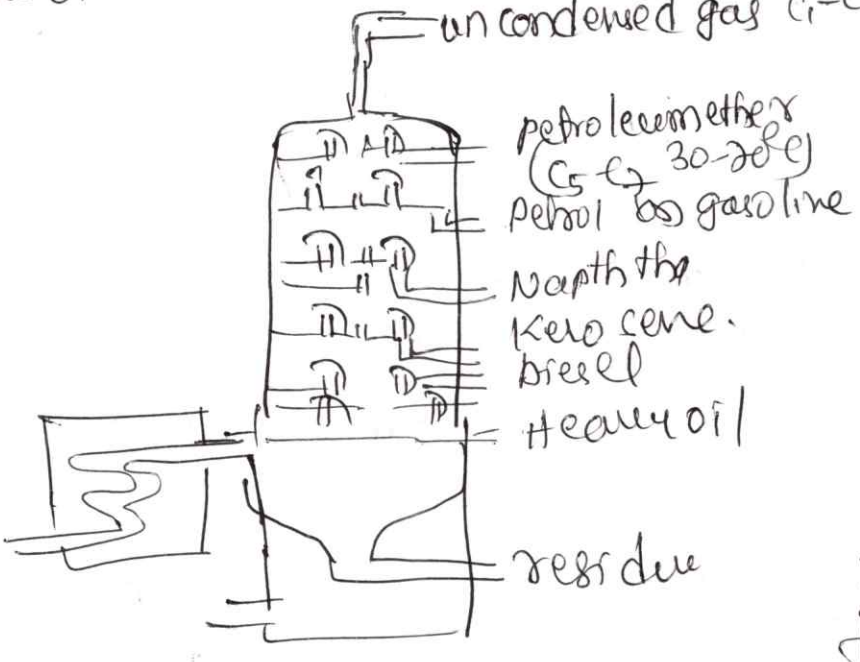
Step-II Fractional distillation:

The crude oil obtained after step I & step-II is then heated at about 400°C in a Iron Retort where by all volatile constituents except Residue are evaporated.

The Hot vapours are then passed up a fractional column which is a tall cylindrical tower containing a no. of horizontal stainless steel trays at short distances.

Each tray is provided with small chimneys covered with a loose cap. As the vapour goes up they become gradually cooler and fractional condensation takes place at different heights of column.

After boiling fraction condenses first while the lower boiler fractions turn by turn.



① Gasoline or petrol:

It is a mixture of hydrocarbons from pentane to decane. This fraction is obtained 40-120°C. This fraction is highly volatile and inflammable and used as fuel for internal combustion IC engines.

② Diesel oil: mixture of higher hydrocarbons. Used as fuel for diesel engines & it CV is 11,000 kcal/kg.

③ Kerosene: It is used as domestic fuel in stoves. as jet engine fuel and for making oil gas.

5q. Explain the determination of ultimate analysis of coal and write its significance.

Ans: The analysis included percentage of C, H, O, N, S & ash content in coal.

Determination of Carbon & Hydrogen:

A known weight of coal is burnt in a stream of pure oxygen in a combustion apparatus. The carbon & Hydrogen present in the sample are converted into CO_2 and H_2O which are passed through 2 bulbs. one bulb containing weighed amount of anhydrous $CaCl_2$ absorb H_2O & another bulb containing KOH absorbs O_2.

$$C + O_2 \longrightarrow CO_2$$

$$2KOH \longrightarrow K_2CO_3 + H_2O$$

$$H_2 + \tfrac{1}{2}O_2 \longrightarrow H_2O$$

(1) (8)

$$CaCl_2 + 7H_2O \longrightarrow CaCl_2 \cdot 7H_2O$$

The wt of $CaCl_2$ & KOH are determined. The increase in weight of $CaCl_2$ bulb represents the weight of H_2O formed while the increase in the weight of KOH bulb represents the CO_2 formed.

Significance: The higher the percentage of carbon and Hydrogen the better is the quality of coal & higher is CV % of carbon helps in assessing the grade of coal.

II determination of N_2 content

Nitrogen in coal is determined by Kjeldahl's method 1 gm weight of powdered coal is heated with conc H_2SO_4 along with K_2SO_4 & $CuSO_4$ in a long necked flask called kjeldahl flask. where K_2SO_4 & $CuSO_4$ are catalysts.

After the soln becomes clear when whole nitrog

is converted into $(NH_4)_2SO_4$; it is treated excess of NaOH to liberate ammonia. The liberated ammonia is distilled into a measured amount of std. acid.

The vol. of unused H_2SO_4 is then determined by titrating against standard NaOH

Thus the amount of acid neutralized by liberated ammonia is determined. from which the N_2 present in the sample is calculated.

$$N_2 + H_2SO_4 \xrightarrow{CuSO_4} (NH_4)_2SO_4.$$

$$(NH_4)_2SO_4 + 2NaOH \longrightarrow 2NH_3\uparrow + Na_2SO_4$$

$$\% \text{ of } N_2 = \frac{\text{Vol. of acid used} \times \text{Normality of acid}}{\text{wt of coal sample taken}} \times \frac{14}{1000} \times 100$$

Significance: Nitrogen doesnot have any significance as it doesn't have CV. It has no CV. Thus quality of coal should have very little N_2 content.

(iii) Determination of "S":

A known wt of sulphure is burnt completely in bomb calorimeter in current of O_2, where in sulpher is present in coal is oxidized to sulphate.

This upon treatment with $BaCl_2$ precipitates the sulphate as $BaSO_4$. The ppt $BaSO_4$ is filtered, washed, dried and heated to constant weight x.

$$S \xrightarrow{O_2} SO_4^{-2} \xrightarrow{BaCl_2} BaSO_4 + 2Cl^-$$

32 gm of 'S' produces 233 gm of $BaSO_4$

? " " 'x' gm of $BaSO_4$

$$\% S = \frac{\text{wt of } BaSO_4}{\text{wt of coal sample}} \times \frac{32}{233} \times 100$$

Significance: 'S' increases CV.

→ The product of combustion SO_2, SO_3 have corrosive effect on equipment & cause air pollution

(D) Determination of O_2:

The % of O_2 is determined by subtracting the sum of percentage of C, H, S, N & ash from 100

$$\% \text{ of } O_2 = 100 - [\% C + \% H + \% N + \% S + \text{ash}]$$

Significance: O_2 content decreases the calorific value of coal high O_2-content coals are characterised by high inherent moisture, low CV. Increase in 1% O_2, content decrease the CV by about 1-2%.

Q6. Explain the construction and working of H_2-O_2 fuel cell & write its advantages.

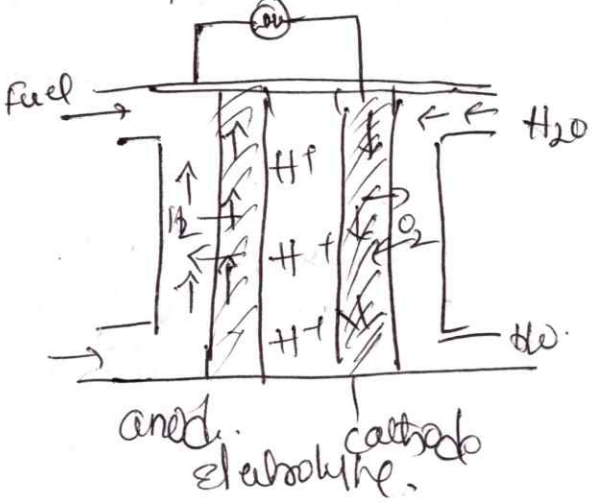
Ans: A fuel cell is a device that produces electricity through a chemical reaction between a source fuel and an oxidant. In a fuel cell the catalyst facilitates the reaction of O_2 & H_2. It is usually made of platinum powder very thinly coated carbon paper.

The catalyst is rough & porous

The fuel cell consists of an anode, a cathode and an electrolyte H_2 is passed through the anode & O_2 is passed through cathode.

At the anode, hydrogen molecule gets split into $e^{\ominus}$s & H^+ The protons pass through electrolyte & $e^{\ominus}$s generate electricity through circuit.

At cathode $e^{\ominus}$, H^+ & O_2 combine to form H_2O molecule.



chemical Reaction

Anode: $H_2 \longrightarrow 2H^+ + 2e^{\ominus}$

cathode: $\frac{1}{2}O_2 + 2H^+ + 2e^{\ominus} \rightarrow H_2O$

cell $H_2 + \frac{1}{2}O_2 \longrightarrow H_2O$

Electrolyte: KOH

Advantages.

⇒ No harmful emissions.
⇒ Environmental friendly.
⇒ continuous power supply
⇒ low maintainance
⇒ used in space & remote areas

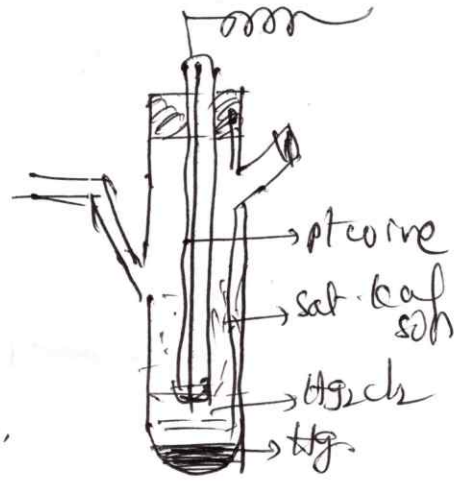
Q. Describe construction & working of calomel electrode with neat diagram.

The calomel electrode is a commonly used reference electrode in Electrochemistry.

1. construction of calomel electrode.

It consists of

- A glass tube with a sidearm.
- pure Hg at the bottom.
- A paste of Hg + Hg_2Cl_2 called calomel
- KCl Saturated (1M (or) 0.1M)
- A platinum wire sealed through the glass, making electrical contact with Hg.
- A porous plug in side tube for contact with test solution



Representation: $Pt \mid Hg \mid Hg_2Cl_2(s) \mid KCl(aq)$

working of calomel electrode:

The calomel electrode works on the reversible reaction b/w Hg & Hg_2Cl_2 in the presence of $Cl^\ominus$ ions.

Electrode rxn: At anode: $Hg + Cl^\ominus \longrightarrow \frac{1}{2} Hg_2Cl_2 + e^\ominus$

At cathod: $\frac{1}{2} Hg_2Cl_2 + e^\ominus \longrightarrow Hg + Cl^\ominus$

$$Hg_2Cl_2 + 2e^\ominus \rightleftharpoons 2Hg + 2Cl^\ominus$$

Electrode potential:

→ used as Reference electrode.
→ measurements of electrode potentials.
→ determination of pH & EMF of cells.

Sat KCl: +0.2415V
1M KCl − 0.280V
0.1M KCl − +0.333V.

Advantages:
- stable and reproducible potential
- simple construction.
- Easy to use in laboratory experiments.

8Q! Define corrosion of metals. Explain the electrochemical theory of corrosion giving its mechanism

A! Corrosion the gradual deterioration of a metal due to chemical or electrochemical reaction with its environment (such as air, moisture or chemicals) resulting in the formation of more stable compounds like oxides, $OH^{\ominus}$ & sulfides.

Electrochemical corrosion:
mechanism: 2 types.

① Evolution of H_2 gas:

This type of corrosion occurs in acidic medium eg. considering the metal Fe, anodic reaction is dissolution of Iron as Fe^{+2} ions with liberation of $e^{\ominus}$s.

$$Fe \longrightarrow Fe^{+2} + 2e^{\ominus}.$$

The $e^{\ominus}$s released flow through the metal from anode to cathode whereas H^+ ions of acidic solution are eliminated as H_2 gas.

$$2H^+ + 2e^{\ominus} \longrightarrow H_2.$$

The overall reaction is $Fe + 2H^+ \longrightarrow Fe_2 + H_2\uparrow$

Absorption of oxygen:

At anode: $Fe \longrightarrow Fe^{+2} + 2e^{\ominus}$ (oxidation)

At cathode: The released electrons flow from anode to cathode through Iron metal. $\frac{1}{2}O_2 + H_2O + 2e^{\ominus} \longrightarrow 2OH^{\ominus}$ (Redn)

$$Fe^{+2} + 2OH^{\ominus} \longrightarrow Fe(OH)_2$$

$$4Fe(OH)_2 + O_2 + 2H_2O \longrightarrow 4Fe(OH)_3.$$

The product called yellow rust corresponds to

$Fe_2O_3 \cdot xH_2O$.

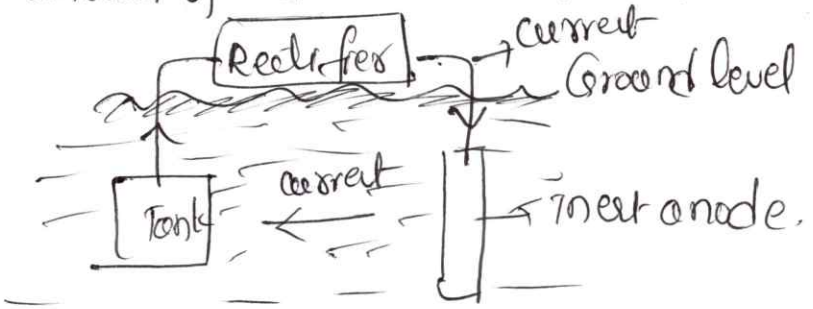
Q2. write a short note on the following.

(A) Impressed current cathodic protection:

Cathodic protection: The main principle in cathodic protection is to force the metal behave like a cathode. Since there will not be any cathodic area without anodic area. So to achieve this auxillary anode is provided in the corroding medium which is connected to an external source of current.

Impressed current cathodic protection:

In immersed current method an impressed current is applied to convert the corroding metal from an anode to a cathode. this can be accomponied by applying sufficient amount of direct current from batteries.



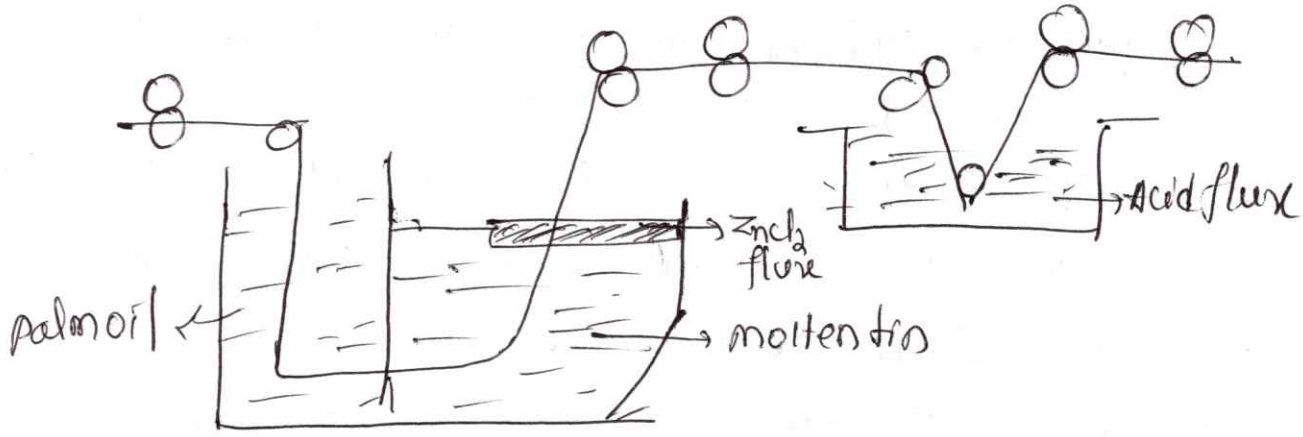
Limitations:

(A) Capital investment & maintance cost

(B) It is difficult to maintain uniform current over the entire metal surface & as result localized corrosion may occur.

(B) Tinning: Tin coating on a metal by hot dipping is called Tinning. In this procen the steel or iron sheet is passed through dil. H_2SO_4 to remove surface impurities. It is then passed through a bath of molten tin which is covered by a flux zinc. After the coating of tin the sheet is passed through palm oil. The palm oil protects the tin coated hot surface against oxidation

Finally the sheet is passed through rollers to produce the thin coat of tin of uniform thickness. Tinning is widely used for coating the steel copper & brass sheets used for making containers used for storing food stuffs.



10@! Classify the polymerization ? Differentiate between addition and condensation polymerization with examples.

⇒ this. Polymerization : It may be defined as the process of linking of joining together small molecules like monomers to make large molecules.

polymerisation is mainly 2 types.

① Addition polymerisation (or) chain poly^n

② step growth (or) Condensation polymerisation.

1) Add^n poly^n (or) chain poly^n :

this poly^n yields an exact mutiple of basic monomeric molecules. The monomeric molecule contains one or more double bond By intermolecular rearragnements of these double bonds makes the molecule bifunctional. In this polymerisation process light heat & pressure (or) catalyst is used to break down the double covalent bonds

↳ It is exothermic reaction.

→ monomer contains '=' (or) '≡' bonds

→ 20 kcal/mole of energy liberated when $\frac{1}{}$ bond

changed to π bond.

⇒ molecular wt of polymer is exact multiple of monomers.
etc. PVC, polystyrene.

(2) condensation (or) step growth polymerisation:

⇒ monomer contains the functional groups like –OH, acids halogens, esters, amines etc.

⇒ they are dibasic acids, diols, diacids diamines etc

⇒ polymer is not the exact multiple of monomers.

⇒ Byproducts are formed.

⇒ It is not the 3 step mechanism.

⇒ No exothermic reaction.

⇒ Initiators are required.

⇒ It is cross linked 3 dimensional polymers are formed.

eg: Bakelite, Nylon 6,6, Teylene etc.

(11Q): Discuss the preperation, properties & applications of Bakelite & PVC.

(a) PVC – poly vinyl chloride.

prep^n: vinyl chloride on polymerisation gives PVC.

$$H_2C = \underset{H}{CH} \xrightarrow{\text{polyn}} \left[H_2C - \underset{Cl}{CH} \right]$$

vinyl chloride. PVC

properties:

⇒ white & colourless powder.

⇒ Hard & rigid.

⇒ Insoluble in H_2O.

⇒ Good electrical insulating material

⇒ Resistant to acids, alkalies, oils, & chemicals.

⇒ Corrosion resistant.

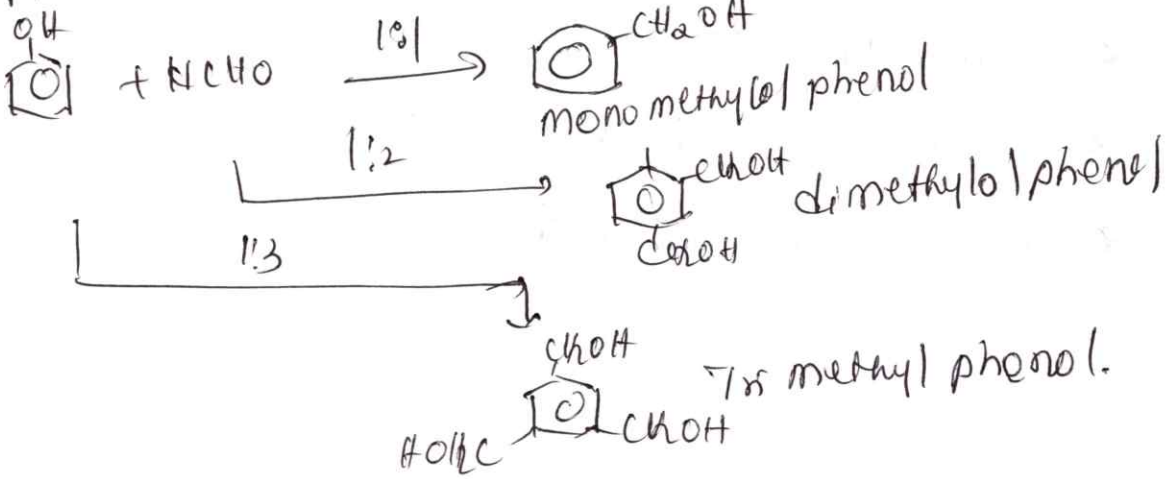
Applications

① Pipes & fittings.
② Electrical wire insulation
③ Flooring & wall coverings.
④ Plastic bottles, containers.
⑤ Rain coats, synthetic leathers.
⑥ medical items like tubings & blood bags.
⑦ window frames & doors.

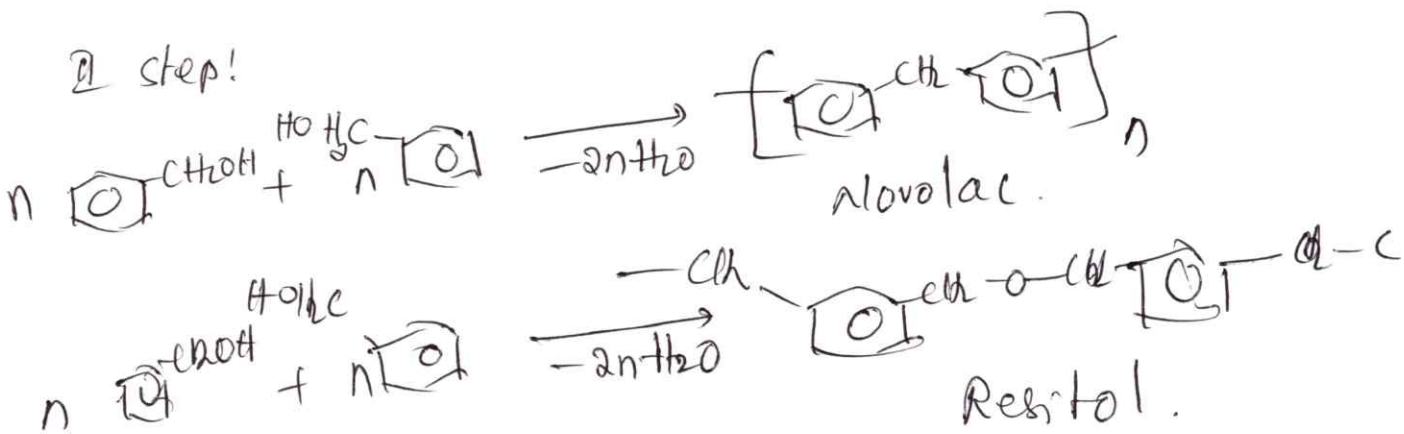
Bakelite: (phenol formaldehyde)

Prepn: phenol & formaldehyde on condensation reaction gives phenol formaldehyde resin. it takes 3 steps.

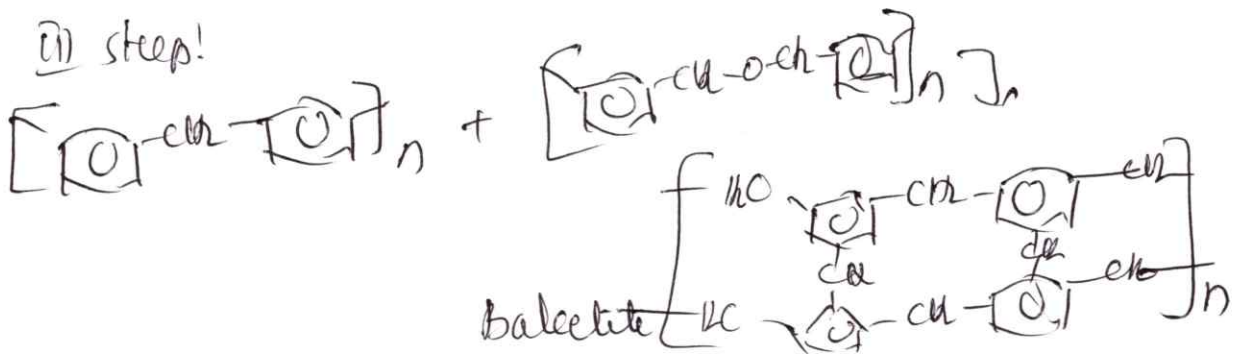
I step:



II step:



III step:



Properties:

⇒ Hard & rigid
⇒ Heat resistant
⇒ Electrical insulator.
⇒ Infusible & insoluble

Applications:

- Electrical switches, plugs, & sockets.
- Switch boards & circuit boards.
- Handles of cooking utensils.
- Casings of electrical appliances.
- Laminated sheets & counter tops.
- Adhesives & binding materials.
- Buttons, bangles & decorative items.

(10)

Scheme of evaluation

PART- A

1(a) what are the specifications of potable water

2 specification ——— 1M.

(b) Definition of break point chlorination ——— 1M

(c) Definition of knocking ——— 1M

(d) composition of CNG ——— 1/2M

composition of LPG ——— 1/2M

(e) Definition of fuel ——— 1/2M

application of application — 1/2M

(f) Nernst's equation ——— 1/2M

formula ——— 1/2M.

(g) Definition of galvanic corrosion - 1M

(h) effects of corrosion of metals - 1M

(i) 2 engineering application of smart materials - 1M

(j) Definition of biodegradable polymers - 1M

PART-B

2Q. Definition of scale & sludge — 2M

Reasons — 2M
effects — 2M
Diagrams — 2M
preventive methods — 2M.

3Q. principle of EDTA — 3M.
Estimation of Hardness of H_2O — 7M.

4Q. Definition of Refining of petroleum — 2M.
Diagram — 3M
procedure — 3M
industrial uses — 2M

5Q. Definition of ultimate analysis — 3M
Analysis of ultimate analysis — 5M
significance — 2M.

6Q. Definition of H_2-O_2 cell — 2M
Diagrams — 3M
chemical reactions — 3M
advantages — 2M.

7Q. Construction of calomel electrode — 3M
Diagram — 2M
chemical reactions — 3M
working — 2M

9(a) Definition of cathodic protection -1m

Description of Impressed current cathodic protection -2m

Diagram -2m

(b) Tinning:

Explanation - 2m

working & Diagram - 2m

applications -1m

10Q: Definition of polymerisation - 2m

Difference b/w addition & condensation polymerisation - 6m

Examples -2m

11Q: preperation of Bakelite & PVC - 3M

preoperities of Bakelite & PVC - 4M

applications of Bakelite & PVC - 3M.