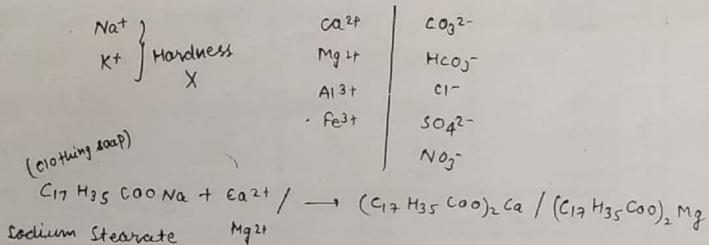


17-08-18

Unit-I : Water

* Hardness :- It is sample of water which does not produce leather is known as hard water. And this property of water is known as hardness.

The soap consuming capacity of water is known as hardness. Hardness is due to multivalent metal ions.

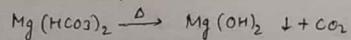
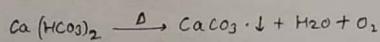


* Types of Hardness :-

i) Temporary Hardness :- It is due to CO_3^{2-} and HCO_3^- of Ca^{2+} and Mg^{2+} .

Ex:- CaCO_3 , $\text{Ca}(\text{HCO}_3)_2$, MgCO_3 , $\text{Mg}(\text{HCO}_3)_2$

It can be removed by simple boiling of water



Temporary hardness is also known as carbonate hardness or alkaline hardness.

POORNIMA

Date	Unit No.	Lecture No.	Faculty	Subject Name	Subject Code	Main Topics:-

(ii) Permanent Hardness - It is due to Cl^- , SO_4^{2-} , NO_3^- of Calcium and Magnesium & other heavy metals.

Ex:- MgCl_2 , MgSO_4 , $\text{Mg}(\text{NO}_3)_2$, CaCl_2 , CaSO_4 , $\text{Ca}(\text{NO}_3)_2$, FeCl_3

It can't be removed by simple boiling of water

To remove permanent hardness, we use chemical method

(i) lime soda method

(ii) zeo lite method

(iii) Ion Exchange Method

* Degree of Hardness :-

Hardness of water is always expressed in the term of CaCO_3 because of two reasons:-

(i) CaCO_3 is the most insoluble hardness causing salt.

(ii) It's molecular weight 100 and it's equivalent weight 50. So it makes calculation easy.

Degree of Hardness = Multiplication factor \times weight of hardness causing salt

Multiplication factor:- $\frac{2 \times \text{eq. wt. of } \text{CaCO}_3 (50)}{2 \times \text{eq. wt. of Hardness causing salt}}$

Main Ideas, Questions & Summary:

Library / Website Ref.:-

Q: A sample of water contains 120 mg/L $MgSO_4$. Calculate the hardness of water.

$$\begin{aligned}
 \text{Degree of Hardness} &= \frac{\text{M.f} \times \text{wt of hardness causing salt}}{2 \times \text{eq.wt. of Hardness causing salt}} \\
 &= \frac{100 \times 120}{2 \times \frac{24+32+64}{2}} \Rightarrow \frac{100 \times 120}{120} \approx 100 \text{ mg/l}
 \end{aligned}$$

Q. $\text{CaCl}_2 = 7.1 \text{ ppm}$, $\text{MgCl}_2 = 9.5 \text{ ppm}$, $\text{MgCO}_3 = 8.4 \text{ ppm}$
 calculate the hardness of water =?

$$\text{Hardness of water} = \frac{100}{2 \times \left(\frac{111}{2} \right)} \times 7 + 1 + \frac{100}{2 \times \left(\frac{95}{2} \right)} \times 9.5 + \frac{100}{2 \times \frac{84}{2}} \\ \Rightarrow \frac{710}{111} + 10 + 10 \Rightarrow \frac{710}{111} + 20 \Rightarrow 26.39 \text{ ppm}$$

Compound	Molecular Weight	Equivalent wt.	M.f.
CaCO_3	100	50	100/100
$\text{Ca}(\text{HCO}_3)_2$	162	81	100/162
MgCO_3	84	42	100/84
$\text{Mg}(\text{HCO}_3)_2$	146	73	100/146
CaCl_2	111	55.5	100/111
MgCl_2	95	47.5	100/95
$\text{Ca}(\text{NO}_3)_2$	164	82	100/164
$\text{Mg}(\text{NO}_3)_2$	148	74	100/148
CaSO_4	136	68	100/136
MgSO_4	120	60	100/120

POORNIMA

Date	Unit No.	Lecture No.	Faculty	Subject Name	Subject Code	Main Topics:-
Compound		Molecular Wt.		Equiv. Wt.		M.f.
$\text{Al}_2(\text{SO}_4)_3$		342		57		100/114
NaAlO_2		82		82		100/82x2
FeSO_4		152		76		100/152
HCO_3^-		61		61		100/122
H^+		1		1		100/2
HCl		36.5		36.5		100/73
H_2SO_4		98		49		100/98
CO_3^{2-}		60		30		100/60

UNIT OF HARDNESS:-

PPM = It is the parts of CaCO_3 equivalent present in 10⁶ parts of water.

2: mg/l = It is the milli gram of CaCO_3 equivalent present in 1 litre of water.

3. C1 (degree clarkes) :- It is the one gram of CaCO_3 equivalent present in 1 gallon of water.

4. °F_A (Degree French) :- It is the parts of CaCO_3 equivalent present in 10^5 parts of water

1 Gallon = 4.55 litres
1 grain = 64.8 mg

Main Ideas, Questions & Summary:

Library / Website Ref.: -

Relations:-

$$1 \text{ ppm} = 1 \text{ mg/L} = 0.1^\circ \text{Fa} = 0.07^\circ \text{Ca}$$

$$1 \text{ mg/L} = 1 \text{ ppm} = 0.1^\circ \text{Fa} = 0.07^\circ \text{Ca}$$

$$1^\circ \text{Fa} = 10 \text{ ppm} = 10 \text{ mg/L} = 7^\circ \text{Ca}$$

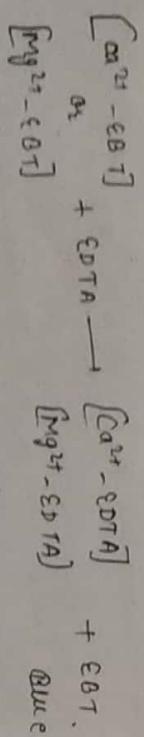
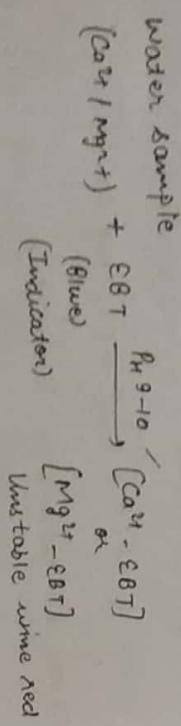
$$1^\circ \text{Ca} = \frac{10}{7} \text{ ppm} = \frac{10}{7} \text{ mg/L} = \frac{10}{7} \cdot 7^\circ \text{Ca}$$

A determination of hardness (estimation of water hardness).-

- ① EDTA Method / Complexometric Titration
- ② Clark's Method / Soap Solution Titration
- ③ O'Hardy's Method

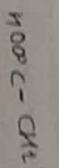
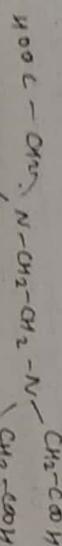
① EDTA Method / Complexometric Titration :-

Principle:-



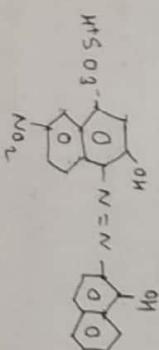
Stable/colourless

Glutamic diamine tetracarboxylic acid / EDTA



POORNIMA

Date	Unit No.	Lecture No.	Faculty	Subject Name	Subject Code	Main Topics:-
				E BT (Eriochrome Black-T)		



Solutions:-

① Standard hard water :- 1gm CaCO₃ + HCl
(Standard)

↓
Ca²⁺
white ppt

↓
Distilled water

② EBT solution :- 3.72 gm di Sodium Salt of EBT
(Intermediate solution → Burnett)
(Dissolve in 1 liter solution)

③ Buffer solution :- NH₄Cl + NH₄OH
64.5 gm 570 ml
↓
1 liter solution

④ EBT Indicator :- 0.5 gm EBT - 100 ml ethyl alcohol

⑤ Boiled water :-
500 ml $\xrightarrow{\Delta}$ 250 ml \longrightarrow 500 ml solution
water sample

Main Ideas, Questions & Summary:-

Library / Website Ref.:-

$$\begin{aligned}\text{Temporary Hardness} &= \text{Total Hardness} - \text{Permanent Hardness} \\ &= \left(\frac{V_1}{V_1} \times 1000 - \frac{V_2}{V_1} \times 1000 \right) \text{ mg/L} \\ &\Rightarrow \sqrt{\frac{1000}{V_1} (V_2 - V_1)} \text{ mg/L}\end{aligned}$$

Ques. Standard hard water was prepared by 52 gram CaCO_3 dissolved in 1 L distilled water and the consumption of EDTA solution is 12 ml with this + 15 ml. EDTA was consumed when titrating with 50 ml water sample and 7 ml EDTA was consumed when titrating with boiled water sample. Calculate temporary, Permanent hardness.

Sols.

POORNIMA

Date	Unit No.	Lecture No.	Faculty	Subject Name	Subject Code	Main Topics:-
1	3	VV SH	CY			

*Municipal water supply/Purification of water:-

*Standards of Potable water:-

Primary Standard

(i) Physical Standard :- Water should be colourless and odourless. It should have pleasant taste. It should be perfectly cool. pH lies between 7-8.5. Turbidity should be less than 10 ppm. Total dissolved solids should be less than 500 ppm & Total hardness should be less than 300 ppm. It should be free from harmful dissolved gases like H_2S .

(ii) Chemical Parameters:-

$\text{Cl}^- = 250 \text{ PPM}$	$\text{NO}_3^- = 45 \text{ PPM}$	Iron = 1 PPM
$\text{F}^- = 1.5 \text{ PPM}$	$\text{Ca}^{2+} = 200 \text{ PPM}$	Magnesium = 0.3 PPM
$\text{SO}_4^{2-} = 200 \text{ PPM}$	$\text{Mg}^{2+} = 100 \text{ PPM}$	Copper = 1.5 PPM
Alkalinity = 200 ppm	Aluminum = 0.1 ppm	Lead (Pb) = 0.01 PPM

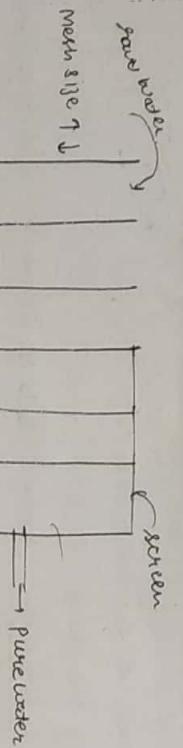
(iii) Biological Parameters :- Drinking water should be free from disease causing or lack of pathogenic bacteria but it should contain $\text{E. coli}/100 \text{ ml}$. It is indicator too for purity of water.

Main Ideas, Questions & Summary:

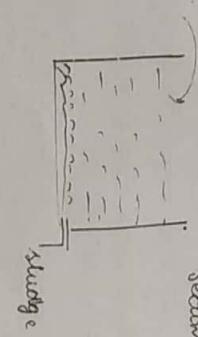
Library / Website Ref.:-

Step of purification of water

① Screening (Removal of Floating Materials):-



② Sedimentation:-



(3) sedimentation with coagulation:- (Removal of fine suspended)

Example :- $\text{K}_2\text{SO}_4 \cdot \text{Al}(\text{SO}_4)_2 \cdot 24\text{H}_2\text{O}$, $\text{FeSO}_4 \cdot 7\text{H}_2\text{O}$, NaAlO_2

(water of distillation)

④ Filtration :- (Removal of colloidal particles) (Sand filters)

(i) Gravity based (Sieve and filter)

(11) Rapid or pressure sand filter

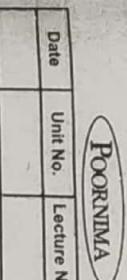
(i) Gravity object

~~Coarse sand~~ → Coarse sand
Fine sand
Fine gravel

BBB—coarse stream gravel

Main Ideas, Questions & Summary

Library / Website Ref.: -



(ii) Rapid Filter:  → outlet from impurification
→ back wash

Raw water
Dwler
finesand (thin)
— Slurry layer of $\text{Al}(\text{OH})_3$

Bump — Coarse sand
Gravel

Filtered water outlet

5) Disinfection:- To kill or destroy all the pathogenic bacteria.

Methods:-

$$(i) \text{ By ozonolysis} \quad O_3 \longrightarrow O_2 + [O]$$

germ + [o] → germs killed

(iii) By UV rays:-
(iv) By KMnO_4 (Oxidising Reagent).

(v) Charivation

(b) Pay C12 gas

(c) ~~CaCO₃~~ Bleaching Powder
(on dry chromosomes)

$$Cl_2 + H_2O \xrightarrow{5-7 pH} HCl + HOCl \longrightarrow \text{Unstable}$$

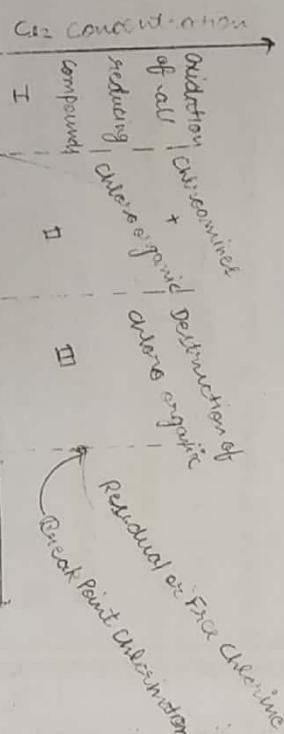
Hypochlorous acid

$$\text{HOCI} \rightarrow \text{HCl} + \text{O}_2$$

* Break Point Chlorination:-

The minimum amount of chlorine which is required for complete disinfection and oxidising (oxidation) of an reducing compound.

It is known as break point chlorination.



Step-1. When we take water and add chlorine in this then all the reducing compound which are presented in water,

begin to start oxidising because Cl₂ is oxidising reagent. On the whole there is no concentration increased. It means concentration is zero of chlorine.

Step-2. When we start to increase Cl₂ dose then Cl₂ concentration begins to increase at certain level. In this step all amine and organic are converted into chloramines and chloroorganic and concentration increasing stops at certain point.

Step-3. When we start to again increase Cl₂ dose then Cl₂ concentration continuously decreases and chlorine

concentration continuously decreases. There is a point in the organic compounds are converted. There is a point in the graph when Cl₂ concentration decreasing stops and that point is known as Break point chlorination.

Step-4. Now there are no chloroorganic compounds. If we increase the Cl₂ dose then Cl₂ concentration will be increased from free chlorine continually.

PORNIMA

Date	Unit No.	Lecture No.	Faculty	Subject Name	Subject Code	Main Topics:-
						In industries in tank or tank on which is used to generate steam

To Boiler :-

An apparatus which is used in boiler for steam generation is known as boiler feed water. It is known as boiler and the water which is used in boiler for steam generation is known as boiler feed water.

* Boiler Trouble:-

① Primary Priming, foaming and carry over

② Boiler corrosion

③ Sludge and scale

④ Fouling and Scale formation Embrittlement

① Priming, foaming and carry over:-

Priming:- The formation of wet steam is known as priming.

Foaming:- (Causes and preventions)

Causes:- (i) May be water level may be extremely high from which wet steam is formed.

(ii) Bubbles are also formed (made) which is also cause of formation of wet steam.

(iii) There may be another reason of the formation of wet steam, i.e. improper boiling.

(iv) High speed of steam is also reason of production of wet steam.

Main Ideas, Questions & Summary:-

Library / Website Ref:-

Prevention

Formation: The formation of foams and bubbles due to presence of oily and greasy substance and this process is known as foaming.

Carry over: When priming and foaming occur together in this

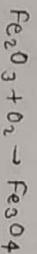
phenomenon is known as carry over.

② Bailey corrosion: The decay and disintegration of boiler material due to its environment is known as

boiler corrosion.

Reason:-

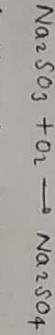
(a) due to dissolved O_2



(Rust)

* Prevention:-

(a) Chemical Method:- $Na_2SO_3 + O_2 \rightarrow Na_2SO_4$



Nitrogen

(b) Mechanical deaeration Method:- The solubility of gases are inversely proportional to

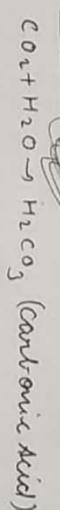
its temperature and directly proportional to its pressure. By the use of this principle we removed oxygen from water.

high temperature
low pressure
High exposed Area
perforated

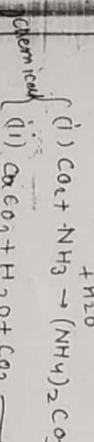
sheets

POORNIMA						
Date	Unit No.	Lecture No.	Faculty	Subject Name	Subject Code	Main Topics:-
2						

(b) due to CO_2

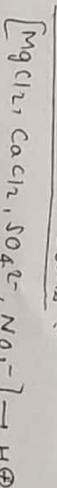


* Prevention:-



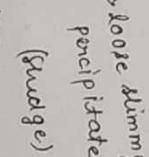
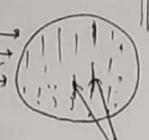
④ Mechanical deaeration:-

(c) due to dissolved SO_2 :-



* Prevention:- To add basic compounds in order to neutralization

⑤ Sludge and Scale:-



* Cause:- $MgCO_3, MgSO_4, CaSO_4, MgCl_2, Ca(HCO_3)_2$

* Disadvantages:-

- wastage of fuel (scale)
- blocking of pipe (sludge)
- Accident
- increase efficiency of boiler(s)
- Boiling (distortion of boiler material) (scale)
- corrosion

Prevention:-

- ① Use soft water (scale)
- ② Blow down operation (scale)
- ③ Thermal shock / hammering (scale)
- ④ By using chemicals (footscale)
- ⑤ By the use of organic substances

Main Ideas, Questions & Summary:-

Library / Website Ref.: -

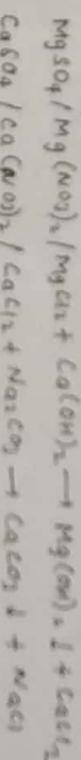
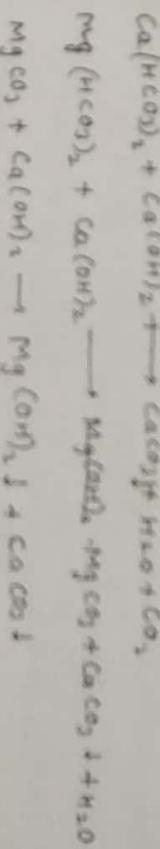
④ Causing brittle

- Q) Caustic Soda-treatment :- The phenomenon by which
water metal sulphides convert into
metal sulphate by the action of caustic soda is known as
 $\text{Na}_2\text{CO}_3 + \text{M}_2\text{S} \rightarrow \text{Na}_2\text{MS} + \text{CO}_2$ Caustic soda treatment

Precaution:-

 - ① By using sodium phosphate instead of sodium during softening water.
 - ② By the use of different organic substances tannin, lignin and agar-agar

Water softening (removal of water):-



$$\text{CaSO}_4 \cdot \text{Ca}(\text{NO}_3)_2 + \text{CaCl}_2 \rightarrow \text{X}$$

Hardness causing salt	Lime & Soda	Hardness Causing Salt	Lime & Soda
CaCO_3	L	CO_2	L
$\text{Ca}(\text{HCO}_3)_2$		H_2S	
MgCO_3		$\text{H}_2\text{C}(\text{HCO}_3)\text{O}_4$	L+5
$\text{Mg}(\text{HCO}_3)_2$	2L	Al_2SiO_5	
MgCl_2		$\text{Fe}_2\text{SiO}_4 \cdot 4\text{H}_2\text{O}$	L+5
MgSO_4	L+S		
$\text{Mg}(\text{NO}_3)_2$		NaAlO_2	-L
CaCl_2		Na_2CO_3	
CaSO_4			L-S
$\text{Ca}(\text{NO}_3)_2$	S		

* External treatment:-
 Lime Soda method (L-S process):- Ca(OH)₂, Na₂CO₃
 lime Soda method (L-S process) :- Ca(OH)₂, Na₂CO₃,
 principle:- In this process we use calculated amount of lime
 and soda and all soluble hardness causing salts
 are converted into insoluble substance.

Main Ideas, Questions & Summary

Library / Website Ref.:
1

POORNIMA

Date	Unit No.	Lecture No.	Faculty	Subject Name	Subject Code	Main Topics:-

Collайд

Cation Exchanger

These are styrene divinyl

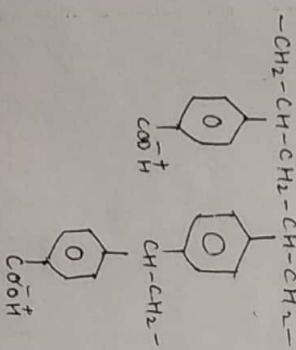
benzene co polymers containing

acidic functional group and

responsible for exchange cations from hard water

Eg :- Amberlite IR-120

Dowex - 50



Anion Exchanger

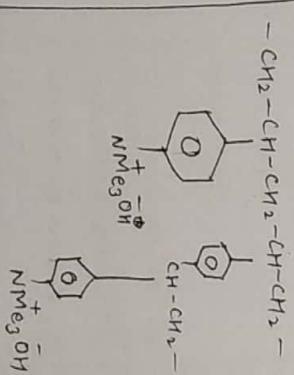
These are styrene divinyl benzene co polymers containing

basic function group and

responsible for exchange anions from hard water

Eg :- Amberlite - 400

Dowex - 3



Internal Treatment :-

Colloidal

Carbonate

Phosphate

Calgon

NaOH

Conditioning

Conditioning

Conditioning

Conditioning

Conditioning

Internal treatment :- An internal treatment generally

we treat

the water sample into the

water - boiler body

in which we add some chemical agents

(sequestering agent) by which impurities will be settled down at the bottom of the tank that can be easily removed through a pipeline or a vessel. this process is known as sequestration (Blow down operation).

External treatment

→ colloidal conditioning

→ carbonate conditioning

→ phosphate conditioning

→ calgon conditioning

→ NaOH

→ electrical conditioning

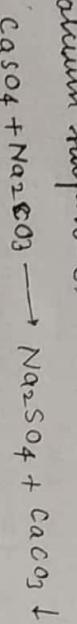
→ radioactive conditioning

→ complexometric conditioning

① Colloidal conditioning :- In this method we add some organic compounds agar like

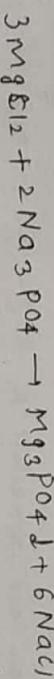
agar-agar gel, tannin, lignin etc. which adds the scale forming into forming salts with them that can be easily removed by blow down operation.

② Carbonate conditioning :- In this method we add sodium carbonate into the boiler water for the removal of hardness that is present but of sodium sulphate.

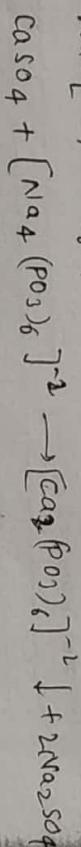
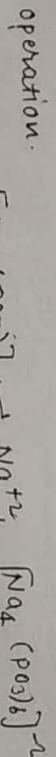


③ Phosphate conditioning :- For the removal of hardness due to the CaCl_2 and MgCl_2 .

generally we add calcium phosphate, for the removal of soft sludge.



④ Colgon conditioning :- Colgon (sodium hexameta-phosphate) is added into the boiler water then it forms a soluble complex with CaSO_4 that can be easily removed by blow down operation.

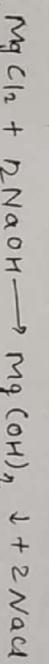


POORNIMA

Date	Unit No.	Lecture No.	Faculty	Subject Name	Subject Code	Main Topics:-

⑤ Addition of addition sodium aluminate :-

Sodium aluminate hydrolyses with water and forms zilatious ppt of Al(OH)_3 and react with MgCl_2 to form precipitate of Mg(OH)_2



⑥ Electrical conditioning → Steel glass bulb containing mercury & (Hg) connected to

a battery are send rotating in the boiler, as water boils, bulb emit electrical discharges which prevents formation of scale.

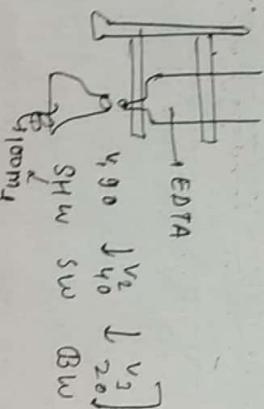
⑦ Radio active conditioning → In boiler body we add some radioactive tablets which prevent formation of scale.

⑧ Complexometric conditioning → When we add EDTA in the water sample then it forms a complex which prevents scale formation

Main Ideas, Questions & Summary:-

Library / Website Ref.: -

Standard hard water.
Solutions →



1 gm of CaCO₃ = 1 L of distilled water

1 ml SHW contains = 1 mg of CaCO₃

(i) Strength of EDTA :-

" 9 ml of EDTA is consumed for = 100 ml of SHW

so for 1 ml amount of EDTA consumed = $\frac{100}{9}$ mg of CaCO₃

so strength of EDTA = $\frac{100}{9}$ mg of CaCO₃

(ii) Total hardness :-

for 100 ml of sample water amount of EDTA consumed = 40 ml

since for 1 ml amount of EDTA consumed = $\frac{100}{9}$ mg of CaCO₃

so for 100 ml of sample water = $\frac{100}{9} \times 40$ mg of CaCO₃

∴ for 1000 ml of sample = $\frac{100}{9} \times \frac{40}{100} \times 1000 = 444.4$ ppm/

(iii) Permanent hardness:-

for 100 ml of Boiled water amount of EDTA consumed

$$= 20 \text{ ml}$$

since for 1 ml amount of EDTA consumed = $\frac{100}{9}$ mg of CaCO₃

so for 100 ml of boiled water = $\frac{100}{9} \times 20$ mg of CaCO₃

so for 100 ml of boiled water = $\frac{100}{9} \times 20$ mg of CaCO₃

Date

Unit No.

Lecture No.

Faculty

Subject Name

Subject Code

Main Topics:-

POORNIMA

∴ for 1000 ml of Boiled water = $\frac{100}{9} \times \frac{20}{100} \times 1000$

$$\Rightarrow \frac{2000}{9} \Rightarrow 222.2 \text{ ppm/mg/L}$$

Ans 8
and Strength of EDTA solution = Molarity × CaCO₃ molar mass

$$= 0.01 \times 100 \text{ g/L} \Rightarrow 1 \text{ g/L} \Rightarrow 1 \text{ mg/ml}$$

so for 1 ml of EDTA = 1 mg of CaCO₃

Total Hardness → ~~feet~~
for 100 ml of sample water amount of EDTA consumed

$$= 20 \text{ ml}$$

for 1 ml amount of EDTA = $20 \text{ ml} \times 1 \text{ mg CaCO}_3$

$$= \frac{20}{100} \times 1000 = 200 \text{ mg of CaCO}_3$$

Permanent Hardness :-

" 100 ml of boiled water amount of EDTA consumed = 10 ml
of
for 1 ml amount of EDTA = $10 \times 1 \text{ mg CaCO}_3$

for 1000 ml of Boiled water → $\frac{10}{100} \times 1000 = 100 \text{ mg of CaCO}_3$

Temporary = Total Hardness - Permanent Hard

$$\text{Temp.} = (200 - 100) \text{ mg of CaCO}_3$$

$$\Rightarrow \boxed{100 \text{ mg/L}}$$

Main Ideas, Questions & Summary:-

Library / Website Ref.: -

Ans. B

1 ml SHW contains = 1 mg of CaCO_3

Some of SHW = 50 mg of CaCO_3

also 50 ml of SHW = 49 ml of EDTA

so 47 ml of EDTA is consumed for 50 ml of SHW

for 1 ml amount of EDTA $\Rightarrow \frac{50}{47}$

Poornima

50, 47, 18, 8

(7)

Date	Unit No.	Lecture No.	Faculty	Subject Name	Subject Code	Main Topics:-

Q.10. What all are the softening methods for treatment of water sample. Unit down its comparative study of L-S process, redite process, ion exchange process.

Main Ideas, Questions & Summary:-

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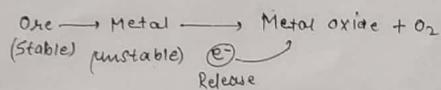
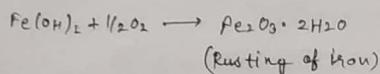
Topic:- Corrosion

Unit:- III

Date - 03-09-18

Corrosion:- Any process of deterioration of metal due to any chemical attack or electrochemical reaction with its environment is known as corrosion.

It can be simply explained by rusting of iron.



* Types of corrosion (Mechanism of corrosion):-

- (i) Dry or chemical corrosion.
- (ii) Wet or electrochemical corrosion
- (iii) The acid theory

(i) dry or chemical corrosion:- This type of corrosion occurs in the absence of moisture with any chemical like H₂, O₂, Cl₂, H₂S etc.

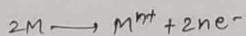
This type of corrosion is of three types:-

- (a) corrosion by Oxygen
 - (b) corrosion by other gases
 - (c) corrosion by Anhydrous liquid
- (a) corrosion by oxygen:- This type of corrosion generally occurs in the presence of Oxygen and in the absence of moisture. By this process metal generally decomposes into metal ions and ~~form~~ electron and

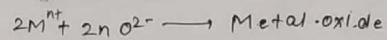
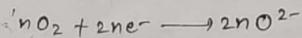
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Date	Unit No.	Lecture No.	Faculty	Subject Name	Subject Code	Main Topics:-

It forms a layer of metal oxide.



(Metal)

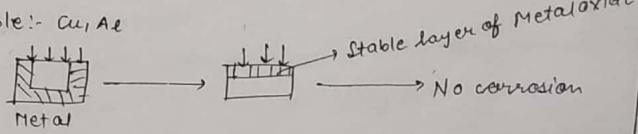


Formation of metal oxide layer and its nature shows the further attacks for corrosion.

* Types of metal oxides layers:-

(i) Stable layer:- Generally In this type of corrosion formation of metal oxide layer is a type of stable layer of metal oxide, So, there will be no corrosion.

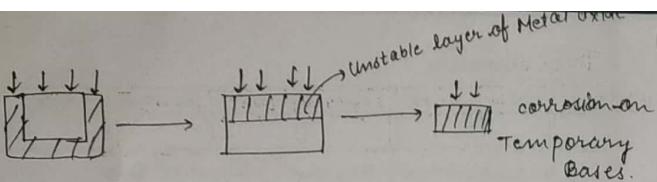
Example:- Cu, Al



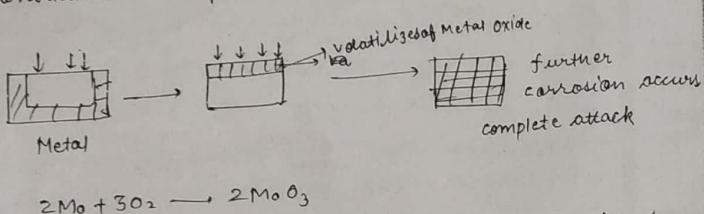
(ii) Unstable:- In this type of corrosion formation of metal oxide layer is of unstable type so layer of metal oxides will be corrode on temporary bases but it will ^{further} corrode the original metal.
For ex:- Ag, Au, Pt.

Main Ideas, Questions & Summary:

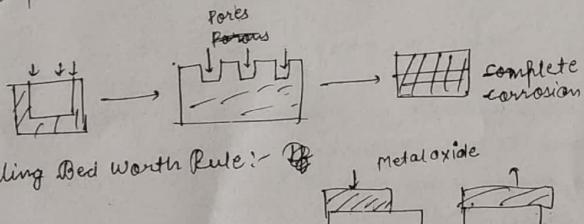
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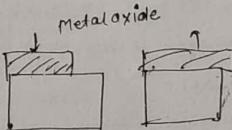
(ii) Volatile:- this type of corrosion occurs when metal is highly volatile. As this first of all metal forms a volatile layer of metal oxides and it further corrodes until complete corrosion occurs like Mo, tungsten.



(iv) Porous:- this type of corrosion generally occurs when on metal pores are present. Chemical directly attacks on pores and it will be continue until complete corrosion occurs. for ex:- Li, Na, K etc.



* Filling Bed Worth Rule:

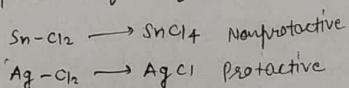


POORNIMA						
Date	Unit No.	Lecture No.	Faculty	Subject Name	Subject Code	Main Topics:-

If the volume of the metal oxide layer is greater as compare to volume of the metal then the formation of the metal oxide layer will be protective and non porous, whereas if the volume of the metal oxide layer is less as compare to metal then formation of metal oxide layer will be non protective and porous.

For ex. Li, K, Na are the examples of non protective layer whereas Al, is the example of protective layer

(b) Corrosion by gases:- Some gases like H_2 , Cl_2 , SO_2 , CO_2 , etc. are the examples of some gases. like Sn in presence of Cl_2 forms SnCl_4 .



Ag react with Cl_2 and forms AgCl .

(c) Corrosion by anhydrous liquid:- Due to the presence of some anhydrous liquid like:- picric acid, alcohol, HF, Br₂ etc. are responsible for corrosion.

Main Ideas, Questions & Summary:-

Library / Website Ref.:-

(iii) Wet or electrochemical corrosion:-

(a) Evolution of hydrogen

(b) Absorption of oxygen

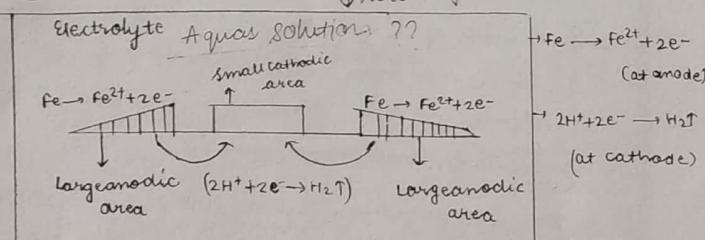
This type of corrosion generally occurs in two conditions:-
 (i) When conductive liquid with varying concentration of O_2 is in contact with metal.

(ii) When two dissimilar metals heat with aqua solution.

In this method at anode reaction will be always same but at cathode the reaction will be depend on (i) evolution of H_2

P. (a) Evolution of $H_2 \uparrow$

Here only one metal used



(i) In acidic medium with the evolution of H_2

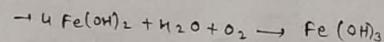
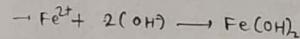
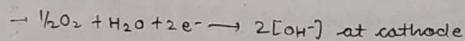
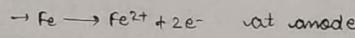
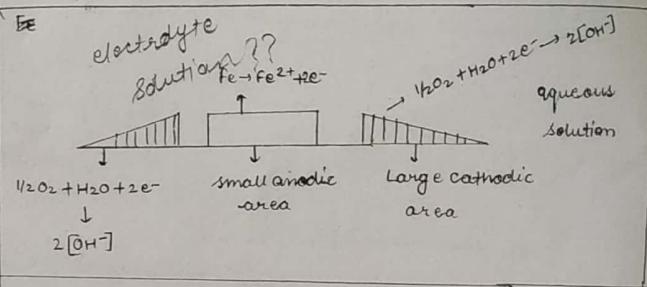
(ii) In this process usually anodic part has large area while cathodic part has small area.

(iii) All metals about H_2 in electrochemical series have a tendency to release its H_2

POORNIMA

Date	Unit No.	Lecture No.	Faculty	Subject Name	Subject Code	Main Topics:-

(b) Absorption of oxygen :- In this process at anode the reaction will be same but at cathode the reaction will be different, due to the presence of aqua solution.



Yellow Rust

Ferrous hydroxide in presence of H_2O and O_2 react and form $Fe(OH)_3$ (Yellow Rust)

If oxygen is less than it forms Black Ferrous Magnetite (Fe_3O_4)

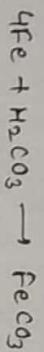
Main Ideas, Questions & Summary:

Library / Website Ref.:-

(iii) The Acid theory :-



carbonic Acid

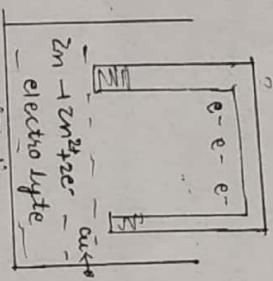


This theory is mainly applicable to rusting of iron in atmosphere, iron in presence of oxygen and water undergoes corrosion.

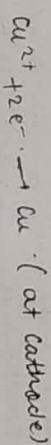
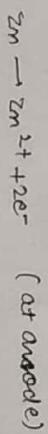
The ferrous carbonate can be oxidized to ferric carbonate which in presence of water forms hydrated ferric oxide. H_2CO_3 is regenerated in this process which causes further attack.

Types of corrosion:-

(i) Galvanic corrosion:-



solution



When two dissimilar metals are immersed in an electrolyte solution and are electrically connected then they form a galvanic cell.

The metal higher in the electrochemical series becomes anode and tends to be attacked. This type of corrosion is called galvanic corrosion.

The metal higher in the series dissolves and electrochemically equivalent amount of hydrogen and electron is deposited at the cathode. So the anode is dissolved and cathode is protected.

For example:- when zinc and copper are electrically connected and immersed in an electrolyte then the zinc which is higher in electrochemical series will react as an anode while Cu will react as an cathode.

By this process copper will be protected with the help of Zn.

(ii) Pitting Corrosion:-

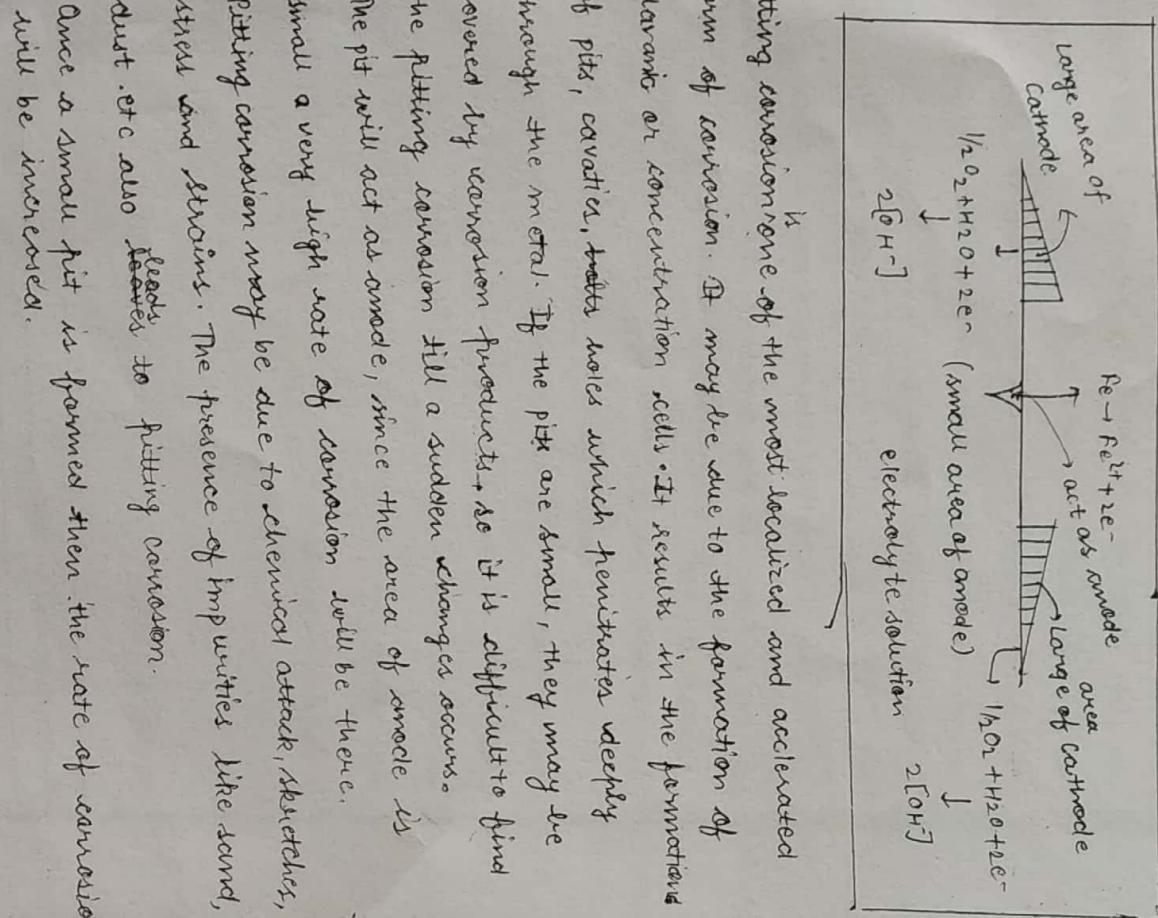
Main Ideas, Questions & Summary:-

Library / Website Ref.-:

POORNIMA

(5)

(i) Pitting corrosion :-



Pitting corrosion:- one of the most localized and accelerated form of corrosion. It may be due to the formation of galvanic or concentration cells. It results in the formation of pits, cavities, holes which penetrates deeply

through the metal. If the pits are small, they may be covered by corrosion products, so it is difficult to find the pitting corrosion till a sudden changes occurs. The pit will act as anode, since the area of anode is small a very high rate of corrosion will be there.

Pitting corrosion may be due to chemical attack, scratches, stress and strains. The presence of impurities like sand, dust etc also leads to pitting corrosion.

Once a small pit is formed then the rate of corrosion will be increased.

(ii)

(iii) Concentration corrosion :- This type of corrosion occurs when same metal is immersed in an electrolyte having different concentrations or different concentrations of dissolved O_2 . The difference in concentration develops a difference in potential. The flow of current is known as differential current.

The concentration cells are of two types :-

i) Metal ion cells :- These are formed by differences in metal ion concentrations.

ii) Oxygen cells :- In this case one part of metal is exposed to different air concentrations from the other part.

Some of the examples are as follows:-

(i) If a copper rod is in contact with 1 dil. and 1 concentrated solution of copper salt solution. The part which is in contact with dilute solution act as an anode and will be corroded.

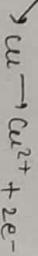
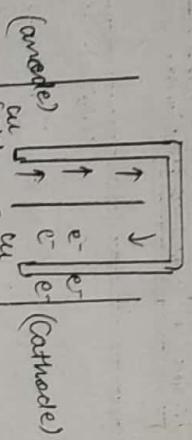
(ii) A metal is partially immersed in a dilute solution of NaCl.

Main Ideas, Questions & Summary:-

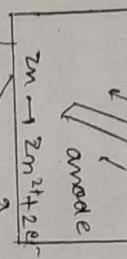
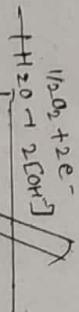
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(i) Metal in cell:-



(ii) Oxygen cells:-

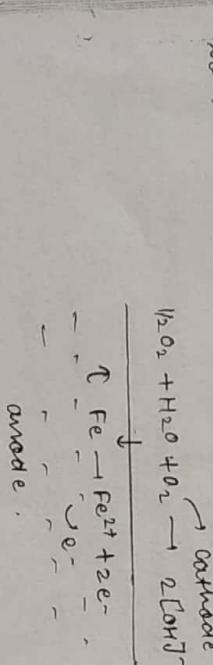


now oxygen concn. less

(iii) Stress corrosion (stress corrosion cracking) :- Stress corrosion cracking is a

process that requires the simultaneous action of a crackling agent and sustained tensile stress. It excludes corrosive agent and sustained tensile stress. It excludes corrosive agent and sustained tensile stress. It excludes corrosive agent and sustained tensile stress. It excludes

corrosion reduced sections that fail by fast fracture.



Poornima

Date	Unit No.	Lecture No.	Faculty	Subject Name	Subject Code	Main Topics:-

Factors influencing corrosion: mainly two factors

that influences the

corrosion of a metal:-

- (i) Nature of metal
- (ii) Environmental factors

(i) Nature of metal :-

(a) Physical state of metal :- The smaller the size of the metal

greater will be the corrosion

(b) Purity of metal :- Pure metal are corrosion resistant. The

impurities if present form galvanic cell and corrosion rate will be increased. In an alloy the

metallic solutions are homogeneous and don't form galvanic cells.

(c) Position in galvanic series :- When two metal alloys are in

contact the metal alloy

higher in galvanic series under go corrosion.

(d) Area of Anode:- Smaller the anodic area higher will be

the rate of corrosion.

Main Ideas, Questions & Summary:-

Library / Website Ref.: -

(ii) Environmental factors:-

(a) pH :- The rate of corrosion for most metals is slow in acidic medium.

(b) temperature :- Rise in temperature increases the rate of corrosion.

(c) Effect of moisture:- higher will be moisture content

greater will be the moisture corrosion.
(d) presence of impurities in atmosphere:- some gases like H_2S , SO_2 , CO_2 present in environment increases the rate of corrosion.

(e) effect of oxygen:- Oxygen is a corrosion stimulator at cathode. whereas corrosion inhibitor at anode.

* Protection against corrosion:- protection from corrosion can be done by following methods:-

① Proper designing:- By designing following point should be.

Avoid the contact of dissimilar metal in corroding medium.

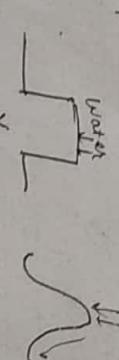
(a) When two dissimilar metal in contact are to be used then it should be as closed as possible in galvanic series.

(b) In any structure or designs, joints and nuts should be minimum.

(c) The anodic metal should be painted or coated

(d) Any scratches in metal increases the rate of corrosion

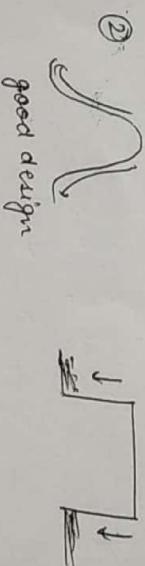
design:-



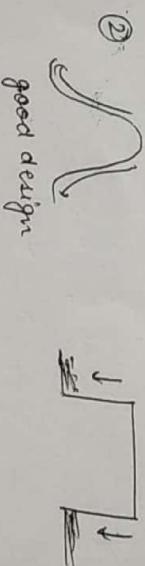
X



poor design



poor design



poor design

② Selection of metal:- pure metal should be preferred since they are corrosion resistant.

alloy ~~can also~~ can also ^{adopt more} be used to avoid corrosion. certain metal are resistant to corrosion than pure metal in homogeneous mixture.

③ Modifying the environment :-

i) Deactivation :- Deactivation remove gases like O_2 , CO_2 , water etc. is done to prevent corrosion.

ii) Neutralization of acids by adding some base or vice versa.

iii) Deactivation by adding some chemicals like: NaHS and hydrazine removed O₂ from environment.

Main Ideas, Questions & Summary:-

Library / Website Ref.: -

when

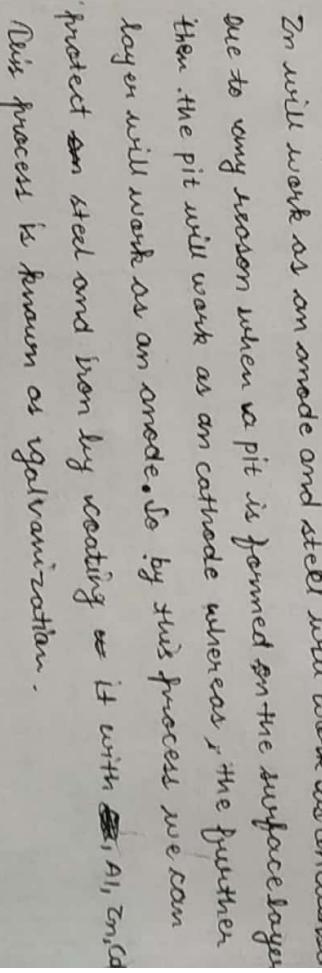
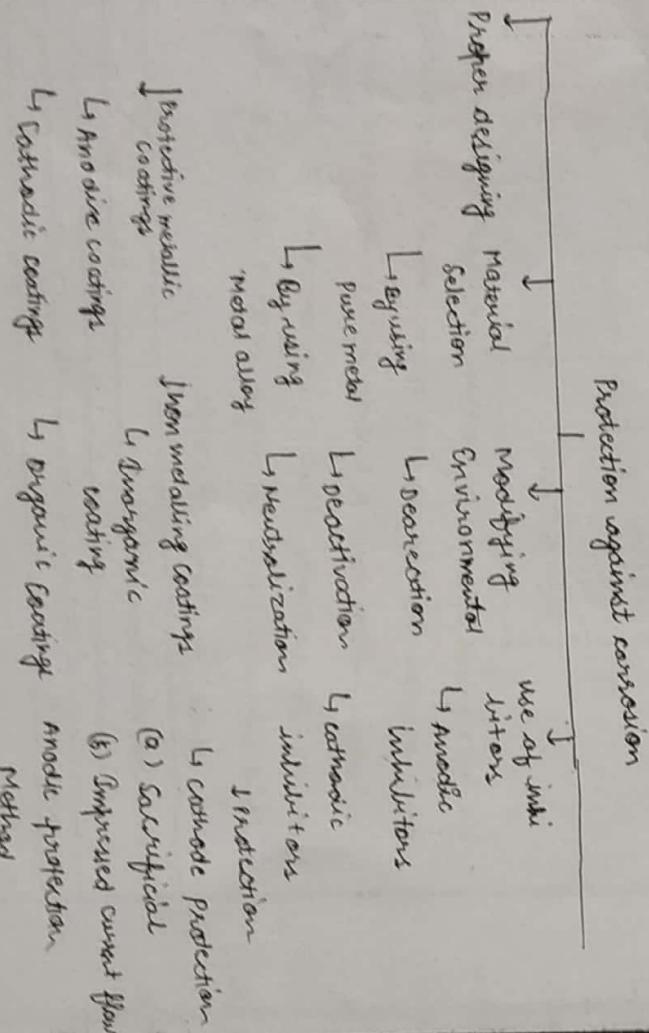
POORNIMA

Date	Unit No.	Lecture No.	Faculty	Subject Name	Subject Code	Main Topics:-

- ④ Inhibitors:- A substance which added to the corrosive medium, effectively decreased the corrosion of a metal, is known as inhibitor.
- Anodic inhibitors :- It get absorbed on anodic surfaces forming a passive film on it.
 - Cathodic Inhibitors slow down the reaction taking place at cathode like amines etc.

- ⑤ Protective metallic coating:- Steel and iron due to their low cost and availability are commonly used in construction process. The protection of these metal are done separating its from corrosive environment using different metallic coating on it.

Protection against corrosion



(i) Anodic coatings! - In this type of protective coatings, coatings is done by adding an applying a layer of anode on material (in metal). For example:- Coating of ^{on} Al and Cd on Steel. In this process first of ^{on} anode layer, we apply a layer of Zn on steel. For the protection of steel, through this process, Zn will work as an anode and steel will work as an cathode due to very reason when a pit is formed on the surface layer then the pit will work as an anode whereas, the further layer will work as an anode. So by this process we can protect steel and iron by coating it with Al, Cd, Ti, Ni, Cr.

- Ex :- Chromates and phosphates.

- Cathodic Inhibitors slow down the reaction taking place at

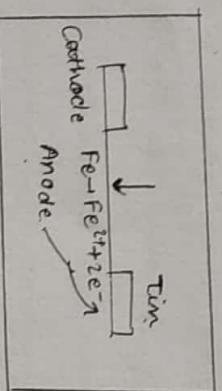
(ii) Cathodic coatings:- For the protection of iron a

layer of tin is applied on it.

By this process iron will work as an anode while tin will work as an cathode (due to electrochemical series).

Hence tin will work as an cathode. So this process will be known as cathodic coating or tinning.

This process is suitable when layer is protective. While if any crack is made on layer then Fe (Anode) will be corroded very fastly as compare to tin (cathode).



⑥ Non metallic coatings:- To protect metal. Some non metallic coating is done,

it is of two types:-

(i) Inorganic coatings:- Inorganic coating like porcelain enamel coating is done on household appliances, to protect from corrosion.

(ii) Organic coatings:- Some organic coatings are done, to protect some metals, like enamel,

paint and varnishes are some of the example of organic coatings. It is not supplying to protect it

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Date	Unit No.	Lecture No.	Faculty	Subject Name	Subject Code	Main Topics

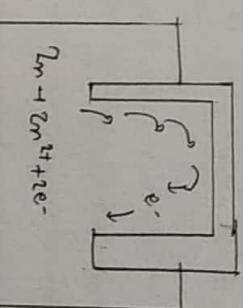
completely from corrosion but it decreases the rate of corrosion like in paint. Zinc oxide, Red lead oxide is present in paint with ferric oxide where zinc oxide and red lead will give a protective layer to paint.

④ Protection :-

(i) Cathodic protection:- To protect anodic part a coating of anodic layer is done over cathode.

It is of two types :-

(a) Sacrificial anodic protection metal :-



In sacrificial anodic protection method to protect anodic part be connected to the more anodic substances. So the main metal that is anode will be converted into anode to cathode. Hence, the main metal protective some corrosion, like plating or coating of Cd, Al and Cu on steel, or zinc on copper.

Main Ideas, Questions & Summary:-

Library / Website Ref.: -

Date	Unit No.	Lecture No.	Faculty	Subject Name	Subject Code	Main Topics:-
10-09	3		Ms. R.S.	Engg. Chem.	IFY2 - 03	

(b) Impressed Current Protection Method:- In this process

The anode is converted into cathode by applying a dc supply of current through this electrons are absorbed to the anode and

it converted into cathode.

It converted into boronite for ex:- graphite and platinum is used for this process.

In underground water, pipeline is also.....

by this process

(ii) Anodic Protection Method:- To protect anode it is converted into first of all

connected with the main anodic system, the main metal does not corrode easily. For example, Fe, Cr, Ti, etc. are protected by applying a layer of anode.

passive layer of anode.

Types of cement:-

```

graph TD
    cement[cement] --> natural[natural cement]
    cement --> pozzolana[pozzolana cement]
    cement --> slag[slag cement]
    cement --> portland[portland]
    natural --- rocks[naturally occurring rocks that contain calcium]
    natural --- noStrength[it does not give strength.]
  
```

(ii) Pozzolana Cement :-
→ It is a ~~evolution~~ mixture of lime and volcanic ash. It gives high strength and it is used in a mixture of portland cement.
It's name is based on a place of Italy - (Pozzolai).

Main Ideas, Questions & Summary

Library / Website Ref.: -

(iii) Slag cement:- It is a mixture of slag of blast furnaces and lime.
It does not have high strength.

(iv) Portland cement:- It is a mixture of lime, Alumina & silica.
(Argillaceous & Calcareous material)

It gives high strength and has more weathering property

Portland Cement:- It is mainly composed of lime, alumina, silica and iron. When added with water it forms a paste which hardens & binds crushed rocks, sand, gravel etc. to form a hard durable mass called concrete.

Its color and appearance is resembled to stones of Isle of Isle of Portland. Hence Aspin named his product as portland cement.

* Raw material of Portland cement:-

(i) Calcareous material :- Calcareous material i.e. ~~Al2O3~~ CaO component such as lime stone, chalk etc.

(ii) Argillaceous material:- Argillaceous material i.e. alumina and silica such as clay, sand, Alumina, fly ash etc

Poornima

Date	Unit No.	Lecture No.	Faculty	Subject Name	Subject Code	Main Topics:-

(iii) Peripherous material :- ie. Fe₂O₃ Components such as clay, iron etc are etc.

(iv) Powdered coal or fuel oil or natural gas

(v) Gypsum (CaSO₄. 2H₂O)

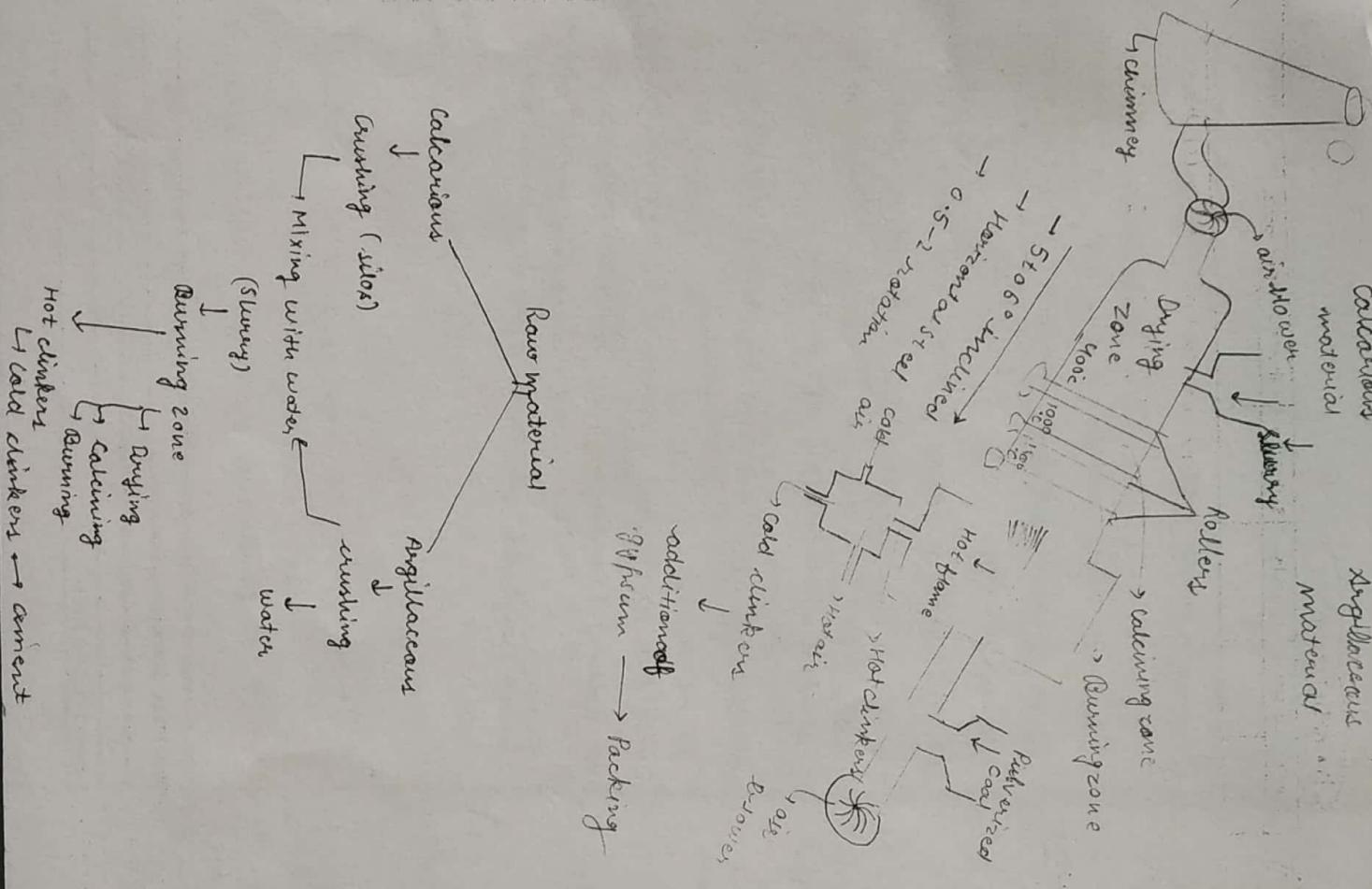
* Manufacturing of Portland cement By Rotary Kiln Technology

In Ideas, Questions & Summary:-

Library / Website Ref.: -

Calcareous material

Argillaceous material



POORNIMA

Date	Unit No.	Lecture No.	Faculty	Subject Name	Subject Code	Main Topics:-

For manufacturing of cement, rotary kiln technology is used. In this process, manufacturing of Portland cement is done by following steps:-

(i) Crushing :- First of all the raw materials that is calcareous material (lime stone, shale etc.) and argillaceous material (alumina, silica and iron) is crushed into small pieces that is 5 inches or 3-4 inches. After crushing separately it is carried into a separate bins and then mixing with each other into a definite proportion then mixing is known as silos.

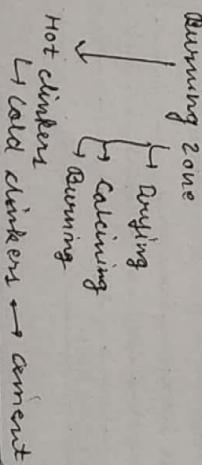
(ii) Mixing :- When mixing is done with water then the material is known as slurry. Based on mixing of water mixing is of two types.

(a) Dry process :- When mixing is done without water, then it is known as dry process.

(b) wet process :- When mixing is done with water, then it is known as wet process.

Main Ideas, Questions & Summary:

Library / Website Ref.:-



Burning zone	Drying
Hot clinkers	Cooling

Library / Website Ref.:-

(iii) Burning:- Slurry is inserted into rotary kiln that is a horizontal steel tube refractory lined tube and slightly 5 to 6° inclined and rotated 0.5 to 2 rotation per minute. In this zone to maintain the temperature we insert pulverized coal into the tube where by burning at the cool sample temperature is maintained. On the basis of temperature rotating kiln has three zones -

(a) Drying zone (400°C) :- In this zone at 400°C from slurry water is evaporated.

(b) Burning zone (1000°C) :- In this zone CaCO_3 is decomposed,

$$\text{CaCO}_3 \longrightarrow \text{CaO} + \text{CO}_2$$

(c) Burning zone (1500°C) :- In this zone at high temperature calcium, alumina and silica

react with each other as follows:-

- ① $2\text{CaO} + \text{SiO}_2 \longrightarrow 2\text{CaO} \cdot \text{SiO}_2$ (dicalcium silicate)
- ② $3\text{CaO} + \text{SiO}_2 \longrightarrow 3\text{CaO} \cdot \text{SiO}_2$ (tricalcium silicate)
- ③ $3\text{CaO} + \text{Al}_2\text{O}_3 \longrightarrow 3\text{CaO} \cdot \text{Al}_2\text{O}_3$ (tricalcium aluminate)
- ④ $4\text{CaO} + \text{Al}_2\text{O}_3 + \text{Fe}_2\text{O}_3 \longrightarrow 4\text{CaO} \cdot \text{Al}_2\text{O}_3 \cdot \text{Fe}_2\text{O}_3$

(tetra calcium alumino ferrite)

- By this process dicalcium silicate, tri calcium silicate, tetra calcium silicate & tetra calcium alumino ferrite are formed.

POORNIMA					
Date	Unit No.	Lecture No.	Faculty	Subject Name	Subject Code

(iv) Formation of hot clinkers:- By burning zone calcium alumina and silica react with each other and form aluminate and sillcate that is the greenish red or blackish in colour which is known as hot clinkers.

(v) Cold clinkers:- After getting hot clinkers it is then separated into separate bins from burning zone where hot clinkers is then changed into cold clinkers with the help of cold air.

(vi) Addition of gypsum and crushing:- After getting cold clinkers it is crushed

into fine powder and gypsum ($\text{CaSO}_4 \cdot 2\text{H}_2\text{O}$) (2-6%) is added

(vii) Packing (Packaging) of cement:- At last cement is added filled into small packages and then it is circulated for further use.

Main Ideas, Questions & Summary:

Library / Website Ref.:-

Raw material of cement :-

of portland
cement :- When cement is mixed with

water, a plastic mass called

cement paste is formed and hydration reaction begin

which results formation of gel and crystalline products.

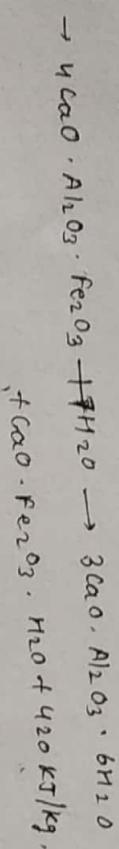
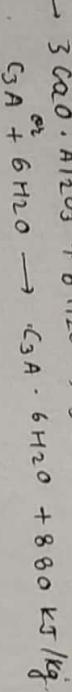
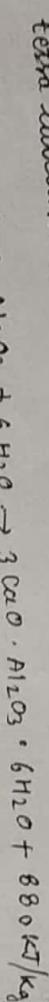
Solidification involves two process:-

- (i) Setting and
- (ii) Hardening

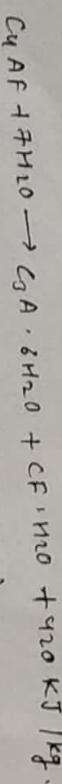
(i) Setting :- Setting is defined as stiffening of the original plastic mass due to initial gel formation.

(ii) Hardening :- Initial setting of cement paste is mainly due to the hydration of

tri calcium alumina (C_3A) and gel formation of tetra calcium alumino ferrite (C_4AF).



Or



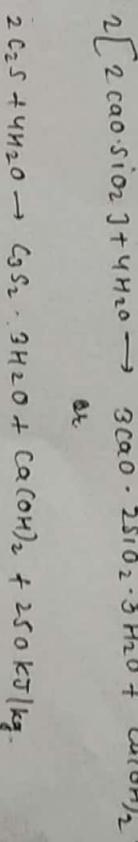
(crystalline) (gel)

Tetra calcium silicates also starts hydrating to tobermorite gel

(which poses a very high surface area and thus very high adhesive property) which also contributes to initial setting.

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Date	Unit No.	Lecture No.	Faculty	Subject Name	Subject Code	Main Topics:-



(tobermorite)
gel

Final setting & hardening :- Final setting & hardening of cement paste due to the

formation of tobermorite gel (formed above) and crystallization of calcium hydroxide and hydrated tri calcium aluminate. Hardening is the development of strength due to the crystallization. After setting hardening starts due to the gradual progress of crystallization in the interior of the mass. The strength developed by cement paste depends upon the amount of gel formed and extent of crystallization.

Main Ideas, Questions & Summary:-

Library / Website Ref.: -

Basic constituents, their significance & function, for

Portland cement.

Constituents	%, Percentage	function
Lime	62-69%	<ul style="list-style-type: none"> (i) To little lime to reduce strength of cement if its content is high then it gives high early strength time but generally increases the setting time. (ii) Too high percentage of lime produces cement of unsound quality & makes it poor disintegration.
Silica	17-25%	The high percentage increases the strength & the setting time.
Alumina	3-8%	Its higher percentage increases the strength & reduces the setting time.
Titanium oxide	2-4%	It imparts characteristics like grey colour, strength & hardness to portland cement.
Magnesium oxide	1-5%	It improves the functionality of lime & contributes the soundness of cement.
Sulfur tri-oxide (SO_3)	1-3%	It imparts soundness to cement when present in small amount.
Alkali oxide	0.3 - 1.0%	<ul style="list-style-type: none"> It present in excess causes the cement - - - - -

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Date	Unit No.	Lecture No.	Faculty	Subject Name	Subject Code	Main Topics:-

Glass: Glass is an amorphous hard, brittle, transparent supercooled liquid of infinite viscosity. It is obtained by fusing a mixture of sodium carbonate, calcium carbonate & silica.

It has no sharp melting point, It is a good electrical insulator not attacked by acid & it is a vitrified product.

Main Ideas, Questions & Summary

Library / Website Ref.: -