Government Women Engineering College, Ajmer

I Mid Term (Branch: CSE) **B.Tech. I Sem. Section -A**

Time: 1 hr. **Maximum marks: 16**

Instruction to Candidates: All Questions are compulsory. Schematic diagrams must be shown wherever necessary. Units of quantities used/ calculated must be stated clearly.

1. Complete the reaction – $CaCl_2$+Soda ⟶…… .+ …….. **01**

Sol. - $CaCl_2$+ Na_2CO_3⟶ 2 NaCl + $CaCO_3$ ↓

2. What is fuel? **01**

Sol. - Fuels are the sources of thermal energy. Chemical fuels are the combustible substacnces which on burning in presence of air, liberates a large amount of heat.

3. Calculate temporary and permanent hardness (in degree Fr.) of a water sample containing $MgCl_2$=10 ppm, $Mg(HCO_3)_2$ = 146 ppm, $CaSO_4$ = 136 ppm. **03**

Sol. -

Salt	Amt. (ppm)	M.F.	$CaCO_3$ equivalent
$MgCl_2$	10	100/95	10.5
$Mg(HCO_3)_2$	146	100/146	100
$CaSO_4$	136	100/136	100

Temporary hardness = 100 ppm

Since 1 ppm = 0.1 degree Fr. , therefore **Temporary hardness = 10 degree Fr**.

Permanent hardness = 10.5+100 = 110.5 ppm = 11.05 degree Fr.

4. Two metals A and B undergo oxidation corrosion in absence of moisture. A corroded faster and corrosion of B takes place negligibly. Predict their Pilling bedworth ratio and give one example for each. **03**

Sol. – According to Pilling bedworth rule metal corrosion depends upon the nature of the oxide layer formed on to the metal surface due to the corrosion. It depends upon the Pilling bedworth ratio.

Pilling bedworth ratio = Volume of the metal oxide formed / Volume of the metal surface

If P.B. Ratio ≥ 1 then Non porous (protective) film is forms, which prevent further corrosion.

If P.B. Ratio < 1 then Porous (non protective) film is forms, hence corrosion takes place at faster rate.

Therefore for metal A P.B. Ratio < 1 and for metal B P.B. Ratio ≥ 1 .

Example metal A = Fe

Metal B = Al

Or

A boiler feed water contains excessive amount of dissolved oxygen, which type of boiler trouble may occur due to its presence? Explain the complete process and its prevention.

Sol. –Excessive amount of dissolved oxygen may cause boiler corrosion. When water is heated in boiler, the dissolved oxygen is get free and reacts wih the iron of boiler at high temperature conditions and forms rust.

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

$4\ Fe(OH)_2 + O_2 \longrightarrow 2\ Fe_2O_3.2H_2O$ Rust

Prevention – It can be prevented by removal of oxygen from boiler feed water. Removal can be done by chemical methods or by mechanical deaeration method.

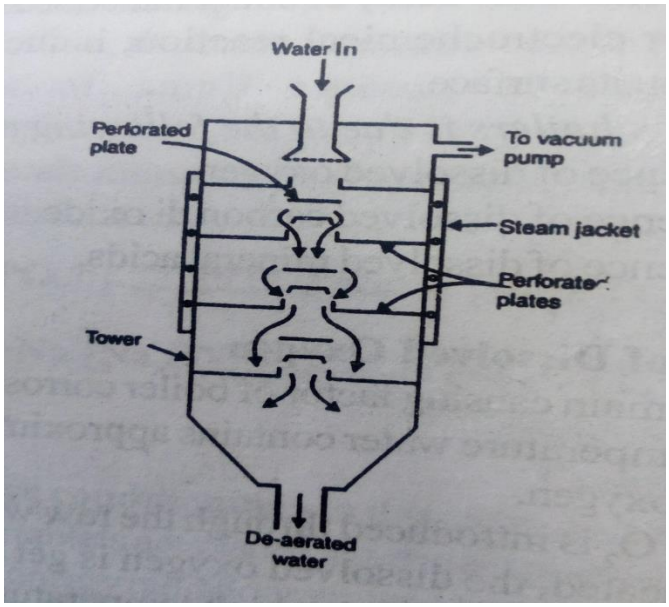
- **Chemical method – Chemically oxygen can be removed by adding sodium sulphite, sodium sulphide or hydrazine to the boiler feed water, these chemicals combine with the oxygen present in water and hence reduces its amount in the water.**

  $2Na_2SO_3 + O_2 \longrightarrow 2Na_2SO_4$

  $Na_2S + O_2 \longrightarrow Na_2SO_4$

  $NH_2\text{-}NH_2 + 2O_2 \longrightarrow 2H_2O + N_2$

- **Mechanical deaeration method – This method is based on the Henry's law and Dalton's law i.e solubility of a gas is directly proportional to pressure and inversely proportional to the temperature. Therefore to decrease the solubility of oxygen in water we maintain high T and low P in the deaeration tower.**



Mechanical deaeration tower

This mechanical deaeration tower is provided with perforated plates and a water spray at the upper end. Tower is heated by steam jacket. Vacuum is created inside the tower using vacuum pump. Large exposed surface, high T and low P reduces the dissolved oxygen content in water. Deaerated water is collected at the bottom.

5. Briefly describe Caustic embrittlement. **04**

Sol - Caustic embrittlement is the phenomenon during which boiler material becomes brittle due to the accumulation of caustic substances in boiler.

Mechanism –

- **If boiler feed water contains excess amount of sodium carbonate, during boiling this sodium carbonate forms NaOH in boiler due to which the boiler water becomes alkaline.**

  $Na_2CO_3 + H_2O \longrightarrow 2NaOH + CO_2$

- **When this slightly alkaline water flows into the minute hair-cracks or crevices, the water evaporates and hence concentration of NaOH increases.**
- **Now, at high T in cracks and at joints under stress, this conc. NaOH dissolves iron and form sodium ferroate.**

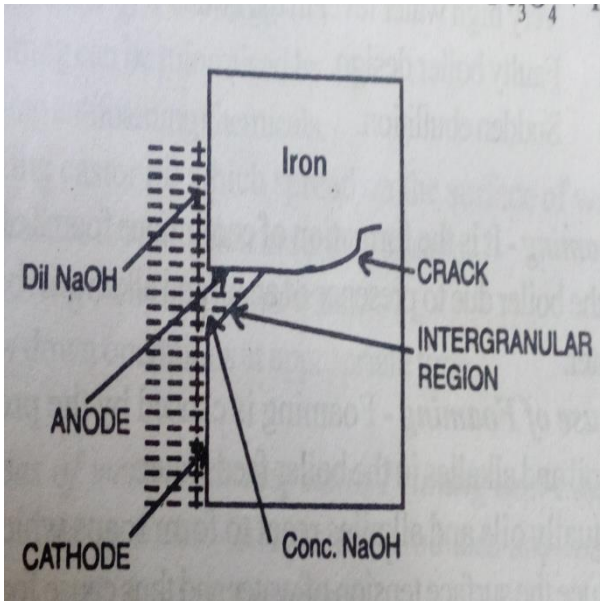
  $Fe + 2\,NaOH \longrightarrow Na_2FeO_2 + H_2$

  sodium ferroate

- **At high T, this sodium ferroate decomposes as -**

  $3Na_2FeO_2 + 4\,H_2O \longrightarrow 6NaOH + Fe_3O_4 + H_2$

  Due to regeneration of NaOH, further dissolution of iron takes place.



Prevention of Caustic Embrittlement –

- **Using sodium phosphate or sodium sulphate for water softening instead of sodium carbonate.**
- **Preventing the entry of NaOH into crevices by bloking them with innocuous harmless substances like tannin or lignin to the boiler feed water.**

6. Calculate the amount of lime and soda required for a water sample containing $MgCl_2$=120 ppm, $Ca(HCO_3)_2$ = 162 ppm and $MgSO_4$=200 ppm, if puityof lime was 98% lime and soda was 85% . **04**

Sol. -

Salt	Amt. (ppm)	M.F.	$CaCO_3$ equivalent	L and S
$MgCl_2$	120	100/95	126.31	L+S
$Ca(HCO_3)_2$	162	100/162	100	L
$MgSO_4$	200	100/120	166.67	L+S

Lime req. = 74/100 ($MgCl_2$ + $Ca(HCO_3)_2$ + $MgSO_4$ in terms of $CaCO_3$ equivalents) * purity factor

= 74/100 (126.31+100+ 166.67) *100/98

= 296.74 mg.

Soda req. = 106/100 ($MgCl_2$ + $MgSO_4$ in terms of $CaCO_3$ equivalents) * purity factor

= 106/100 (126.31+166.67) * 100/85

= 365.36 mg.

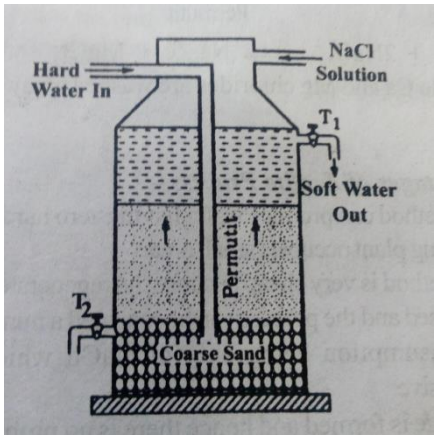
Or

Briefly explain the water softening by Zeolite process.

Sol. – Zeolite is the sodium aluminium orthosilicate with the formula $Na_2Al_2Si_2O_8.x\ H_2O$ or Na_2Ze, where $Ze = Al_2Si_2O_8.x\ H_2O$.

It can exchange its sodium ions easily with the heavy metal ions such as Ca and Mg ions.

Process -



Zeolite softener consists of a steel tank packed with a thick layer of zeolite. Hard water is percolated through the zeolite, the ca and Mg ions present in the hard water are replaced by the Na ions of the zeolite, and the resulting soft water is collected from tap T_1.

Reactions –

- **$Mg/Ca(HCO_3)_2$ + Na_2Ze ⟶ $Mg/CaZe$ + 2 $NaHCO_3$**
- **$Mg/CaCl_2$ + Na_2Ze ⟶ $Mg/CaZe$ + 2 NaCl**
- **$Mg/CaSO_4$ + Na_2Ze ⟶ $Mg/CaZe$ + Na_2SO_4**

Thus both temp. and permanent hardness can be removed by this method.

Regeneration of Zeolite – Exhausted zeolite can be regenerated by passing 10% NaCl solution.

$Mg/CaZe$ + 2 NaCl ⟶ Na_2Ze + $Mg/CaCl_2$

$Mg/CaCl_2$ solutions washes away through tap T_2.

Advantages –

- **It can produce zero hardness water.**
- **Occupies small area**
- **No sludge is forms hence no problem of sludge disposal.**
- **Economic process.**

Disadvatages –

- **Turbid water/acidic water can not be softened by this softener.**
- **Mn^{+2}, Pb and Fe^{+3} ions can not be removed by zeolite.**
- **It removes only cations while all the anions (HCO_3^-, OH^-, SO_4^{-2}, CO_3^{-2} etc.)remains in the water which may further cause many problems in boilers.**