**

**I Mid Term examination**

**Session: 2017-18**

**B.Tech I Year (II Semester)**

**Subject with code: Engineering Chemistry (CY-101)**

Time: 2hrs.

 SET - A M.M.:20

**Instruction for students:**

Question paper contains two sections. Sec A- compulsory (which includes 8 short answers type questions of 0.5 marks each). Sec B- contains 06 Questions out of which any 04 questions to be attempt by the student (4 marks each).

 **Sec-A**

Q.1 Answer the following questions -

(a) What are characteristics of drinking water?

 (b) Why are chloramines better than chlorine for sterilization of water?

 © Write the basic principle involved in lime –Soda process

(d) Write the difference between internal and external treatment process

(e) The hardness of 5000 litre of water sample was completely removed by passing it through zeolite container . zeolite required 100 litre of solution containing 10 ,000gm/lit of NaCl for regeneration .Determine the hardness of water ?

(f) Differentiate between scale and sludge process

(g) why hardness is calculated in terms of CaCo3 equivalent?

(h) Define and classify fuels (04 Marks)

 **Sec-B**

Q.2 Explain demineralization process of water softening with diagram

Q.3. **Discuss the EDTA method for the determination of hardness of water**

Q.4 What is boiler troubles? Discuss their consequences?

Q.5 Compare lime –soda method, zeolite method and ion exchange methods for softening of hard water

Q.6 Describe the manufacture of metallurgical coke by Beehive oven method . discuss the recovery of by product s.

Q.7 analysis of water sample gave following results

CaSo4 -0.4 g/l, MgCO3 =0.44g/l, CaCO3 =2 g/l MgSO4 =0.80g/l MgCl2=0.78g/l SiO2 =2.40 g/l, NaCl =2.50 g/l. Calculate the amount of lime and soda required to soften 20,000 litres of water .if purity of lime is 90% and that of soda is 95%

 (04\*04=16 Marks)

**(a) What are characteristics of drinking water?**

Ans - (1) it should be clear ,colorless and odorless

(2) it should be good in taste

(3) it should be perfectly cool

(4) its turbidity should be less than 10 ppm

(5) it should be free from harmful gases like h2s

(6) Its pH should be in the range of 7 -8.5

(7) Total hardness should be less than 500ppm ]

(8) Total dissolved solids should be less than 500 ppm

(9) it should be free from disease producing bactria and E.coli must be under permissible limits

(10) chloride ,fluoride and sulphate content s should be less than 250 ppm ,1.5 ppm and 200 ppm respectively

**(b) Why are chloramines better than chlorine for sterilization of water?**

 Ans (1) Chloramine is quite stable

1. It does not impact any disagreeable odour or bad taste to treated water

**© Write the basic principle involved in lime –Soda process**

ANS - this method hard water is treated with calculated amount of slaked lime and soda ash in reaction tanks, so as to convert hardness producing chemicals into insoluble compounds which are then removed by settling and filtration. If this process is carried out at room temperature it is called Cold lime soda process and if carried out at higher temperature is known as hot lime soda process.

Treatment with lime:

1. Removal of temporary hardness of Ca+2

Ca(HCO3)2+Ca(OH)2→2CaCO3+2H2O

1. Removal of Temporary hardness of Mg+2

Mg(HCO3)2+2Ca(OH)2→Mg(OH)2+2CaCO3+2H2O

1. Removal of Permanent hardness of Mg+2

MgCl2+Ca(OH)2→Mg(OH)2+CaCl2

MgSO4+Ca(OH)2→Mg(OH)2+CaSO4

Mg(NO3)2+Ca(OH)2→Mg(OH)2+Ca(NO3)2

1. Removal of CO2

CO2+Ca(OH)2→CaCO3+H2O

1. Removal of acids

2HCl+Ca(OH)2→CaCl2+2H2O

H2SO4+Ca(OH)2→CaSO4+2H2O

1. Removal of bicarbonates of Na+  and  K+

2NaHCO3+Ca(OH)2→CaCO3+Na2CO3+2H2O

FeSO4+Ca(OH)2→CaSO4+Fe(OH)2

Al2(SO4)3+3Ca(OH)2→3CaSO4+2Al(OH)3

NaAlO2+2H2O.→Al(OH)3+NaOH

 Treatment with soda:

Removal of Permanent hardness of Ca+2

CaCl2+Na2CO3→CaCO3+2NaCl

CaSO4+Na2CO3→CaCO3+Na2SO4

Ca(NO3)2+Na2CO3→CaCO3+2NaNO3

**(d) Write the difference between internal and external treatment process**

|  |  |  |
| --- | --- | --- |
| s.no.  | Internal treatment  | External treatment  |
| 1 | I t is carried out inside the boiler  | It is carried out outside the boiler before the entry of water in boiler  |
| 2 | It is corrective process  | It is preventive process  |
| 3 | It is required in low pressure boiler  | It is required in high pressure boiler  |
| 4 | It involves Carbonate ,colloidial phosphatre ,calgon conditioning  | It involved the lime –soda ,zeolite and ion exchange process  |

**(e) The hardness of 5000 litre of water sample was completely removed by passing it through zeolite container . zeolite required 100 litre of solution containing 10 ,000gm/lit of NaCl for regeneration .Determine the hardness of water**

Ans – hardness (mg/lit ) = 50 \* V2 \*1000 \* 50

 **V1 \*58.5**

**= 10\*100\*1000\*50**

**5000 \* 58.5**

**= 170.94 mg/lit**

**(f) Differentiate between scale and sludge process**

If the water contains hardness causing salts like MgSO4, MgCl2 ,CaSO4 , Ca (HCO3)2 on evaporation, the salts are precipitated to produce scale and sludge.

|  |  |
| --- | --- |
| sludge | scale: |
| Loose, slimy , non-adherent precipitate | Hard, thick , strong adherent precipitate |
| Due to salts like MgSO4 , MgCl2 | Due to salts like CaSO4 , Ca(HCO3)2 |
| Due to poor conductance, they decrease the boiler efficiency to lesser extent and causing chocking in the pipelines. | Due to poor conductance, they decrease the boiler efficiency to maximum extent, cause reduced fuel economy , improper boiling, boiler explosion etc., |
| Usually sludge get deposited where flow rate is low or where bends in the lines  | Scales are formed throughtout the surface of boilers  |
| Formed at comparatively colder portion of the boiler  | Formed generally at heated portions of the boiler  |
| It can be prevented by periodical replacement of concentrated hard water by fresh water. This process is known as “blow down” method. | It can be prevented by special methods like i)external treatment of ion exchange , ii)Internal carbonate, phosphate, Calgon conditioning iii)Mechanical hard scrubbing methods. |

(**g) why hardness is calculated in terms of CaCo3 equivalent?**

Ans - (1) Its molecular weight is 100 and equivalent weight is 50 is a whole number, which is easily calculated

(2)It is most insoluble salts that can be precipitated in water treatment

**(h) Define and classify fuels**

A fuel is a substance which gives heat energy on combustion. A fuel contains carbon and hydrogen as main combustible elements. fuel is any material that can be made to react with other substances so that it releases chemical or nuclear energy as heat or to be used for work. heat energy released by reactions of fuels is converted into mechanical energy via a heat engine.

Classification of fuel -According to occurrence

* 1. **Primary fuels** which occur in nature as such, e.g. coal, petroleum and natural gas.
* 2. **Secondary fuels** which are **derived from the primary fuels**, e.g. coke, gasoline, coal gas, etc.

2. according to aggregation

* Both primary and secondary fuels may be further classified based upon their physical state as
* (i) solid fuels – primary solid fuel – wood , secondary solid fuel - coke ,charcoal
* (ii) liquid fuels –primary liquid fuel – crude oil ,secondary liquid fuel – petrol ,kerosene
* (iii) gaseous fuels. **-** primary gaseous fuel –natural gas ,secondary gas fuel – water gas ,

**Q.2 Explain demineralization process of water softening with diagram.**

Ion exchange method (Demineralization)] Ion exchange is an adsorption phenomenon where the mechanism of adsorption is electrostatic. Electrostatic forces hold ions to charged functional groups on the surface of the ion exchange resin. The adsorbed ions replace ions that are on the resin surface on a 1:1 charge basis.

Exchange resins are insoluble, crosslinked, high molecular weight organic polymer with porous structure. The functional group attached to the chain is responsible for exchanging the ions. Ion exchange resins are

Cationic Exchangers:

- functional groups derived from acids e.g., R-SO3H (sulphonic), R-COOH (carboxylic).



 . Anionic Exchangers: functional groups derived from quaternary ammonia compounds, R4N-OH, primary and secondary amines, R-NH3OH or R-R’-NH2OH





**Working:** Here all the cations and anions are completely removed. It uses two column of cation exchange column and anion exchange column filled with resins. . The water is fed into cylinder –I where all the cations are replaced by RH Resins.

**2RH + Ca++ → R2Ca + 2H+**

 **2RH + Mg ++ → R2Mg + 2H+**

The cation free water is fed to cylinder II, where all the anions are replaced

**ROH + Cl- → RCl + OH-**

 **2ROH + CO3 → R2CO3 + 2OH-**

So, the resultant water is free from all types of ions.

**H+ + OH- -----→ H2O**

**Regeneration:** On prolonged use, as all the resins are exhausted, there will be no H+ or OH – ions to exchange the unwanted ions. So, they have to be regenerated. Cation resins are regenerated by HCl and anion resins by NaOH.

2RH+ + Ca2+◊R2 Ca2+ + 2 H+ R2’ SO4 2R’OH- + SO4◊2- + 2 OH-

2- Advantages of Ion exchange method:

Can be used for high pressure boilers also.

 It can treat highly acidic or alkaline water.

 We can get pure water as hardness as low of 2 ppm.

**Drawbacks of Ion exchange method**: i) Expensive

 ii) Fe, Mn cannot be removed as they form complexes with resins

 iii) Cannot be used for turbid water as they clog the resins. Note - Differences between soft water and dematerialized water. S. No Soft water Dematerialized

**Q.3 Discuss the EDTA method for the determination of hardness of water .**

Ans - EDTA stands for Ethylene Diamine Tetra Acetic acid. As it is insoluble in water, we use its disodium salt.

Principle - Hardness of water can be determined by complexometry using Ethylene diamine tetra acetic acid (EDTA) as titrant, Ammonium Chloride – Ammonium Hydroxide buffer solution of pH-10.1 and Eriochrome black –T as the metal indicator

Structure of EDTA:



By nature, Eriochrome Black T indicator is blue in colour. When EBT indicator is added to water sample, it forms a wine red coloured unstable Ca-Mg-EBT complex.

This reaction is carried out under a basic PH of 8- 10 using ammonia buffer.

Ca2+/Mg2+ in water + EBT → [Ca / Mg – EBT] unstable wine red complex

When EDTA is titrated against the complex, EDTA replaces all the EBT and forms a stable Ca / Mg –EDTA complex. The liberated EBT indicates the end point as steel blue.

[Ca/Mg  –EBT]+EDTA→[Ca/Mg–   EDTA]+EBT

 (Wine red/unstable)                (Stable)              (Steel blue)

So, the end point is the colour change from wine red to steel blue.

2. Chemicals required*:*

a) Standard hard water – 1g CaCO3 + dil. HCl – made up to 1 Lr.

b) EDTA solution – 4 gms of EDTA sodium salt / 1 Lr of water

c) EBT Indicator – 0.5g EBT / 100 ml alcohol

d) Ammonia buffer - 67.5g Ammoniumchloride +570ml Ammonia-- made up to 1Lr

*Procedure:*

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| s.no.  | Content  | Standardization of EDTA | Estimation of TotalHardness | Estimation ofpermanent Hardness |
| 1 | Burette | EDTA | Standard EDTA | Standard EDTA |
| 2 | Pipette(20 ml) | Std. Hardwater | Sample water | Boiled water |
| 3 |  Additionalsolution | 10ml of NH3buffer | 10ml of NH3buffer | 10ml of NH3buffer |
| 4 | Indicator | 2-3 drops EBT | 2-3 drops EBT | 2-3 drops EBT |
| 5 | Endpoint | Wine red to steelblue | Wine red to steelblue | Wine red to steel blue |
| 6 | Volume | V1 | V2 | V3 |
| 7. | Formula | 20/V1 mg ofCaCO3 | V2/V1X1000 ppm | V3/V1X1000 ppm |

Calculation:

Step1 – Standardisation of EDTA

1 ml of Std. Hard water = 1 mg of CaCO3 (Given)

So, 20 ml of Std. Hard water = 20 mg of CaCO3

V1 ml of EDTA is required for = 20 mg of CaCO3

Therefore, 1ml of EDTA = 20 / V1 mg of CaCO3

Step 2: Finding Total hardness:

20ml of sample water required = V2 ml of EDTA

= V 2/v1 X 20 mg of CaCO3

Therefore, 1000ml of sample requires = V2/V1X 20 X 1000 mg of CaCO3

Hence, total hardness = V2/V1 X 1000 ppm

Step 3: Finding Permanent hardness:

20ml of boiled water required = V3 ml of EDTA

= V3/V1 X 20 mg of CaCO3

Therefore, 1000ml of boiled sample requires = V3/V1 X 20 X 1000 mg of CaCO3

Hence, permanent hardness = V3/V1 X 1000 ppm

Step 4 : Temporary hardness = Total hardness – permanent hardness

**Q.4 What is boiler troubles? Discuss their consequences**?

 Boiler troubles: Sludge, scale, priming and foaming, caustic embrittlement, boiler corrosion are collectively known as boiler troubles.

A. Caustic Embrittlement: (Inter crystalline cracking of boiler metal) It is the intercrystalline cracking of boiler due to Na2CO3. In high pressure, Na2CO3 undergoes hydrolysis to produce NaOH. This makes water caustic. The NaOH contenting water flows into the minute hair-cracks.

 2 NaOH + CO2 Na2CO3 + H2O

This NaOH occupies the hair line cracks of boiler metal and converts the insoluble Fe into soluble Sodium Ferroate. Thus it makes the cracks bigger in bents, joints and crevices.

 Na2FeO2 + H2 ↑◊Fe + 2 NaOH ( Insoluble) (Soluble)

Prevention of caustic embrittlement:

1. As softening agent, we can use sodium phosphate instead of sodium carbonate.

2. The hair line cracks can be sealed by waxy materials like Tannin and Lignin.

B. Sludge and scale : If the water contains hardness causing salts like MgSO4, MgCl2 ,CaSO4 , Ca (HCO3)2 on evaporation, the salts are precipitated to produce scale and sludge. Differences between sludge and scale: No Sludge Scale

C. Priming and Foaming:

1)Due to rapid boiling, the steam may carry some water droplets along with it. This is called wet steam .The process of wet steam production is called Priming. It can reduce the heat of the steam and cause corrosion in the pipelines.

Priming is due to: a) Improper design of boiler b) High water level c) High velocity of steam d) Uneven boiling

Priming can be controlled by i)Proper boiler design ii)Maintaining proper water level iii)Proper boiling

2)If oils and greases are present, they produce stable bubbles on the water surface.This will increase the wet steam production. This is known as “Foaming”.

Foaming is prevented by adding i) Anti foaming agents (e.g.) synthetic poly amides , castor oil ii) Coagulants (e.g.) Aluminium hydroxide

3) Foaming and priming are collectively known as ‘ Carry over”.

Boiler Corrosion It may be due to three major reasons: i) Dissolved Oxygen ii) Dissolved CO2 iii) Dissolved salts like MgCl2

Corrosion Due to dissolved oxygen : Dissolved oxygen in presence of water, causes corrosion.

4 Fe (OH)3◊4Fe + 6 H2O + 3O2 (Rust)

Prevention from oxygen:

 a) Chemical method - 2 Na2SO4◊i)Adding Sodium Sulphite: 2 Na2SO3 + O2

This method results in other precipitates which can have some side effects. So this method is less preferred. N2 + 2 H2O◊

ii)Adding Hydrazine: N2H4 + O2 This method results in inert gas and pure water, and has no side effects. So it is preferred.

b) Mechanical deaeration method:

1. This is based on the principle that at high temperature , low pressure and high exposed area, the solubility of gases in water is decreased. So, the gases can be expelled easily.

2. Here, the water is fed into the mechanical deaerator which is provided with vacuum pump, heaters and perforated plates.

3. The out coming water will be free from dissolved gases. .

Corrosion due to CO2 Salts like Calcium bicarbonate on heating produces CO2 . CO2 dissolves in water to form carbonic acid which corrodes the boiler metal.

∆ CaCO3 + H2O + CO2 →Ca(HCO3)2 H2CO3→ H2O + CO2

Prevention from CO2 1. Chemical method: By adding calculated amount of ammonium hydroxide (NH4)2CO3 + H2O◊2NH4OH + CO2

 2. Mechanical deaeration method ( similar to oxygen method) Corrosion due to Dissolved salts like MgCl2 Dissolved salts like MgCl2 cause acid formation. This will be prevented by alkali neutralisation. Mg(OH)2 + 2 HCl (Corrosive acid)◊MgCl2 + 2 H2O Neutralisation: Excess acidic nature is neutralized by adding alkalis and vice versa. NaCl + H2O◊HCl + NaOH

**Q.5 Compare lime –soda method, zeolite method and ion exchange methods for softening of hard water**

|  |  |  |  |
| --- | --- | --- | --- |
| s.no.  | Lime –soda method  | Zeolite method  | Ion exchange method  |
| 1 | Residual hardness 15-30ppm  | Residual hardness 10-15 ppm | Residual hardness 0-2 ppm |
| 2 | Automation is not possible  | Automation is possible | Automation is possible |
| 3 | Capital cost is low  | Cost of plant and material is higher  | Cost of plant and material is higher |
| 4 | Operating expensive are high  | Operating expensive are low | Operating expensive are high |
| 5 | It can be used for acidic and alkaline water  | It can be used for acidic water | There are no such limitations  |
| 6 | Plant occupies large space  | Plant occupies less space | Plant occupies moderate large space |
| 7 | Raw water can have suspended impurities  | Raw water must be free suspended impurities.otherwise pores of zeolite material are blocked  | Raw water must be free from suspended impurities |
| 8 | Soft water contains less amount of dissolved solids  | More dissolved solids  | Free from dissolved solids  |
| 9 | Soften water is not good for boilers  | Good for boilers  | Soft water is to be used in high pressure boilers  |
| 10 | Hardness of raw water must be known in advance  | Control test comprises only in checking the hardness of water  | Control test comprises only in checking the hardness of water |
| 11 | Coagulation ,sedimentation of suspended impurities,filtration and removal of ppt are involved  | No such steps  | No such steps |

**Q.6 Describe the manufacture of metallurgical coke by Beehive oven method . discuss the recovery of by product s.**

 (04\*04=16 Marks)

 It is the earlist and cheapest process for manufacturing metallurgical coke .

Structure of beehive oven - A beehive oven is a simple firebrick chamber built with an arched roof so that the shape inside is that of an old-fashioned beehive. Its dimensions are typically 4 m in width and 2.5 m in height. Beehive ovens are usually built in rows, one oven beside another with common walls between neighboring ovens. Such a row of ovens is termed a battery. A battery usually consists of many ovens, sometimes hundreds, in a row. Typical cross section of a beehive **oven is shown in Fig** 1.



There are two openings one at the top for the charging of coal and other in one side for air supply as well as for coke discharge .these opening can b e opened or closed as desired.

Working - Coal is charged into an empty oven through the hole at the apex of the dome. It forms a cone-shaped pile which is levelled to a uniform layer by means of a rake passed through the door to produce an even layer of about 600 mm to 900 mm deep.

The carbonization process is started by means of the heat retained in the walls of the oven from the previous charge of coal. Almost immediately after charging gas consisting of volatile matter is produced from the coal. The air for combustion is admitted through an opening at the top of the oven door or through side door. Start of carbonization produces volatile matter which is burnt inside the partially closed side door. Carbonization proceeds from top to bottom. Heat is supplied by the burning volatile matter so no by-products are recovered. The exhaust gases are allowed to escape to the atmosphere.

The time of coking which depends largely on the depth of the layer of coal, ranges from 48 to 72 hours. As coking proceeds, the volume of gas evolved decreases, and the size of the opening in the door is correspondingly decreased or by introducing bricks at the top opening. This regulates the quantity of air and prevents the entrance of an excessive volume of air, which otherwise would burn part of the coke and might be sufficient to cool the oven as well.

The hot coke is quenched with water and discharged, manually through the side door. When coking is complete, the door is opened and the white hot coke is quenched by stream of water directed through the opening. The quenched coke is then raked from the oven manually and loaded into train cars for transport. The walls and roof retain enough heat to initiate carbonization of the next charge.

Disadvantage of beehive oven method -

1. The biggest demerits of this method is that no recovery of by products takes place.
2. Yields of coke is lower due to partial combustion
3. Lack of flexibility of operation

Q.7 analysis of water sample gave following results

CaSo4 -0.4 g/l, MgCO3 =0.44g/l, CaCO3 =2 g/l MgSO4 =0.80g/l MgCl2=0.78g/l SiO2 =2.40 g/l, NaCl =2.50 g/l. Calculate the amount of lime and soda required to soften 20,000 litres of water .if purity of lime is 90% and that of soda is 95%

|  |  |  |  |
| --- | --- | --- | --- |
| s.no.  | substances | Amount of substances | CaCO3 equivalent |
| 1 | CaSo4 | 0.4\*1000= 400 mg/L | 100\*400/136 =294.11 |
| 2 | MgCO3 | 0.44\*1000 =440mg/L | 100\*440/84 =523.8 |
| 3 | CaCO3 | 2\*1000=2000mg/L | 100\*2000/100 =2000 |
| 4 | MgSO4 | 0.8\*1000= 800mg/L | 100\*800/120 =666.6 |
| 5 | MgCl2 | 0.78\*1000 =780mg/L | 100\*780/95= 821.05 |
| 6 | SiO2 | - | - |
| 7 | NaCl | - | - |

Lime requirement = 74/100 ( 2\* MgCO3 + CaCO3 + MgSO4+ MgCl2) mg/L \*vol. of water \*100 /purity

= 74/100( 2\*523.8+ 2000+666.6+821.05)mg/L \* 20,000 \*100/90

= 74.1579 kg

Soda requirement = 106/100 (CaSo4 + MgSO4 + MgCl2 ) mg/L \*vol. of water \*100 /purity

= 39.76 Kg

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**Sec-A**

Q.1 Answer the following questions -

(a) Explains temporary and permanent hardness of water

(b) A water sample contain 204 mg of CaCO3 per litre . Calculate the hardness in terms of caco3 equivalent

(c) What are the Unit of Hardness

(d) What is fuel?

(e) What are the characteristics of water?

(f) Describe caustic embrittlement. How can they be prevented?

(g) Write the characteristics of a good fuel

(h) What is carbonization process (04 Marks)

**Sec-B**

Q.2 Explain break point chlorination in detail and give its advantages over other methods of chlorination.

Q.3 Describe the manufacture of metallurgical coke by otto- Hoffmann, s by product oven. Discuss the recovery of by products.

Q.4 Dscribes lime –soda process for softening of hard water. give the advantage s of this water process ?

Q5 Write complete process of water treatment

Q 6 What is Zeolite method and how it is useful for softening of water?

Q.7analysis of water sample gave following results

Ca(HCO3)2-48.6 mg/l,CaSo4 -54.4 mg/l, Mg(HCO3)2 =29.2mg/l,MgSO4 =4.8mg/l MgCl2=3.8mg/l SiO2 =2.40 g/l, CaCl2 =33.3mg/l. Calculate the amount of lime and soda required to soften one million litres of water .(04\*04=16 Marks)

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**Sec-A**

Q.1 Answer the following questions

(a)Explains temporary and permanent hardness of water

Ans Temporary hardness of water caused by dissolved bicarbonates of Ca and Mg. It also known as ‘alkaline or carbonate hardness ‘Temporary hardness can be removed by boiling of water.

Ca (HCO3)2 → CaCO3↓ + H2O + CO2↑

Permanent hardness Caused by CaCl2, MgCl2, Ca (NO3)2, CaSO4, MgSO4, FeSO4, Al2 (SO4)3

. It also known as ‘non carbonate hardness ‘it cannot be removed by boiling of water.

 (b) A water sample contain 204 mg of CaCO3 per liter . Calculate the hardness in terms of caco3 equivalent

Hardness (mg/L) as CaCO3 = M2+(mg/L) X Eq. wt. of CaCO3 ( 50)

 Eq. wt. of M2+

=204\*50%50 = 204 ppm

(c) what are the Unit of Hardness

Parts per million (ppm) - 1parts of CaCO3 dissolve 106 parts of water

Milligram per liter - 1miligram of CaCO3 equiv. hardness per 1 liter of water (ppm= mg/L.)

Degree Clark’s - 1 part of CaCO3 equivalent in 70,000 parts of water

Degree French - 1 part of CaCO3equivalent in105 parts of water

(d) What is fuel ?

A fuel is a combustible substance containing carbon as the main constituent which on proper burning gives large amount of heat that can be used economically for domestic and industrial purposes. During the process of combustion of a fuel, the atoms of carbon, hydrogen, etc combine with oxygen with simultaneous liberation of heat. The calorific value of a fuel depends mainly on the two elements.

 C + O2 CO2 + 94 kcals.

 2H2 + O2 2H2 O + 68.5 kcals.

(e) What are the characteristics of water?

 Water should be Free from color, turbidity, organic matter, Fe and Mn.It should be Soft and clear. Free from pathogens, color, odor and suspended impurities and not too hard, should contain less of chlorides.

(f) Describe caustic embrittlement. How can they be prevented?

A form of corrosion caused by high concentration of NaOH in the boiler feed water. It is a type of electrochemical corrosion occurs when the concentration of NaOH is above 100 ppm. It occurs at the stressed parts like bends, joints, rivets etc.Caustic embrittlement can be prevented by using sodium phosphate as the softening agent instead of Na2CO3.adding chemicals such as tannin, lignin to the boiler water. They block the hairline cracks.

(g) Write the characteristics of a good fuel

* A good fuel should have high calorific value.
* A good fuel should have moderate ignition temperature.
* A good fuel should have low moisture content as moisture content reduces the calorific value.
* A good fuel should have low contents of non-combustible material
* A good fuel should have moderate rate of combustion on burning,
* Fuel should not give out objectionable and poisonous gases
* A good fuel should be easy to handle and transport at low

(h) What is carbonization process (04 Marks)

Conversion of coal into coke in the absence of air and in presence of high temperature.

 In the absence of air

Coal → coke

 **Sec-B**

Q.2 Explain break point chlorination in detail and give its advantages over other methods of chlorination

The breakpoint chlorination is the point at which the disinfection demand has been met, or all undesirable contaminants in the pool have been oxidized. Think of as a tipping point, at which oxidation is complete, and further additions of shock chlorine or other oxidizer are unnecessary and unfruitful.



Breakpoint chlorination:

The point at which the added chlorine completely removes bacteria, NH3, Organic andinorganic impurities is known as “Breakpoint chlorination”.

The water contains: a) Bacteria b) Ammonia c)Organic impurity (sewage)

d) Inorganic salt impurities (Effluents, H2S , Fe salts)

1. When we add chlorine, first it kills bacteria and oxidizes some inorganic impurities.

2. The added chlorine is completely consumed. (A).

3. Further addition of chlorine is used to combine with ammonia to form chloramines

compounds. So, the residual chlorine content is increased upto (B).

4.As saturation level is attained, the chloramines begin to decompose to release chlorine

which is utilized to remove all the types organic and inorganic impurities. So, residual chlorine level decreases. (C).

5. At point (C), the added chlorine removes all the types of impurities. So, the point is known as “Break point chlorination”.

6. After this point, further addition of chlorine is not at all utilized and simply increases the residual chlorine content.(along CD)Diagram for break point chlorination:

Advantages of break point chlorination: (Significance)

i)It is used to remove Bacteria , Ammonia ,Organic impurity (sewage) ,Inorganic salt impurities ( Effluents, H2S , Fe salts) from water.

ii)It prevents the growth of any weeds in water.

Q.3 Describe the manufacture of metallurgical coke by otto- Hoffmann, s by product oven .discuss the recovery of by product s.\

**Otto Hoffman's by-product oven**:

In order to: (1) increase the thermal efficiency of the carbonization process, and (ii) recover valuable by-product (like coal gas, ammonia, benzol oil, tar, etc.), Otto Hoffman developed modern by-product coke oven which, unlike beehive oven, is heated externally by a portion of coal gas produced during the process itself or by producer gas or by blast furnace gas. Moreover, the heating is done on the basis of "regenerative system of heat economy", i.e., utilizing the waste flue gases for heating the checker-work of bricks.

The by-product coke oven consists of number of narrow silica chambers (each about 10 to 12 m long, 3 to 4 m high and 0.40 to 0.45 m wide) erected side-by-side with vertical flues in-between them to form a sort of battery. Each chamber is provided with a charging hole at the top, a gas off-take and a refractory-lined cast iron door at each ends for discharging coke.

A charge consisting of finely crushed coal is introduced through the charging holes at the top of chambers, which are then closed tightly at both ends to prevent any access of air. The coke ovens are heated to 1,200°C by burning gaseous fuel (like producer gas) and usually employing a regenerative principle to achieve as econom­ical heating as possible. The flue gases produced during combustion, before escaping to chimney, pass on their sensible heat to one of the two sets of checker brick-work, until this brick-work has been raised to a temperature of about 1,000°C. The flow of heating gases is then reversed and the inlet gases are passed through the heated checker brick-work, which thus serves to preheat the inlet gases. The flue gases are then allowed to pass through the second set of checker bricks to heat it. This checker-work then serves to preheat the inlet gases. Thus, this cycle goes on. The heating is actually continued, till the evolution of volatile matter ceases completely. Carbonization of a charge of coal takes about between 11 to 18 hour When carbonization is completed; a massive ram pushes the red hot coke into a truck. It is subsequently quenched by a water spray ('wet quenching'). In place of wet quenching, "dry quenching" offers advantages, because the coke produced is more strong, dense, graphitized and non-reactive. In this method, the red hot coke is placed in a chamber and cooled by passing inert gases from boilers (like nitrogen). The heated inert gases are then circulated to boilers, where they generate steam. The coke produced by 'dry quenching' is cheaper, drier and contains lesser dust than 'wet-quenched' coke.



Q.4 Dscribes lime –soda process for softening of hard water. Give the advantage s of this water process?

Soda lime is a process used in water treatment to remove [Hardness](http://textilelearner.blogspot.com/2012/03/what-is-hardness-of-water-potential.html) from water. This process is now obsolete but was very useful for the treatment of large volumes of hard water. Addition of lime (CaO) and soda (Na2CO3) to the hard water precipitates calcium as the carbonate, and magnesium as its hydroxide. The amounts of the two chemicals required are easily calculated from the analysis of the water and stoichiometry of the reactions. The lime‐soda uses lime, Ca (OH)2 and soda ash, Na2CO3, to precipitate hardness from solution.

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| **Soda lime water softening process** |
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Carbon dioxide and carbonate hardness (calcium and Magnesium bicarbonate) are complexed by lime. In this process Calcium and Magnesium ions are precipitated by the addition of lime (Ca(OH)2and soda ash (Na2CO3).

**Following are the reactions that takes place in this process:**

As slacked lime is added to a water, it will react with any carbon dioxide present as follows:

Ca(OH)2 + CO2 → CaCO3 ↓ + H2O....(1)

The lime will react with carbonate hardness as follows:

Ca(OH)2+Ca(HCO3)2→2CaCO3↓+2H2O....

Ca(OH)2+Mg(HCO3)2→MgCO3+CaCO3↓+2H2O

The product magnesium carbonate in equation 3 is soluble. To removemagnesium carbonatemorelimeisadded

Ca(OH)2+MgCO3→CaCO3↓+Mg(OH)2↓.....
Also, magnesium non-carbonate hardness, such as magnesium sulfate, is removed:

Ca(OH)2+MgSO4→CaSO4+Mg(OH)2↓...

Lime addition removes only magnesium hardness and calcium carbonate hardness. magnesium is precipitated, however, an equivalent amount of calcium is added. The water now contains the original calcium non-carbonate hardness and the calcium non-carbonate hardness. Soda ash is added to remove calcium non-carbonate hardness:

Na2CO3+CaSO4→Na2SO4+CaCO3↓..

To precipitate CaCO3 requires a pH of about 9.5; and to precipitate Mg(OH)2 requires a pH of about 10.8, therefore, an excess lime of about 1.25 meq/l is required to raise the pH.

The amount of lime required: lime (meq/l) = carbon dioxide (meq/l) + carbonate hardness (meq/l) + magnesium ion (meq/l) + 1.25 (meq/l)

The amount of soda ash required: soda ash (meq/l) = non-carbonate hardness (meq/l)

After softening, the water will have high pH and contain the excess lime and the magnesium hydroxide and the calcium carbonate that did not precipitate. Recarbonation (adding carbon dioxide) is used to stabilize the water. The excess lime and magnesium hydroxide are stabilized by adding carbon dioxide, which also reduces pH from 10.8 to 9.5 as the following:

CO2+Ca(OH)2→CaCO3↓+H2O

CO2+Mg(OH)2→MgCO3+H2O

**Limitations**Lime soda softening cannot produce a water at completely free of hardness because of the solubility (little) of CaCO3 and Mg(OH)2. Thus the minimum calcium hardness can be achieved is about 30 mg/L as CaCO3, and the magnesium hardness is about 10 mg/L as CaCO3. We normally tolerate a final total hardness on the order of 75 to 120 mg/L as CaCO3, but the magnesium content should not exceed 40 mg/L as CaCO3 (because a greater hardness of magnesium forms scales on heat exchange elements).

Q5 Write complete process of water treatment?

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| Treatment |  Done by  | Purpose |
| Screening | Screening shutterswith variable sized holes | Removes floating material likewood, plastic, papers |
| Aeration | Mechanical aerator | Removes Oxygen, Carbon-dioxide, toxic gases, Fe, Mn salts |
| Sedimentation | Allowing the water tostand for 2 – 6 hrs ina tank | Removes 75% of suspendedimpurities |
| Coagulation | Adding alum,Al2(SO4)3  Al (OH)3 | Removes 100% suspendedand colloidal impurities, clay |
| Filtration | Filter bed | Removes bacteria, colour,odour, small dust particles |
| Sterilization/Disinfection | Boiling, ozone,chlorine, UV radiation | Destroys bacteria |

Flow diagram:

Screening → Aeration →Sedimentation→Coagulation→Filtration→Sterilization

Out of the above said methods, filtration and sterilization play a vital role in domestic water treatment.

Filtration:

Filter bed consists of four layers i.e., Fine sand, coarse sand, fine gravel and coarse gravel. When water is passed through this, all the colour, odour, part of bacteria are removed. The bed needs periodic regeneration.

Diagram:

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sterilisation:

Removal of bacteria is sterilization or disinfection. There are four important

Sterilization methods.

1. Boiling

2. Using ozone

3. UV treatment

4. Chlorination

a. Passing Chlorine gas or solution

b. Adding chloramines salt

c. Adding bleaching powder

1. By boiling for 10 – 15 minutes, water can be sterilized. But it affects the taste and can not be used for higher volume water.

2. By using Ozone, (with the usual dosage of 2-3ppm for 10 – 15 minutes in

Disinfection tank) we produce nascent oxygen which is powerful disinfectant. Its excess is not harmful, since it is unstable and decomposes into oxygen. But, it is costly. It cannot be used and stored for long time as it is unstable.

O3 →O2 + [ O] , this nascent oxygen kills bacteria.

3. By passing UV radiations from mercury vapor lamp, the swimming pool water can be sterilized. But it is costly and turbid water cannot be treated.

4. by chlorination:

a) Chlorine gas or solution bubbling will kill bacteria.

b) Adding chlorine and ammonia (2:1) will form chloramine. It decomposes slowly to release chlorine which kills bacteria. Its excess does not produce any irritating odor. It imparts a good taste to treated water.

Cl2 + NH3 →ClNH2 (Chloramine)+HCl

c) Bleaching powder (CaOCl2) reacts with water and forms hypochlorous acid which kills bacteria. Generally, 1kg powder is used for 1000 kiloliters of water.

CaOCl2 + H2O →Ca (OH)2 + Cl2

Cl2 + H2O →HCl + HOCl

(Hypochlorous acid which kills bacteria)

It should be noted that chlorine should be always added a little higher than the break point chlorination for perfect disinfection.

Q 6 What is Zeolite method and how it is useful for softening of water?

* Zeolite is also known as Permutit.
* The general formula of zeolite: Hydrated sodium aluminosilicate – Na2O.Al2O3.xSiO2.yH2O; x = 2 – 10, y = 2 – 6
* Natrolite – Na2O.Al2O3.3SiO2.2H2O
* It holds sodium ions loosely that is replaced by calcium or magnesium.
* It is of two types natural and synthetic.
* Natural zeolites are green sand and are usually non-porous.
* Permutit – artificial zeolite, porous.
* Sodium zeolite – Na2Ze which exchange Na+ ions with the hardness producing ions like Ca2+, Mg2+ in water.



CHEMICAL REACTIONS

 Na2Z +CaCl2 →CaZ +2NaCl

 Na2Z +MgCl2 →MgZ +2NaCl

 Na2Z +CaSO4 →CaZ +Na2SO4

 Na2Z +MgSO4 →MgZ +Na2SO4

 Na2Z +Ca(HCO3 )2 →CaZ +2NaHCO3

 Na2Z +Mg(HCO3 )2 →MgZ +2NaHCO3

**REGENERATION OF ZEOLITE**

CaZ+ 2NaCl→ Na2Z +CaCl2

MgZ+ 2NaCl→ Na2Z +MgCl2

Advantage of Zeolite method

Remove almost complete hardness and produce water up to 10ppm hardness. No sludge formation occurs. Method is cheap since zeolite can be reuse.

Disadvantage of Zeolite method

Treated water contains more sodium salt. Method is not useful for treatment of turbid water.

Q.7 analysis of water sample gave following results

CaSo4 -0.4 g/l, MgCO3 =0.44g/l, CaCO3 =2 g/l MgSO4 =0.80g/l MgCl2=0.78g/l SiO2 =2.40 g/l, NaCl =2.50 g/l. Calculate the amount of lime and soda required to soften 20,000 litres of water .if purity of lime is 90% and that of soda is 95%

Q.7 7analysis of water sample gave following results

Ca(HCO3)2-48.6 mg/l,CaSo4 -54.4 mg/l, Mg(HCO3)2 =29.2mg/l,MgSO4 =4.8mg/l MgCl2=3.8mg/l SiO2 =2.40 mg/l, CaCl2 =33.3mg/l. Calculate the amount of lime and soda required to soften one million litres of water .(04\*04=16 Marks)

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| s.no.  | substances | CaCO3 equivalent |
| 1 | Ca(HCO3)2 | 48.6\*50/81 =30 |
| 2 | Mg(HCO3)2 | 29.2\*50/73=20 |
| 3 | CaCl2 | 33.3\*50/55.5=30 |
| 4 | MgSO4 | 4.8\*50/60=4 |
| 5 | MgCl2 | 3.8\*50/47.5= 4 |
| 6 | CaSO4 | 54.4\*50/68=40 |
| 7 | SiO2 | - |

Lime requirement = 74/100 (Ca(HCO3)2+2\* Mg(HCO3)2+ MgSO4+ MgCl2) mg/L \*vol. of water \*100 /purity

= 74/100(30+ 2(20)+4 +4)mg/L \* 106

= 57.72kg

Soda requirement = 106/100 (CaCl2 + CaSO4 + MgCl2 + MgSO4)mg/L \*vol. of water \*100 /purity

= 82.68 Kg