AKSHAT
C3-3
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Somaiya TRUST

Batch: Roll No.:
Experiment / assignment / tutorial No. ______
Grade: AA/ AB / BB / BC / CC / CD / DD

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# Module - 1

Q1. Determine the hardness of water sample prepared by dissolving 1.36 gram of $CaCl_2$ in 500 ml distilled water.

⇒ Given mass of $CaCl_2$ = 1.36 gm

Volume of distilled water = 500 ml

∴ $CaCl_2$ equivalent = $\frac{1.36 g}{500 ml}$ = 2.72 g/L = 2720 mg/L

mol. weight of $CaCO_3$ = 100
mol. weight of $CaCl_2$ = 111

100g of $CaCO_3$ = 111g of $CaCl_2$
100 ppm of $CaCO_3$ = 111 ppm of $CaCl_2$

∴ 1 ppm of $CaCl_2$ = 0.901 ppm of $CaCO_3$
∴ 2720 ppm of $CaCl_2$ = $CaCO_3$ equivalent hardness

∴ $\boxed{\text{Hardness} = 2720 \times 0.901 = 2450.72 \text{ ppm}}$

Q2. Convert 50° clarke of hardness in mg/L and °french

⇒ Given: Hardness = 50°cl

0.07°cl = 1mg/L = 0.1°fr

∴ Hardness in mg/L = $\frac{50}{0.07}$ = 714.286 mg/L

$\boxed{\therefore \text{Hardness in } °fr = \frac{50}{0.07} \times 0.1 = 71.428 °fr}$

Q3. Calculate the temporary hardness of water sample if it contains $MgSO_4$ = 12ppm, $CaCl_2$ = 11.1 ppm, $MgCO_3$ = 16.8 ppm, $Na(HCO_3)$ = 13 ppm.

=>

| Constituent (PPm) | M.F | $CaCO_3$ equivalent | Hardness |
|---|---|---|---|
| $MgSO_4$ = 12 PPm | 100/120 | 100/120 × 12 = 10 PPm | P |
| $CaCl_2$ = 11.1 PPm | 100/111 | 100/111 × 11.1 = 10 PPm | P |
| $MgCO_3$ = 16.8 PPm | 100/84 | 100/84 × 16.8 = 20 PPm | T |
| $NaHCO_3$ = 13 PPm | - | - | - |

Temporary Hardness = 20 PPm

Q4. Calculate total Hardness of water sample if 50 ml water sample required 12ml of M/20 EDTA solution for titration using EBT.

=> Given : concentration of EDTA = M/20 = 0.05 M
volume of EDTA required = 12 ml
volume of water sample = 50ml

1000 ml of 1M EDTA = 100g of $CaCO_3$ ....(Avagadro no. of molecule)

∴ 1ml of 1M EDTA = 100 mg of $CaCO_3$

∴ 1 ml of 0.05 M EDTA = 100 × 0.05 mg of $CaCO_3$.

50 ml of Water Sample = 12 ml of 0.05 M EDTA

50 ml of water Sample = 12 × 5 = 60 mg of $CaCO_3$.

1000 ml of Water Sample = 60 × 20 = 1200 mg of $CaCO_3$

$\boxed{\text{Hardness of Water Sample = 1200 ppm}}$

Q5. Calculate the amount of lime required for the softening of 50,000 liter of water sample having following impurities: $MgCl_2 = 1.9$ ppm, $CaSO_4 = 6.8$ ppm, $Mg(HCO_3)_2 = 7.3$ ppm; $Ca(HCO_3)_2 = 4.05$ ppm.

⇒

| Impurities | M.F | $CaCO_3$ equivalent | Requirement |
|---|---|---|---|
| $MgCl_2 = 1.9$ ppm | 100/95 | 100/95 × 1.95 = 2 ppm | L + S |
| $CaSO_4 = 6.8$ ppm | 100/136 | 100/136 × 6.8 = 5 ppm | S |
| $Mg(HCO_3)_2 = 7.3$ ppm | 100/146 | 100/146 × 7.3 = 5 ppm | 2L |
| $Ca(HCO_3)_2 = 4.05$ ppm | 100/162 | 100/162 × 4.05 = 2.5 ppm | L |

$$\text{Lime Required} = \frac{74\,[Mg^{+2}\text{ permanent} + 2\,Mg^{+2}\text{ temp} + Ca^{+2}\text{ temp}] \times \text{volume of water}}{100 \times 1000 \times \%\text{ Purity}}$$

$$= \frac{74\,[2 + 2(5) + (2.5)] \times 50000}{100 \times 1000 \times 100} = \frac{74 \times 14.5 \times 50000}{100 \times 1000 \times 100}$$

$$\boxed{\text{Lime required} = 5.365\text{ Kg}}$$

$$\text{Soda required} = \frac{106\,[Mg^{+2}\text{ Perm.} + Ca^{+2}\text{ Perm}] \times \text{V. of water}}{100 \times 1000 \times \%\text{ Purity}}$$

$$= \frac{106 \times 7 \times 50000}{100 \times 1000 \times 100} = 2.310\text{ g}$$

$$\boxed{\text{Soda required} = 2.310\text{ Kg}}$$

Q6:- Calculate the amount of soda required for the softening of 25,000 liter of water sample having following impurities: $CaCl_2 = 1.11$ ppm, $MgSO_4 = 6$ ppm, $Na(HCO_3)_2 = 7.3$ ppm, $Ca(HCO_3)_2 = 4.05$ ppm, $CO_2 = 22$ p[illegible]
$HCl = 7.3$ ppm.

=> 

| Impurities | M.F | $CaCO_3$ equivalent | Requirement |
|---|---|---|---|
| $CaCl_2$ = 1.11 ppm | 100/111 | 100/111 × 1.11 = 1 ppm | S |
| $MgSO_4$ = 6 ppm | 100/120 | 100/120 × 6 = 5 ppm | L+S |
| $Na(HCO_3)_2$ = 7.3 ppm | 100/84 | 100/84 × 7.3 = 8.69 ppm | L−S |
| $Ca(HCO_3)_2$ = 4.05 ppm | 100/162 | 100/162 × 4.05 = 2.5 ppm | L |
| $CO_2$ = 22 ppm | 100/44 | 100/44 × 22 = 50 ppm | L |
| HCL = 7.3 ppm | 100/36.5 | 100/36.5 × 7.3 = 20 ppm | L+S |

$$\text{Soda Required} = \frac{106\,[Ca^{+2}\text{ perm} + Mg^{+2}\text{ perm} - HCO_3^-\text{ temp} + H^+] \times V \text{ of water}}{100 \times 1000 \times \%\text{ Purity}}$$

$$= \frac{106\,[1+5-8.69+20]}{100 \times 1000 \times 100} \times 25000 = \frac{106 \times 17.31 \times 25000}{100 \times 1000 \times 1000}$$

$$\boxed{\text{Soda required} = 4.8572 \text{ Kg}}$$

Q7. Calculate the COD of effluent water sample if 50 ml of water sample on refluxing with 30 ml 0.05 N $K_2Cr_2O_7$ solution required 12 ml of 0.05 N FAS solution while black ~~to~~ titration reading in 33 ml.

=> Given : Volume of water sample = 50 ml
Volume of FAS in blank titration $(V_1)$ = 33 ml
Volume of FAS in blank titration $(V_2)$ = 12 ml.
normallity of FAS = 0.05

$$COD = \frac{(V_1 - V_2) \times N_{FAS} \times 8000}{\text{Volume of Sample}} = \frac{(33-12) \times 0.05 \times 8000}{50}$$

$$\boxed{COD = 168 \text{ ppm}}$$

Q8:- Calculate the equivalence of $CaCO_3$ hardness in degrees Clarke for the Following:-
(a) 7.4 mg of $Mg(NO_3)_2$ in 750 ml distilled water.

⇒ given: Mass of $Mg(NO_3)_2$ = 7.4 mg
Volume of water = 750 ml
$Mg(NO_3)_2$ equivalent = 7.4 mg / 750 ml = 9.87 mg/L.

100 g of $CaCO_3$ = 148 g of $Mg(NO_3)_2$
148 mg/L of $Mg(NO_3)_2$ = 100 mg/L of $CaCO_3$
9.87 mg/L of $Mg(NO_3)_2$ = Hardness in $CaCO_3$

$$\text{Hardness} = \frac{9.87}{147} \times 100 = 6.669 \text{ mg/L}$$

1 mg/L = 0.07 °cl.
6.669 mg/L = Hardness in °cl

$$\boxed{\text{Hardness} = 6.669 \times 0.07 = 0.467\,°cl.}$$

Q9. ~~Har~~ Calculate the equivalence of $CaCO_3$ hardness if 200 Lit of 0.1 N HCL used in regenration of Cation exchange column.

⇒ Hardness of water = 200 L of 0.1N HCL
1 equivalent of HCL = 1 equivalent of $CaCO_3$
0.1 N of HCL = 0.1 N of $CaCO_3$.

Hardness of water = 200 × 0.1 N $CaCO_3$
= 20 L of 1 N $CaCO_3$

1 L of 1N $CaCO_3$ = 50 g of $CaCO_3$
Hardness = 20 × 50 g/L of $CaCO_3$ = 1000 g/L $CaCO_3$

$$\boxed{\text{Hardness} = 1000000 \text{ mg/L } CaCO_3 = 1000000 \text{ ppm}}$$

Q10. Calculate the equivalence of $CaCO_3$ hardness if 150 lit of 10 % NaCl solution is required for regeneration of zeolite column.

⇒ given: Volume of NaCl solution = 150 L

% purity = 10 %

150 L of 10 % NaCl = $150 \times \frac{10}{100}$ = 15 g = 15000 mg

58.5 mg of NaCl = 50 mg of $CaCO_3$.

15000 mg of NaCl = Hardness of $CaCO_3$.

$$\boxed{\text{Hardness} = \frac{15000}{58.5} \times 50 = 12820.513 \text{ ppm}}$$

Q11. Calculate the equivalence of $CaCO_3$ hardness of EDTA Solution if 50 ml of standard hard water solution (1.11 g $CaCl_2$ in 1000 ml) required 21 ml of EDTA Solution for titration.

⇒ 1000 ml of S.H.W Solution = 1.11 g $CaCl_2$

1000 ml of S.H.W Solution = 1 g $CaCO_3$

.... (100 g $CaCO_3$ = 111 g $CaCl_2$)

∴ 1 ml of SHW Solution = 1 mg of $CaCO_3$

∴ $\boxed{\text{50 ml of SHW Solution} = \text{50 mg of } CaCO_3}$

50 ml of SHW Solution = 21 ml of EDTA

∴ 21 ml of EDTA = 50 mg of $CaCO_3$

∴ 1 ml of EDTA = $\frac{50}{21}$ mg of $CaCO_3$ = 2.381 mg $CaCO_3$

∴ 1000 ml of EDTA = 2381 mg of $CaCO_3$

∴ Hardness ~~of ed~~ of EDTA = 2381 ppm.

$\boxed{\text{CaCO}_3 \text{ equivalent hardness of } \text{EDTA Solution} = 2381 \text{ ppm.}}$

# MODULE - 3

Q1. Calculate the GCV of coal if its composition is as follows: C = 82%, H = 5%, S = 3%, N = 2%, Ash = Remaining

=> given => C = 82%
H = 5%
S = 3%
N = 2%
Ash = Remaining.

By Dulong's formula

$$GCV = 1/100 \times [8080 \times C + 34500 \times (H - O/8) + 2240 \times S]$$
$$GCV = 1/100 \times [8080 \times 82 + 34500 \times 5 + 2240 \times 3]$$
$$GCV = 1/100 \times 841780$$
$$\boxed{GCV = 8417.80 \text{ Kcal/kg}}$$

Q2. Calculate the NCV of coal if its composition is as follows: C = 90%, H = 4%, S = 2%, N = 1%, Ash = Remaining.

=> given => C = 90%, S = 2%
H = 4%, N = 1%
Ash = Remaining.

By Dulong's formula

$$GCV = 1/100 \times [8080 \times C + 34500 (H - O/8) + 2240 / S]$$
$$GCV = 1/100 \times [8080 \times 90 + 34500 \times 4 + 2240 \times 2]$$
$$GCV = 1/100 \times 869680$$
$$\boxed{GCV = 8696.80 \text{ Kcal/kg}}$$

$$NCV = HCV - [9/100 \times H \times 587]$$
$$NCV = 8696.80 - [0.09 \times 4 \times 587]$$
$$NCV = 8696.80 - 211.32$$
$$\boxed{NCV = 8485.42 \text{ Kcal/kg}}$$

Q3. Calculate the moisture % of coal if 1.2 g of coal is heated at 100° C for 1h gives residue of 0.88g.

⇒ given: Weight of coal sample $= W = 1.2g$
Weight of coal sample after heating $= 0.88g$

$$\% \text{ Moisture} = \frac{\text{change in weight}}{\text{weight of coal sample}} \times 100 = \frac{(W_1 - W_2)}{W} \times 100$$

$$\boxed{\% \text{ Moisture} = \frac{1.2 - 0.88 \times 100}{1.2} = 26.67\%}$$

Q4. Calculate the % V.M of coal having 10% moisture content if 1.8 g of coal is heated at 920°c for 7 minutes gives residue of 1.09 g.

⇒ Given: % Moisture $= 10\%$
weight of coal sample $= W_1 = 1.8g$
weight after heating at 925°c $= W_2 = 1.09g$
weight after removing moisture $= W_1$

$$W_1 = W - \frac{\% m \times W}{100} = 1.8 - \frac{1.8 \times 10}{100} = 1.8 - 0.18$$

$$\boxed{W_1 = 1.62g}$$

$$\% \text{ VM} = \frac{\text{Volatile matter}}{\text{weight of coal sample}} \times 100 = \frac{W_1 - W_2 \times 100}{W}$$

$$= \frac{1.62 - 1.09 \times 100}{1.8}$$

$$\boxed{\% \text{ VM} = 29.44\%}$$

Q5. Calculate the % Ash of Coal having 10% moisture content if 1.8g of coal is heated at 750°c for 30 minutes gives residue of 0.63g.

=> given: Weight of Coal Sample $= W = 1.8g$
% moisture $= 10\%$
weight of residue $= W_3 = 0.63g$
Weight of ash $= W_3 = 0.63g$

$$\% \text{ Ash} = \frac{W_3}{W} \times 100 = \frac{0.63}{1.8} \times 100$$

$$\boxed{\% \text{ Ash} = 35\%}$$

Q6. Calculate % C of Coal if 1.56g of coal in combustion experiment gave increase in mass of KOH tube 4.8g.

=> given:- weight of coal sample $= 1.56g$
increase in mass of KOH tube $= 4.8g$

$$\% C = \frac{\text{increase in mass of KOH} \times 12 \times 100}{\text{weight of coal sample} \times 44} = \frac{4.8 \times 12 \times 100}{1.56 \times 44}$$

$$\boxed{\% C = 83.92\%}$$

Q7. Calculate % H of Coal if 1.56g of Coal in Combustion experiment gave increase in mass of $CaCl_2$ tube 1.2g.

=> Given: Weight of Coal Sample $= 1.56g$
increase in mass of $CaCl_2$ tube $= 1.2g$

$$\% H = \frac{\text{increase in mass of } CaCl_2 \times 2 \times 100}{\text{weight of Coal Sample} \times 18} = \frac{1.2 \times 2 \times 100}{1.56 \times 18}$$

$$\boxed{\% H = 8.55\%}$$

Q8. Calculate the % N if 2.8g of Coal in Kjeldahls experiment required 15ml of 0.05 N KOH Solution for neutralization while blank titration is 28ml of 0.05 N KOH Solution

⇒ Given :- Weight of Sample = 2.8 g
blank titration = 0.05 N 28 ml KOH
back titration = 0.05N 15 ml KOH
V. of KOH Used = 28 − 15 = 13ml 0.05 N KOH
Volume of KOH used = Volume of acid used

$$\% N = \frac{\text{Volume of acid used} \times \text{Normality} \times 1.4}{\text{Weight of Sample}}$$

$$\% N = \frac{13 \times 0.05 \times 1.4}{2.8}$$

$$\boxed{\% N = 0.325}$$

Q.9. Calculate % S in coal if 1.75g of coal in Bomb Calorimeter experiment gave mass of 0.66 g $BaSO_4$ residue.

⇒ given :- weight of Coal sample = 1.75g
Weight of $BaSO_4$ residue = 0.66g

$$\% S = \frac{\text{Weight of } BaSO_4 \text{ residue used} \times 32 \times 100}{\text{weight of Coal sample} \times 233}$$

$$\% S = \frac{0.66 \times 32 \times 100}{1.75 \times 233}$$

$$\boxed{\% S = 5.18\%}$$

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Q10. Calculate amount of Oxygen required for combustion of 5kg coal if it contains :- C = 85 %, H = 4 %, S = 2%, N = 1%, Ash = 4%

=> given :- weight of coal = 5kg

$C = 85\% = 85/100 \times 5 = 4.25$ kg

$H = 4\% = 4/100 \times 5 = 0.2$ kg

$S = 2\% = 2/100 \times 5 = 0.1$ kg

$N = 1\% = 2/100 \times 5 = 0.05$ kg

$Ash = 4\% = 4/100 \times 5 = 0.2$ kg

$O = 4\% = 4/100 \times 5 = 0.2$ kg.

oxygen required $= \frac{32}{12} \times 4.25 + 8\left[\frac{0.2}{1} - \frac{0.2}{8}\right] + 0.1$

$\boxed{\text{oxygen required} = 12.83 \text{ kg.}}$

Q.11. Calculate the mass and the volume of air required for combustion of coal if 2kg of coal required 4.85 kg of oxygen for combustion if 10 % excess air is required for combustion.

=> Given : weight of coal = 2kg
quantity of oxygen = 4.85 kg

quantity of air $= \frac{\text{oxygen quantity}}{23} \times 100 = \frac{4.85 \times 100}{23}$

mass of air $= 21.08 + 10/100 \times 21.087 = 23.20$ kg

volume of air $= \frac{\text{Quantity of air} \times 22.4}{28.94} = \frac{23.20 \times 22.4}{28.94}$

$\boxed{\text{Volume of air} = 17.96 \ m^3}$

## Module-5

Q1. Calculate the Absorbance of $KMnO_4$ solution if it transmits 60% of incident radiation at 650 nm wavelength and 1.5 cm path length.

⇒ Given: $\% T = 60\%$

wavelength = 650 nm

path length = $l = 1.5$ cm

$A = 2 - \log [\% T] = 2 - \log [60]$

$\boxed{A = 0.2218}$

Q2. Calculate the Absorbance of $K_2Cr_2O_7$ solution if it absorbs 50% of incident radiation at 380 nm wavelength and 1.2 cm path length.

⇒ Given :- Absorbance = A = 50 %

$\% T = 100 - 50 = 50\%$

wavelength = 380 nm

Path length = $l = 1.2$ cm

$A = 2 - \log [\% T] = 2 - \log [50]$

$\boxed{A = 0.3010}$

Q3. A solution of tryptophan has an absorbance of 0.56 at 280 nm in cuvette of 0.75 cm path length. Calculate concentration of solution if absorptivity of solution is $6.4 \times 10^3$ L mol$^{-1}$ cm$^{-1}$.

⇒ given:- $A = 0.56$

Path length = $l = 0.75$ cm

$\varepsilon = 6.4 \times 10^3$ L mol$^{-1}$ cm$^{-1}$

$$A = \varepsilon c l$$

$$c = \frac{A}{\varepsilon l} = \frac{0.56}{0.75 \times 6.4 \times 10^3}$$

$$\boxed{c = 1.167 \times 10^{-4} \text{ mol/L}}$$

Q4: A solution of aspirin shows transmittance of 0.45 at 230nm in cuvette of path length 2cm, calculate ~~concentration~~ the absorbance of same solution if measurements were done using 1cm path length at same wavelength.

⇒ given:–

| | | |
|---|---|---|
| wavelength | 2cm | 1cm |
| Transmittance | 0.45 | ? |
| Absorbance | ? | ? |

$$A_{old} = -\log [T_{old}] = -\log (0.45)$$

$$A_{old} = 0.3469$$

$$\varepsilon = \frac{A_{old}}{Cl_{old}} = \frac{A_{new}}{Cl_{new}} \quad \therefore \frac{0.3469}{0.45} = \frac{A_{new}}{1}$$

$$\boxed{\text{Absorbance} = A_{new} = 0.1825}$$

Q5.. Calculate Molar absorbity of 10 −3 M solution having 0.334 absorbance measured in cuvette of path length of 1.2cm.

⇒ Given: concentration $= c = 10^{-3}$ M

Absorbance $= A = 0.334$

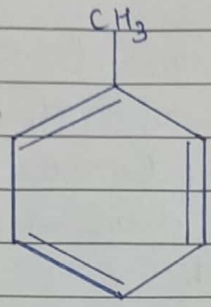
cuvette length $= l = 1.2$cm

$$\varepsilon = \frac{A}{cl} = \frac{0.334}{1.2 \times 10^{-3}} = 278.33 \text{ L mol}^{-1} \text{cm}^{-1}$$

$$\boxed{\varepsilon = 278.33 \text{ L mol}^{-1} \text{cm}^{-1}.}$$

Q6. Calculate the total number of theoretical fundamental modes of vibration for toluene and benzene.

⇒ Toluene – $C_7H_8$



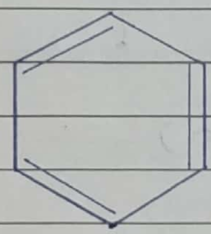
Toluene is non linear molecule

no. of atoms = 7 C + 8 H = 15

no. of Vibrational Nodes = $3n - 6$

$\boxed{\text{no. of Vibrational Nodes} = 3(15) - 6 \Rightarrow 39}$

Benzene – $C_6H_6$



Benzene is non linear molecule

no. of Atoms = 6C + 6H = 12

$\boxed{\text{no. of Vibrational Nodes} = 3(12) - 6 \Rightarrow 30}$